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Michael Hamwi

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DISSERTATION

FOR THE UNIVERSITY OF BORDEAUX PREPARED AT ESTIA

ECOLE DOCTORALE SCIENCE PHYSIQUES ET DE L'INGENIEUR

SPECIALITE AUTOMATIQUE, PRODUCTIQUE, SIGNAL & IMAGE, INGENIERIE
COGNITQUE

Understanding and analysing business models in the context of energy transition.

Proposition of the DRBMC (Demand Response Business Model Canvas) to design a new entrepreneur's Business model in Demand Response markets

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List of acronyms

BM: Business Model	28
BMI: Business Model Innovation	75
BRP: Balance Responsible Party.....	31
CHP: Combined Heat and Power	63
CPP: Critical Peak Pricing	192
DA: Day-ahead.....	36
DER: Distributed Energy Resource.....	192
DR: Demand Response	62
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DRP: Demand Response Provider.....	63
DSM: Demand-Side Management	49
DSO: Distribution System Operator.....	29
EBM: Energy Business Model	48
EMS: Energy Management System.....	161
ESCO: Energy Service Company.....	60
EV: Electric Vehicle.....	79
FCR: a. Frequency Containment Reserves.....	191
FERC: Federal Energy Regulatory Commission.....	191
FR: Frequency Regulation.....	159
<i>FRR: Frequency Restoration Reserves.....</i>	191
GHG: Greenhouse Gas.....	31
HCPV: High Concentrated Photovoltaics	104
HVAC: Heating, Ventilation and Air Conditioning	159
ICT; Information Communication Technology.....	28
ITC: Investment Tax Credit	59
LV: Low Voltage	79
PSS: Product-Service System.....	51
PV: Photovoltaic	52
RBV: Resource-based View.....	81
<i>RR: Replacement Reserve</i>	191
<i>RT: Real-Time</i>	36
RTE: Réseau de Transport d'Electricité.....	105
RTP: Real-Time Pricing.....	192
SBM: Sustainable Business Model	51
SO: System Operator.....	63
SoC: State-of-Charge	178
SPE: Special Purpose Entity.....	59
TOU: Time of Use.....	192
TSO: Transmission System Operator.....	29
UCTE: Coordination of Transmission of Electricity.....	191
USC; Utility-Sponsored Community	58
USCS: Utility-Sponsored Community Solar	58
VPP: Virtual Power Plant.....	63

Résumé de thèse

Cette thèse contribue au processus entrepreneurial dans le secteur de l'énergie en explorant les modèles économiques des start-ups qui développent de nouvelles offres produits-services dans le domaine de la transition énergétique pour favoriser le développement durable. L'auteur étudie les éléments du modèle d'affaires de différentes start-ups et en particulier dans le domaine émergent de la « réponse à la demande » (noté RD). La RD fait partie du domaine de la gestion de la demande et a été reconnue comme un modèle d'affaires durable (Khripko et al., 2017) car les modèles d'affaires de la RD valorisent la flexibilité énergétique des consommateurs, principalement en modifiant la consommation d'électricité en réponse à des paiements incitatifs ou par l'éducation, afin de réduire la consommation d'électricité lorsque la fiabilité du réseau est compromise (Albadi and El-Saadany, 2008). La réponse à la demande monétise la flexibilité énergétique des consommateurs, en proposant de « jouer » sur l'évolution de l'utilisation de l'électricité par rapport aux modes de consommation normaux en réponse à des incitations au paiement ou de prix de l'électricité pour induire une baisse de la consommation d'électricité par ces compromis.

Motivation et questions de recherche

La motivation principale de cette thèse est de comprendre les processus d'innovation supportés par le développement des différents modèles d'affaire des start-ups énergétiques et d'analyser comment les nouvelles offres de DR peuvent être mises en œuvre par les entreprises énergétiques existantes ou par de nouveaux acteurs entrant dans le secteur de l'énergie.

En synthèse, la question de recherche principale peut s'énoncer comme suit :

Comment le concept de modèle d'affaires peut-il contribuer à aider les entrepreneurs à développer de nouvelles activités de DR dans le contexte de la transition énergétique ?

L'auteur traite cette problématique au travers de trois questions de recherche :

Quels sont les modèles d'affaires émergents dans le domaine de l'énergie et comment peuvent-ils être analysés et classifiés ?

Comment les entreprises en démarrage dans le secteur de l'énergie poursuivent-elles l'innovation par leur modèle d'entreprise ?

Comment le concept de modèle d'affaires peut-il contribuer au développement d'activités innovantes de réponse à la demande ?

Méthodologie de recherche et contributions principales

La méthodologie de recherche mise en œuvre de cette thèse se décompose en quatre phases qui sont adaptées de (Blessing et al., 1998; Blessing and Chakrabarti, 2009) :

La première phase, qui est la clarification de la recherche, contient une *revue de la littérature systématique*, synthétisée dans un ensemble de 22 Modèles d'Affaires Energétiques (MAE). En outre, les MAEs identifiées sont regroupées en huit modèles (patterns).

La deuxième phase est une *étude descriptive* relative aux modèles d'affaires énergétiques, dans laquelle des données empiriques sur les nouveaux modèles d'affaires ont été recueillies auprès de 15 entreprises en démarrage dans le domaine de l'énergie, labellisées en tant que start-ups du réseau InnoEnergy. InnoEnergy est une organisation européenne qui compte dans son

réseau plus de 170 start-ups travaillant dans différents domaines de l'énergie. Une approche exploratoire a été utilisée pour étudier les changements innovants dans les modèles d'affaires apportés par ces nouveaux acteurs du marché, afin de caractériser les « Innovations par le Modèle d'affaires (IMA) ».

La troisième phase est une *étude prescriptive* dans laquelle l'expérience accumulée dans cette recherche a été exploitée et traduite dans la création d'un « Canevas de Modèle d'Affaires de Réponse à la Demande (CMARD) », qui peut se définir comme un outil conceptuel pour soutenir les entrepreneurs de l'énergie dans le développement de modèles d'affaires d'offres liées à la RD. Au cours de cette phase, l'outil est basé sur un modèle ontologique sur le domaine spécifique de la RD.

La dernière et la quatrième phase est *l'étude descriptive* sur la réponse à la demande. Dans cette phase, l'auteur propose trois expérimentations sur le terrain avec trois start-ups différentes, afin de tester la pertinence de l'outil CMARD développé.

En synthèse, la thèse apporte à la communauté scientifique un état de l'art des modèles d'affaires existants, une analyse des start-ups émergentes et un cadre pour la classification des modèles d'affaires des start-ups dans le secteur énergétique. De plus, ce travail propose un outil pour la gestion des modèles d'affaires spécifiques pour le domaine de la DR. Ces résultats peuvent également aider les entrepreneurs à explorer des nouvelles opportunités pour la DR, à mieux comprendre et à fournir un cadre d'analyse des expériences entrepreneuriales existants.

Revue de la littérature systématique des modèles d'affaires énergétiques :

Comme nous l'avons décrit ci-dessus, la première étape a consisté à effectuer une revue de la littérature systématique. Cette première approche exploratoire vise à examiner et à synthétiser l'information à jour et les travaux sur le sujet des modèles d'affaires principalement utilisés dans le domaine de l'énergie. À cette étape, le point de vue du système d'activités (Activity system) (Zott and Amit, 2010) sur les modèles d'affaires a été utilisé pour analyser et ainsi classer les MAEs identifiées dans la littérature. Par conséquent, l'auteur a utilisé un cadre d'analyse composé :

- De 3 éléments de description du MAE : le contenu de l'activité, la structure de l'activité et la gouvernance de l'activité
- Et 4 critères de conception : la nouveauté, le verrouillage, les complémentarités et l'efficacité.

Ce cadre a été utilisé pour catégoriser et cartographier les modèles d'affaires observés selon huit modèles (ou *patterns*) : « Passer au vert », « Bâtir des collectivités énergétiques », « Offrir des fonctionnalités », « Optimiser l'exploitation du réseau », « proposition de valeur combinée », « Agir localement », « Croissance », « exécution plate-forme »

« Passer au vert » est le premier modèle et se réfère à la substitution des ressources de base des modèles commerciaux traditionnels par des ressources plus durables telles que le remplacement des technologies énergétiques à base de combustibles fossiles par des technologies d'énergie renouvelable. Ce pattern comporte deux types de MAE. Premièrement, l'énergie renouvelable « Énergie Renouvelable du côté fournisseur » dans laquelle les services publics d'énergie transforment leur modèle d'affaires et fournissent de l'énergie renouvelable au client. Deuxièmement, la MAE « Prosommatrice » qui fait référence au financement et à l'installation de systèmes d'énergie renouvelable du côté des consommateurs.

« Bâtir des collectivités énergétiques » est le deuxième pattern et fait référence à l'intégration de la notion de collectivité dans les liens et la mise en place de nouvelles relations entre les parties-prenantes concernées. Il contient quatre types de MAE. « collectivité parrainée par les énergie fournisseurs » est la première et fait référence à la création de collectivités énergétiques organisées par les services publics d'énergie « Fonds Commun de Créances » est la deuxième MAE et désigne un groupe d'investisseurs qui investissent et installent des systèmes d'énergie renouvelable du côté des consommateurs et bénéficient d'incitatifs publics tels que le crédit d'impôt à l'investissement. La « coopérative énergétique » est la troisième MAE et concerne un groupe de citoyens qui investit dans des projets d'énergie renouvelable et s'appuie sur des principes démocratiques dans la gouvernance coopérative. La « marque blanche » est la quatrième MAE qui est un fournisseur d'énergie indépendant qui relie les communautés locales renouvelables et les consommateurs locaux en utilisant une licence de tiers.

Le troisième modèle de MAE est « Offrir des fonctionnalités » est basé sur le remplacement des offres de produits par une fourniture de systèmes produit-service qui surmonte certains obstacles tels que le coût initial. Ce pattern contient trois types de MAE. Premièrement, les « Société de services énergétiques », qui sont des entreprises qui fournissent des services énergétiques pour réduire la consommation d'énergie en utilisant des systèmes énergétiques plus efficaces, comprenant le financement, le contrôle et l'entretien de l'équipement. Deuxièmement, le « tiers propriétaire » est un MAE de service qui fournit le financement et l'installation d'un système d'énergie renouvelable (comme par exemple des panneaux solaires photovoltaïque) à installer sur le site du consommateur. Troisièmement, le MAE « Renouvelable côté client » est un service fourni par un service public d'énergie dans lequel ce dernier, finance et installe un système d'énergie renouvelable sur le site du consommateur.

Le quatrième modèle de MAE est l' « optimisation de l'exploitation du réseau » et fait référence aux services complémentaires qui associent la production d'énergie décentralisée ou la charge des consommateurs, à l'optimisation des opérations du réseau (p. ex., fiabilité, sécurité et efficacité). Voici trois MAE identifiés. Le MAE « réponse à la demande » incorpore la modification des profils de charge du consommateur en réponse aux incitatifs ou aux changements des prix de l'électricité lorsque le réseau fait face à des fluctuations économiques élevées ou lorsque la fiabilité du réseau est compromise. Le MAE « Centrale électrique virtuelle » comprend une agrégation et une coordination d'un grand nombre d'unités de production à petite échelle afin de fournir des services flexibles à l'opérateur de réseau. Enfin, la « Gestion active du réseau distribué » est la monétisation des flexibilités d'énergie renouvelable par la gestion active de ces ressources afin de fournir certains services aux opérateurs de réseau de distribution tels que la gestion de la congestion et le contrôle de la tension.

Le cinquième modèle est la « proposition de valeur combinée », qui décrit l'intégration des produits et services énergétiques (p. ex., panneaux solaires photovoltaïques) dans les produits d'autres industries (p. ex., construction de bâtiments). Il comprend deux MAE. Le MAE « véhicule à réseau /domicile », qui consiste à agréger et à coordonner les capacités de stockage électrique des véhicules électriques (VE) afin de fournir des services d'équilibrage et de fiabilité au gestionnaire du système. Le MAE « System photovoltaïque de vente croisée » décrit la vente de systèmes de panneaux photovoltaïques comme faisant partie intégrante d'un nouveau projet d'habitation.

Le sixième modèle est nommé « Agir localement » et fait référence à l'exploitation des services de réponse à la demande qui appariant localement les unités de production locales à des

charges locales. Trois MAE sont incluses dans ce pattern. Le « E-balance » vise à équilibrer localement la consommation et la production de manière intelligente et efficace afin d'améliorer la fiabilité et l'efficacité du réseau à basse et moyenne tension. Deuxièmement, dans le MAE « mutualiser locale et manche », l'agrégateur local met en commun un groupe de générations locales et fournit ensuite l'énergie à un consommateur local ou à un groupe de consommateurs. Enfin, le MAE « hub énergétique » se réfère à un système d'énergie local qui médiate plusieurs vecteurs d'énergie (énergie électrique, thermique et chimique) qui optimise la gestion de l'énergie et intègre des unités de conversion et de stockage d'énergie.

Le septième modèle est appelée « accroissement » et vise à générer des économies d'échelle en agrégeant les ressources d'approvisionnement en énergie ou les produits de la demande d'énergie. Il est composé de deux MAE. Dans le premier MAE, le « modèle de réseau d'une grande entreprise », un fournisseur de services énergétiques crée une unité d'approvisionnement en chaleur à faible coût fondée sur des économies d'échelle dans l'approvisionnement en carburant (p. ex., biocarburant, copeaux de bois, etc.). Dans le cadre de l'« achat collectif », le deuxième MAE, une organisation, offre un service d'achat, d'installation et de maintien d'un système renouvelable sur le site du client. Dans les deux cas, les abonnés bénéficient de la disponibilité d'informations telles que la sélection des fournisseurs, la négociation des prix, l'assurance, etc.

Le huitième et dernier modèle, appelé « exécution plate-forme », fait référence aux gains d'efficacité générés par la création de plates-formes numériques énergétiques rendant les transactions plus transparentes et plus rapides, simplifiant les processus et augmentant la disponibilité des informations. Trois MAEs sont identifiés dans ce modèle. Le premier MAE, le « peer-to-peer », consiste en une plate-forme logicielle jouant un rôle d'intermédiaire entre les consommateurs et les systèmes de production distribués, où les consommateurs peuvent choisir leur bouquet énergétique et comparer différents tarifs. Le second MAE, le « financement participatif pour les énergies renouvelables », est décrit comme une innovation organisationnelle dont le but principal est de collecter des fonds et de financer des projets d'énergies renouvelables de manière collective et ainsi de développer des projets d'énergie renouvelable. Enfin, la « plate-forme de services d'équilibrage de l'électricité » est un MAE basé sur une plate-forme d'adaptation entre les fournisseurs qui ne peuvent pas prédire leur production d'énergie renouvelable et les consommateurs qui participent à la gestion de la demande d'énergie et qui sont vulnérables à la volatilité des prix de l'électricité en temps réel. Son objectif est de fournir un service de réponse à la demande aux fournisseurs d'électricité et de réduire les factures des consommateurs en optimisant et en gérant l'électricité domestique

À la fin de l'analyse documentaire et de la clarification de la recherche, l'auteur analyse les similitudes et les différences entre les modèles d'affaires émergents et les différences entre les logiques de modèles d'affaires utilisés. La principale justification au-delà de ce résultat est que le passage à un système énergétique durable nécessitera d'une connaissance de la façon dont la création de valeur est réalisée dans chacun des modèles définis. Par cette classification et cette analyse, l'auteur tente de répondre à la première question de recherche formulée.

Une étude descriptive spécifique des start-ups du secteur de l'énergie avec la proposition d'un cadre pour formaliser les processus d'IMA

Au cours de la deuxième phase concernant l'étude descriptive liée aux modèles d'entreprise de l'énergie, l'auteur s'est concentré sur les modèles d'affaires spécifique des start-

ups du secteur de l'énergie. Cette décision a été motivée par de nombreux facteurs. Tout d'abord, il y a peu d'études de recherche qui sont effectuées sur ces modèles d'affaires des entreprises en démarrage dans le secteur de l'énergie. Deuxièmement, dans ce secteur, les innovations sont souvent apportées par les entreprises en démarrage plutôt que par les grandes entreprises du domaine. Troisièmement, l'auteur a été lauréat d'un appel à participation et a eu l'occasion de participer à un réseau européen de jeunes entreprises du secteur de l'énergie dirigé par « InnoEnergy », ayant ainsi accès à de nouvelles sources d'information et de données empiriques. L'échantillon comprend dix start-ups françaises, deux néerlandaises, une portugaise, une espagnole et une irlandaise. Leurs principales activités comprennent l'énergie solaire, les véhicules électriques, la gestion du réseau de distribution, la réponse à la demande, l'efficacité énergétique, la prévision des énergies renouvelables, la gestion de l'énergie des bâtiments, la gestion de l'énergie des centres de données et le stockage de l'énergie.

La méthode employée est basée sur une approche d'études de cas multiples comprenant la collecte et l'analyse de données. L'auteur s'est appuyé sur une source primaire de données provenant des entrevues et sur une deuxième source de données provenant d'articles, de blogs, de sites web, etc. L'analyse des données s'est faite en deux étapes. La première étape consistait à examiner les données recueillies et à analyser le contenu au moyen d'une approche inductive. À la deuxième étape, on a utilisé une approche déductive et d'appariement des modèles pour établir une correspondance entre les cas identifiés et un cadre théorique constitué à partir de la documentation sur les Innovations par le Modèle d'affaire (IMA). On procède à une alternance itérative des processus d'induction et de déduction pour affiner les résultats. Enfin, un cadre décrivant le processus d'IMA des jeunes entreprises du secteur de l'énergie a été décrit à partir d'une combinaison de la théorie de l'innovation par le modèle d'affaires et des données empiriques tirées des études de cas. Ce cadre permet d'expliquer comment les IMA sont constitués et comprend trois grandes phases : l'exploration des possibilités, la saisie du modèle d'affaires et l'incidence du modèle d'affaires. Il vise à répondre à la deuxième question de recherche en proposant un cadre relativement générique.

La première phase, qui est l'exploration des opportunités, décrit la façon dont une opportunité a été reconnue sur les marchés de l'énergie. Il a été constaté que la détection d'une opportunité nécessite une connaissance préalable du domaine et une motivation. Les entrepreneurs reconnaissent une imperfection du marché et la transforment en une offre. Les imperfections du marché décrivent les défaillances des marchés de l'énergie et des modes de consommation d'énergie pour répondre aux besoins sociaux et environnementaux, et les modèles d'affaires des start-ups cherchent à corriger ces imperfections du marché en abordant cinq questions : les problèmes d'inefficacité énergétique, les externalités énergétiques, les mauvais mécanismes de tarification de l'énergie, la distribution imparfaite de l'information et la réglementation inappropriée. Enfin, le succès de l'exploration des possibilités est associé à une approche centrée sur l'utilisateur qui tient compte des besoins du client et de son comportement.

La deuxième phase du processus d'IMA, la saisie du modèle d'affaires, illustre la configuration de la valeur et explique chaque modèle d'entreprise à la lumière de cinq éléments : la proposition de valeur, les segments de marché, le modèle de croissance, les capacités et le modèle de coût-revenu. L'analyse de l'élément MAE des start-ups montre qu'elles peuvent être classées en trois groupes distincts : Le réseau orienté, le logiciel orienté et le produit orienté. Les entreprises axées sur le réseau sont des médiateurs qui relient les clients et fournissent des services de réseautage qui permettent de nouvelles formes de relations d'échange. Les entreprises

axées sur le logiciel créent de la valeur dans le système énergétique en numérisant les transactions et les fonctions du système. Les entreprises axées sur les produits sont des entreprises qui inventent de nouveaux produits liés au système énergétique.

Six propositions de valeur distinctes sont observées : accessibilité aux énergies renouvelables, productivité des technologies propres, efficacité énergétique, intégration des technologies propres, flexibilité, autonomie énergétique ? Les segments de marché des cas étudiés peuvent être décrits par trois groupes principaux de clients. Le premier segment est celui des clients des technologies d'énergie renouvelable (par ex. PV), le deuxième est le segment des clients de l'efficacité énergétique et le troisième est celui des clients de la flexibilité de charge. Le modèle de croissance montre que trois modèles de croissance distincts ont été utilisés pour accroître la part de marché des jeunes entreprises du secteur de l'énergie : l'effet de levier sur les partenaires, la création d'une plateforme et l'entretien du modèle d'affaires. En ce qui concerne les capacités, la synthèse des résultats montre que six capacités distinctes sont identifiées. La première capacité est la « capacité du client », c'est-à-dire la capacité des entreprises en démarrage à bien comprendre les besoins du client et la façon dont elles peuvent répondre à ce besoin. Le résultat montre que la capacité du client est associée à la conception d'un produit-service pratique et abordable qui peut générer des économies. Le deuxième est la « capacité du marché », qui est liée à la connaissance des concurrents, de la réglementation du marché et des segments de marché. La « mise en réseau » est une capacité et un moyen d'accéder à certaines compétences et connaissances manquées en construisant une plate-forme de contacts, ce qui compense le manque de connaissances dans des domaines spécifiques des entreprises. En outre, l'auteur a identifié les capacités technologiques, entrepreneuriales et de durabilité. Enfin, le modèle coûts-recettes comprend les principaux types de coûts et de revenus. Cinq grandes sources de revenus ont été détectées : les clients payent directement pour des produits novateurs comme par exemple un nouveau système de fixation solaire photovoltaïque conçu pour les toits plats et minces. Les clients payent pour une licence d'innovation. L'abonnement, qui est principalement associé aux modèles d'affaires des logiciels. Enfin, les clients payent pour la prestation de services comme les services de flexibilité ou l'augmentation de l'autonomie des véhicules électriques et les réductions fiscales

La dernière et la troisième phase du processus d'IMA, l'impact du modèle opérationnel, explique l'impact de l'IMA en prenant trois critères d'évaluation : l'avantage concurrentiel, le degré d'innovation et l'impact sur la durabilité. En ce qui concerne l'avantage concurrentiel, l'auteur a analysé les principales sources de l'avantage concurrentiel des MAE. Le degré d'innovation évalue l'IMA en fonction de sa nouveauté sur le marché et de sa nouveauté pour l'industrie. Enfin, l'impact sur la durabilité décrit les valeurs sociales et environnementales créées par les jeunes entreprises du secteur de l'énergie.

L'auteur recommande ainsi aux gestionnaires d'entreprises et aux entrepreneurs qui cherchent à élaborer un modèle d'affaires durable dans le secteur de l'énergie d'utiliser le processus d'IMA pour lancer ou analyser leur modèle d'affaire actuel. L'auteur suggère également que les entrepreneurs identifient les capacités nécessaires pour développer leurs activités et étudient comment ces capacités peuvent être obtenues et utilisées pour améliorer la conception future ou actuelle des modèles d'affaires. Cette identification du processus d'IMA peut être d'une utilité pratique pour les décideurs et aide à décrire les obstacles auxquels se heurtent les entrepreneurs du secteur de l'énergie, comme par exemples les règlements défavorables.

Vers des Modèles d'affaires de réponse à la demande

Dans le dernier chapitre, la thèse converge et se concentre sur les modèles d'affaires de réponse à la demande. L'objectif est de fournir un canevas de modèle d'affaires de réponse à la demande (CMARD) qui est un cadre de modèle d'affaires qui décrit et représente les aspects clés des pratiques d'affaires dans le secteur spécifique de la réponse à la demande. Le cadre a également été transformé en un cadre pratique et utile qui peut aider les entrepreneurs à explorer et à exploiter de nouveaux débouchés commerciaux, pour leur permettre d'élaborer de nouveaux modèles d'affaires de réponse à la demande.

Dans cette optique, l'auteur propose une étude normative. Pour ce faire, une autre revue littéraire a été effectuée sur l'intersection des activités de réponse à la demande et du concept de modèle opérationnel. En outre, une étude de cas parmi les quinze start-ups étudiées initialement a été analysée plus en profondeur : l'entreprise Energy Pool, qui a été le premier agrégateur d'énergie en France à fournir des services de réponse à la demande. Enfin, une approche expérimentale a été mise en place pour examiner l'utilité du canevas CMARD et trois tests ont été réalisés pour évaluer et détecter ses avantages et ses inconvénients.

Dans cette phase, le cadre théorique du CMARD est construit sur la perspective de système d'activité sur le modèle d'affaires, qui consiste en trois éléments de conception : contenu, structure et gouvernance. L'élément de contenu se réfère à la sélection d'activités, l'élément de structure décrit comment les activités sont liées et l'élément de gouvernance se réfère aux acteurs qui exécutent les activités. La définition de modèle d'entreprise basée sur des objets, des concepts et leurs relations, vise à représenter l'expression de la logique de l'entreprise dans une description simplifiée. Une logique d'ontologie a été employée pour développer le canevas CMARD en utilisant des données tant de l'examen de littérature que de l'étude de cas. Le CMARD consiste en douze éléments distincts mais liés.

Les trois premiers éléments décrivent « les activités de contenu » d'un modèle d'affaire orienté sur la réponse à la demande: « Objet précieux », « le mécanisme de réponse » et « la proposition de valeur » « Objet précieux » désigne la ressource qui produit la flexibilité d'énergie (par exemple, la charge d'usine industrielle, une flotte de véhicules électriques, une source de chaleur combinée, etc.). « Le mécanisme de réponse » est un processus de minutage et modélise la façon dont les flexibilités définies ont été alignées et coordonnées (par exemple. Accumulation, Changement de charge, stockage, etc.). « La proposition de valeur » est l'avantage pour l'utilisateur final du service créé, et correspond au résultat de l'exploitation d'une ressource flexible utilisée dans un mécanisme approprié. Notamment, les modèles d'affaires de type réponse à la demande correspond généralement à des situations gagnant-gagnant où les avantages sont alloués pour toutes les parties-prenantes qu'elles soient du côté de l'offre ou de la demande.

Les activités de structure ont trois éléments : « segment du marché », des « caractéristiques de transaction » et « l'infrastructure de communication ». Le segment du marché se réfère à la catégorisation des clients ou des acheteurs et sont définis comme la capacité de service du marché, réserves, etc. Les caractéristiques de transaction sont la télémétrie, les normes de performance et les paramètres planifiés avancés qui définissent et imposent les conditions de livraison du service de réponse à la demande. Il définit les caractéristiques de transaction entre les partis impliqués. L'infrastructure de communication est le réseau qui soutient la connexion, la communication et l'alignement des acteurs impliqués.

La gouvernance d'activité consiste en trois éléments : « la disponibilité de objets précieux », « les opérations de service » et « l'échelle de proximité ». La disponibilité de objets précieux se réfère à la capacité disponible d'un actif ou une charge qui peut être fournie sans diminuer l'efficacité de valeur ou le confort des usagers. Généralement, la réponse à la demande compte sur la modification dans les modèles de consommation et cette modification est liée au comportement des consommateurs et d'autres facteurs comme le temps et la disponibilité d'une ressource variable. Les opérations du service désignent les activités opérationnelles et les efforts sur place et hors site qui sont nécessaires pour activer le service de réponse à la demande. L'échelle de proximité définit le niveau où la flexibilité a son effet. Par exemple, la flexibilité peut s'appliquer aux problèmes à l'échelle locale sur le réseau de distribution et au niveau national du réseau de transport et de distribution.

La saisie de la valeur à partir du modèle opérationnel de la demande a été intégrée dans la perspective du système d'activités et est décrite par trois éléments : « coût de transaction », « coût d'intervention » et « modèle de revenu ». Le « coût de transaction » est le coût de l'identification, de l'activation, du raccordement et de la communication avec les objets de valeur de la réponse à la demande. Le « coût d'intervention » est le coût de l'exploration des différents modèles de consommation, en définissant leur mécanisme d'intervention et en rémunérant le client pour son changement de comportement. Enfin, le « modèle du revenu » est la manière dont les avantages monétaires sont générés par la prestation du service de réponse à la demande. Les revenus comportent deux parties, l'une appartenant au fournisseur (p. ex., agrégateur) et l'autre au client (p. ex., charge).

Afin de tester le canevas proposé, une deuxième étude sur l'utilisabilité du CMARD a été développée. Trois tests ont été réalisés avec trois start-ups. En général, les résultats des tests montrent que le canevas CMARD a de la valeur pour les participants, cependant, plus de simplification devrait être envisagée dans le développement futur. Les participants insistent sur le rôle de du canevas CMARD en tant que dispositif de représentation du modèle existant et comme support à la génération de nouvelles idées pour faire évoluer le modèle d'affaires vers des offres de type réponse à la demande.

Conclusion et perspectives

Les communautés d'entrepreneurs, d'industriels et de chercheurs continuent de consacrer une attention considérable à la transition énergétique. Cependant, on en sait peu sur les nouveaux modèles d'affaires qui font avancer la transition énergétique. Cette thèse répond précisément à ce constat et vise à esquisser les modèles d'affaires des actuels et nouveaux entrepreneurs, leur rôle dans la transition énergétique et leur potentiel pour accélérer cette transition.

Sur le plan scientifique, la thèse propose de nouvelles connaissances sur la façon de faciliter l'innovation dans les modèles d'affaires en analysant les modèles d'affaires actuels, en décrivant leurs processus et structures et propose un outil conceptuel (CMARD) pour formaliser ces éléments. Les résultats de cette recherche appuient également sur les activités d'idéation des entrepreneurs, les pratiques de conception de modèles d'affaires et le processus d'exploration de nouvelles possibilités pour les entrepreneurs.

Sur le plan méthodologique, le canevas CMARD peut mener à la conception et/ou l'intégration de nouvelles offres de réponse à la demande au sein des entreprises existantes, ou à la création de nouvelles entreprises qui captent la valeur de la flexibilité énergétique. Les perspectives opérationnelles du canevas CMARD se déclinent en cinq axes : premièrement, avec

ses douze éléments, le CMARD peut préparer les gestionnaires à mieux connaître le concept de Réponse à la demande, car il aborde et décrit la plupart des exigences de ce domaine. Deuxièmement, la représentation simplifiée du CMARD peut être utilisée par les directeurs pour façonner leur idée originale en un modèle d'affaire complet, ou bien il peut aider à trouver de nouvelles configurations pour des modèles d'affaires existants, apporter des ajustements à un ou plusieurs des éléments proposés et trouver des alternatives novatrices. Troisièmement, le CMARD peut être utilisé pour cerner les inefficacités et les avantages concurrentiels. Il permet ainsi aux entreprises de comparer leur modèle d'affaire avec celui de leurs concurrents et de cerner les domaines d'amélioration. Quatrièmement, le CMARD peut être utile pour rendre les relations et les interdépendances entre les éléments plus explicites. Enfin, il précise les aspects de gouvernance, car il soutient l'identification des rôles et des responsabilités des parties concernées, en particulier le rôle du client, qui est un aspect clé du service de réponse à la demande. Pour conclure, les applications potentielles de l'outil permettent de modéliser une représentation d'une compréhension commune du modèle d'affaire entre les parties prenantes, tout en stimulant l'idéation et la proposition d'idées nouvelles.

Conclusion

Dans ce mémoire, l'auteur défend la thèse suivante : dans le contexte de la transition énergétique, le concept de modèle d'affaires en tant qu'outil conceptuel est une approche utile pour explorer, innover et créer de nouvelles pratiques socio-économiques dans les marchés de réponse à la demande, développant ainsi l'éco-flexibilité et ayant un grand potentiel pour ajouter des valeurs écologiques, sociales et économiques à nos systèmes d'énergie.

Chapter 1

Introduction générale

Le changement climatique constitue une menace fondamentale pour les lieux, les espèces et les moyens de subsistance des populations. Récemment, le risque lié au changement climatique a été considéré comme ayant plus de dommages potentiels que les armes de destruction massive, les crises de l'eau, la migration involontaire à grande échelle et le choc sévère des prix de l'énergie (Forum économique mondial, 2016). La menace du changement climatique peut être atténuée en réduisant les émissions de gaz à effet de serre des différentes activités humaines et les activités énergétiques constituent une partie importante. En Europe, et selon l'Agence européenne de l'énergie, les émissions du secteur de l'énergie ont contribué à environ 78 % des émissions totales de l'UE en 2017 (AEE, 2018). Notamment, le système électrique est responsable de la plus grande partie de ces émissions. Par conséquent, une réduction significative de l'intensité énergétique et une décarbonisation rapide du secteur de l'électricité devraient avoir lieu dans un court laps de temps.

Même si le réseau électrique constitue un enjeu important, peu de mesures ont été prises pour faire avancer le processus de décarbonisation. Le système énergétique est principalement organisé de manière verticale avec de gros monopoles établis depuis des décennies et repose sur un petit nombre de centrales centralisées à grande échelle reliées par d'énormes infrastructures de réseau. Toutefois, depuis les années 1990, ce système énergétique a été réexaminé afin de répondre à l'appel de la transition énergétique ainsi qu'aux changements technologiques critiques, y compris les technologies de l'énergie renouvelable et les technologies de communication. L'un des changements majeurs a été le dégroupage de l'exploitation de la société d'énergie en unités commerciales distinctes dans lesquelles les fournisseurs d'électricité et la production d'énergie opèrent désormais sur des marchés concurrentiels de l'électricité, alors que le transport et la distribution d'électricité sont restés unis dans les monopoles. Ce changement crucial permet à de nouveaux acteurs du marché de participer à la transition énergétique et permet de faire émerger de nouveaux modèles d'affaires dans ce secteur.

Certains chercheurs pensent que les problèmes de transition énergétique peuvent être réglés par les grands fournisseurs d'énergie historiques qui peuvent développer de nouvelles initiatives et adapter leur modèle d'affaires aux nouvelles technologies d'énergie renouvelable. (Apajalahti et al., 2015; Helms, 2016; Nillesen et Pollitt, 2016; Richter, 2013). D'autres auteurs s'attendent à ce que les nouveaux entrepreneurs fassent progresser la transition énergétique en créant des modèles d'affaires novateurs qui freinent les émissions de carbone du système énergétique et accélèrent le processus de décarbonisation. (Hellström et al., 2015; Huijben et Verbong, 2013; Okkonen et Suhonen, 2010; Överholm, 2017; Wainstein et Bumpus, 2016).

Récemment, on a remarqué que les grands fournisseurs d'énergie souffrent de ce qu'on appelle la « spirale de la mort », qui est un phénomène qui décrit la diminution du nombre de clients des services publics d'énergie au détriment profit des nouvelles entreprises axées sur la technologie de l'énergie renouvelable et de l'efficacité énergétique. Les clients qui quittent ces entreprises historiques sont séduits par des offres innovantes proposées par de nouveaux acteurs du marché qui proposent ainsi de capturer la valeur de manière différentes. Ainsi, étudier les modèles d'affaires émergents de ces nouveaux entrepreneurs présente selon nous un grand intérêt scientifique, sociétal et économique pour les chercheurs et les praticiens du domaine.

Dans cette thèse, l'auteur se focalise sur le concept de modèle d'entreprise et étudie le rôle des modèles d'affaires innovants dans la poussée du système énergétique actuel vers la durabilité. En effet, l'objectif est de soutenir les entrepreneurs et de leur fournir de nouvelles connaissances basées sur la modélisation des pratiques et des modèles d'affaire notamment émergents. L'idée est d'utiliser de manière centrale le concept du modèle d'affaires qui est une manière de modéliser les changements ou les transformations (Demil et Lecocq, 2010), que l'on peut appliquer afin d'en améliorer le rendement ou bien en choisissant de développer un modèle d'affaires différent (Bucherer et coll., 2012; Massa et Testa, 2011), qui est un axe que nous qualifierons de Innovations par le Modèle d'affaires (IMA).

Le rôle spécifique des IMA dans le secteur de l'énergie a été peu étudié dans la littérature (Hall et Roelich, 2016). Par conséquent, la littérature existante dans le domaine du MA a été principalement utilisée pour étudier les transformations du secteur de l'énergie notamment des apports techniques en produits économiques (Chesbrough et Rosenbloom, 2002), sources d'une création de valeur supérieure et d'avantages compétitifs (Zott et al., 2011), et émergence d'innovations durables (Boons et Lüdeke-Freund, 2013)

L'intégration d'une part importante des ressources d'énergie renouvelable (RER) dans le système électrique joue un rôle central dans l'atteinte des objectifs clés de l'UE pour 2020 et la réduction des émissions de carbone. Parmi les différents RER, la capacité solaire et éolienne devrait augmenter considérablement dans les prochaines années. Malgré les avantages écologiques potentiels découlant de l'adoption à grande échelle de la production d'énergie éolienne et solaire, leur caractère incertain peut mettre le système d'électricité en danger et présenter de nouveaux défis techniques et économiques aux gestionnaires de réseau. Ces défis découlent de la nature fluctuante de la production d'énergies renouvelables et de leur dépendance aux conditions météorologiques. Étant donné que la majorité des systèmes d'alimentation ont été conçus pour faire face à la fluctuation de la demande, il est indéterminé si le système d'alimentation peut répondre à la fois à la fluctuation de la demande et à la variation de la production. Afin de tenir compte des incertitudes supplémentaire, le système d'alimentation doit donc maintenir une quantité accrue de réserve. La réponse à la demande est considérée comme une alternative permettant de proposer une réserve fiable et rentable (Paterakis et al., 2017)

La réponse à la demande (RD) est souvent considérée comme une source appropriée d'une telle flexibilité et contribue à une partie essentielle pour déployer des réseaux dits intelligents (smartgrid) (Good et al., 2017). La réponse à la demande est décrite comme le changement ou la modification de l'utilisation de l'électricité par les utilisateurs finaux par rapport à leurs habitudes de consommation normales en réponse à un signal, normalement économique (Albadi et El-Saadany, 2008), mais pas nécessairement car peut être en réponse à une motivation écologique. La RD a deux approches concernant ses applications : l'explicite et l'implicite. La première est fondée sur des incitatifs, c'est-à-dire que les consommateurs reçoivent un paiement direct de l'acheteur de la flexibilité électrique (p. ex., le gestionnaire du réseau de transport ou l'agrégateur) lorsqu'ils ajustent leurs ressources à la demande (générations ou charges). La seconde est fondée sur les prix et les participants réagissent aux signaux dynamiques de prix du marché ou du réseau.

Les avantages de la réponse à la demande ont été décrits comme une augmentation de l'efficacité de l'exploitation du réseau et de l'investissement dans la production, en particulier comme un mécanisme efficace pour gérer les fluctuations de l'énergie renouvelable et pour faciliter l'intégration de la production intermittente. La RD contribue à la diminution de la demande de pointe prévue, ce qui permet de diminuer ou retarder de futurs coûteux investissements (Paterakis et coll., 2017). En outre, la RD améliore le fonctionnement du réseau de distribution et réduit ses coûts d'exploitation en traitant les problèmes liés au contrôle de la tension et à la gestion de la congestion, réduisant ainsi les coûts d'entretien et les dommages de l'infrastructure. Enfin, la RD a des effets positifs sur les marchés de l'électricité et peut réduire et stabiliser les prix de l'électricité, contrôler la puissance du marché et accroître les avantages économiques pour les consommateurs (Siano, 2014).

Les services liés à la RD peuvent créer de la valeur pour différents intervenants, y compris le gestionnaire de réseau de transport, exploitant de réseau de distribution, les unités de production, les producteurs, le client/la charge (Behrangrad, 2015). En ce qui concerne l'exploitant du système, le service de RD peut améliorer la fiabilité du système en fournissant des services de réserve et de régulation de la fréquence, ce qui augmente la pertinence du réseau pour atténuer les futures pointes de charge. Le service de RD crée également de la valeur pour les parties prenantes de la production qui peuvent bénéficier d'un coût de production variable inférieur en augmentant la flexibilité des ressources énergétiques intermittentes. Le service de façonnage de charge peut créer un profil de charge souhaitable pour la génération et la vente au détail des parties prenantes.

En dépit de l'importante amélioration écologique et économique que la RD peut générer dans le système électrique, le développement est limité dans l'UE car présente encore certains défis (Sisinni et al., 2017). Premièrement, dans certains pays de l'UE, la RD n'existe pas, ce qui pourrait s'expliquer par une incertitude du cadre réglementaire de la RD, ou le fait que les principaux intervenants n'ont pas besoin de la RD (souvent parce que le système de génération est surdimensionné). Deuxièmement, les agrégateurs de production ou consommation électrique, préfèrent contrôler la charge des usines industrielles plutôt que des charges commerciales et résidentielles. La principale raison est la puissance élevée des sites industriels et donc le nombre réduit des sites à devoir gérer; alors que dans le secteur résidentiel ou commercial, les agrégateurs sont obligés de gérer un nombre important de sites avec un profil changeant car ils dépendent des aspects comportementaux des utilisateurs. L'engagement des occupants est fondamental pour assurer la rentabilité et peut être nécessaire pour activer les actions de RD sans limiter le confort des usagers.

Ainsi avec ce travail, l'auteur cherche à construire un outil de conceptualisation de modèle d'entreprise, appelé « Canevas de Modèle d'Affaires de Réponse à la Demande (CMARD) » qui peut être utilisé par les nouveaux entrants et les entrepreneurs à la recherche de la création de modèles d'affaires durables dans les marchés de réponse à la demande. De plus, ces travaux contribuent à la littérature émergente qui établit un lien entre les modèles d'affaires (MA) et la transition énergétique (Hannon et al., 2015; Huijben et Verbong, 2013; Richter, 2013; Wainstein et Bumpus, 2016).

La thèse est structurée comme suit :

Le chapitre 1 présente le sujet de la thèse, le contexte, la problématique de recherche et son questionnement scientifique.

Le chapitre 2 présente le cadre théorique, décrit l'état de l'art de ce qui a été étudié dans le domaine de la recherche sur les modèles d'affaires liés à l'énergie et résume le résultat dans une typologie composée de vingt-deux modèles d'affaires et huit modèles-types (patterns).

Le Chapitre 3 décrit le processus des Modèles d'Affaires Innovant des startups du domaine de l'énergie, formalisé à partir de données empiriques tirées de multiples études de cas issus du réseau européen InnoEnergy.

Au chapitre 4, ces travaux de recherche convergent sur un modèle d'affaires focalisé sur la réponse à la demande à l'aide d'une revue de la littérature et d'une approche spécifique sur une étude de cas. Un outil de conceptualisation de modèle d'entreprise sur la réponse à la demande, le CMARD, est proposé et testé.

Enfin, le chapitre 5 conclut sur les principales contributions et discute des perspectives de ces travaux.

Au sein de ce manuscrit, l'auteur défend la thèse suivante :

« Dans le contexte de la transition énergétique, le concept de modèle d'affaires en tant qu'outil conceptuel est une approche utile pour explorer, innover et créer de nouvelles pratiques dans les marchés de réponse à la demande, développant ainsi la flexibilité de la demande, incrémentant la robustesse et diminuant l'impact sur l'environnement du système électrique actuel. »

General introduction

Climate change poses a fundamental threat for the survival of many species. Recently, the risk of climate change has been considered to pose a greater potential threat than weapons of mass destruction, water crises, large-scale involuntary migration and a severe energy price shock (World Economic Forum, 2016). The threat of Climate change can be mitigated by reducing greenhouse gas emissions resulting from different human activities and energy activities constitute a salient part. In Europe, and according to the European Energy Agency, emissions from the energy sector contributed about 78% of total EU emissions in 2017 (EEA, 2018). Notably, the electrical power system is responsible for the highest proportion of these emissions. Therefore, a significant reduction in energy intensity and the rapid decarbonization of the electricity are urgently required.

The electrical power system plays a substantial role in meeting carbon emission targets for climate change mitigation, but little has been done to push the decarbonization process forward. The energy system has been organised in monopolies for decades and is based on a small number of centralised large-scale fossil fuel plants connected by a huge network infrastructure. However, since the 1990s this energy system has been called into question in order to respond to the call for the energy transition as well as critical technological changes, including both renewable energy technologies and information communication technologies. One of the prominent changes was the unbundling of energy company operations into separate business units in which electricity retailers and energy generation operate in competitive electricity markets, whereas electricity transmission and distribution units remained in

monopolies. This critical change allows new market players to take part in the energy transition and a new business model to flourish.

Some scholars believe that energy transition issues can be handled by energy utilities which can take the lead and adapt their business models to new renewable energy technologies (Apajalahti et al., 2015; Helms, 2016; Nillesen and Pollitt, 2016; Richter, 2013), whereas, others expect that new entrepreneurs will move the energy transition forward by creating innovative business models that holds back the energy system's carbon emissions and accelerate the decarbonization process (Hellström et al., 2015; Huijben and Verbong, 2013; Okkonen and Suhonen, 2010; Överholm, 2017; Wainstein and Bumpus, 2016).

Recently, it has been noticed that energy utilities are suffering from what is called the “spiral death”, which is a phenomenon that describes the decreasing number of energy utility customers at the expense of renewable energy and energy efficiency technology-based companies. Those escaping customers are served by new market actors who offer new values. Investigating the business models of those new entrepreneurs has a great scientific, societal and economic interest for academics and practitioners in this field.

In this thesis, the author focuses on the business model concept and investigates the role of innovative business models in pushing the current energy system towards sustainability. Furthermore, the goal is to support entrepreneurs and provide them new knowledge based on the modelisation of up-to-date business practices. The idea is to use a central perspective of business models, which is a way to model change or transformation (Demil and Lecocq, 2010) that can be applied to enhance performance by choosing a new business model (Bucherer et al., 2012; Massa and Testa, 2011), which is a field that will be referred to as business model innovation (BMI).

The specific role of BMI in the energy sector has been rarely investigated in the literature (Hall and Roelich, 2016). Therefore, the existing literature in the field of BM has been used mainly to investigate energy sector transformations from technical inputs to economic outputs (Chesbrough and Rosenbloom, 2002), sources of higher value creation and competitive advantages (Zott et al., 2011), and the emergence of sustainable innovations (Boons and Lüdeke-Freund, 2013).

Integrating a high share of renewable energy resources (RER) in the power system plays a central role in meeting the key EU targets for 2020 and cutting carbon emissions. Among the various RER, solar and wind capacity is expected to increase significantly over the next few years. Despite the potential ecological benefits of the large-scale adoption of wind and solar power generation, their uncertain nature may put the power system at risk and present the system's operators with new technical and economic challenges. These challenges arise from fluctuations in the production of renewable energies and their dependency on weather conditions. Since most of power systems were designed to deal with fluctuation in demand, it seems indeterminate if the power system can serve both fluctuation in demand and variable generation. In order to take into account additional uncertainty, power systems should maintain an increased amount of reserve. The demand response has been addressed as an alternative that proposes a reliable and cost-efficient reserve (Paterakis et al., 2017).

Demand response (DR) is often considered an appropriate source of such flexibility and contributes to an essential part of the smart grid (Good et al., 2017). DR is described as the change or modification in the electrical usage by end-user customers based on normal consumption patterns in response to some signal, normally an economic one (Albadi and El-Saadany, 2008), but not necessarily (it might also be in response to an ecological motivation). DR has two approaches regarding its applications: one explicit, the other implicit. The former is incentive-based in which consumers receive direct payment from the flexibility purchaser (e.g. transmission system operator or aggregator) upon their adjustments to their demand-side resources (generations or/and loads). The latter is price-based, and participants react to dynamic market or network pricing signals.

The benefits of demand response have been outlined as an increase in grid operation efficiency and generation investment, and particularly as a cost-efficient mechanism to handle renewable energy fluctuations and to facilitate the integration of intermittent generation. DR contributes to reducing forecasted peak demand, thus it may postpone future planned investments (Paterakis et al., 2017). Furthermore, DR enhances distribution system operations and reduces operational costs by handling problems related to voltage control and congestion management, thus reducing maintenance costs and damaging the infrastructure. Finally, DR has positive effects on electricity markets and can lower and stabilise electricity prices, control of market power and increase the economic benefits for consumers (Siano, 2014).

DR services can create value for different stakeholders, including Transmission System Operator (TSO), Distribution System Operator (DSO), generation units, retailers, customer/load (Behrangrad, 2015). Regarding the System Operator, the DR service can enhance system reliability by delivering ancillary and frequency regulation services, increasing grid adequacy and mitigating future load peaks. The DR service creates value for generation stakeholders as well. Generation stakeholders can benefit from lower variable generation costs by increasing the flexibility of intermittent energy resources. The load shaping service can create a desirable load profile for generation and retailing stakeholders.

Despite the significant ecological as well as economic improvements DR can generate in the electric power system, its development is limited in the EU because it is associated with certain challenges (Sisinni et al., 2017). First, in some EU countries, DR does not exist, which might be explained by an uncertain regulatory framework or by the fact that key stakeholders do not need DR (often because the generation system is over-dimensioned). Second, aggregators in the electricity sector prefer load control of industrial plants rather than using other loads, such as commercial and residential loads. The main reason is because industrial plants usually have high power and there are few units to manage, whereas in the commercial or residential sector, aggregators are obliged to deal with a large number of load units with changing profiles due to behavioural aspects. Occupant engagement is fundamental to ensure profitability and may be required to activate DR actions without limiting comfortability.

With this work, the author seeks to build a Demand Response Business Model Canvas (DRBMC), a business model conceptual tool that can be used by new entrants and entrepreneurs, who are looking to the create sustainable business models in demand response markets. Furthermore, this work contributes to an emerging literature linking BM and the

energy transition (Hannon et al., 2015; Huijben and Verbong, 2013; Richter, 2013; Wainstein and Bumpus, 2016).

The thesis is structured as follows:

Chapter 1 presents the subject of this thesis, the context and research questions.

Chapter 2 provides the background literature's theoretical framework, outlines what has been studied in the area of energy business models and summarises the results with twenty-two business models and eight patterns.

Chapter 3 describes the BMI process for the energy start-ups based on empirical data from multiple case studies issued from the European network InnoEnergy.

In Chapter 4 the focus of the research converges on particular energy business models related to demand response using a literature review and single case study approach. A business model conceptual tool on demand response, the DRBMC, is proposed and tested.

Finally, Chapter 5 concludes with the main contributions and discusses further research.

In this manuscript the author defends the following thesis: *in the context of the energy transition, the business model concept is a useful approach to explore, innovate and create novel socio-economic practices in demand response markets, thus developing the flexibility, increasing the robustness and decreasing the environmental impact of current power systems.*

1. Introduction

The idea of this research on business models (BMs) for the energy¹ transition emerged in a specific period characterised by: the flourishing of distributed renewable energy technologies, the emergence of advanced Information Communication Technologies (ICT)s for the energy sector and the liberalisation of energy markets, which went from being monopolies to competitive markets allowing new market actors to participate and create new BMs.

The increasing attention paid to the global issue of climate change was largely what drove European energy policymakers to accelerate policies in favour of decarbonising the European power system. Since 1990, market-based investments in renewable energy technologies have been increasing, while coal and nuclear represented by large-scale energy plants has been decreasing (cf. Figure 1). This shows that the coal and nuclear power plants were built under the regulated market period, and the share of renewable energies has been increasing with support schemes (IEA, 2016). It should be noticed is worth noting that renewable energy investments over the last decade have been policy-driven with support schemes and subsidies.

Driving climate change under control requires tough choices and ambitious commitments by all those involved in the energy sector. Some scholars argue that energy utilities could be leaders in transforming current energy systems (Helms, 2016; Richter, 2013). Others believe that new market actors, who are creating new environmentally sustainable BMs, more likely to beat climate change (Bolton and Hannon, 2016; Huijben and Verbong, 2013; Strupeit and Palm, 2016; Wainstein and Bumpus, 2016).

Energy utilities have recently been suffering from what is called a “spiral death”, which is a phenomenon that describes the decreasing number of energy utility customers at the expense of companies based on renewable energies and energy efficient technologies (Costello and Hemphill, 2014). Those escaping customers are served by new market actors who offer new values. Investigating the business models of those new market actors is of great value to analyse how these actors are positioned in the electricity value chain and to identify how value propositions are created and delivered. In this thesis, the author investigates the emerging business models, their new values propositions, the way they are created, their innovations and environmental benefits, thus their role in pushing forward the power system towards sustainability. The goal is to add value to the academic field of research on the business model and energy transition.

In this thesis, the author employs the business model concept and investigates the role of the innovative business models in ecologically and efficiently balancing the grid by making modifications in the consumption patterns, what has been termed “Demand Response”. The idea is to employ a central perspective of business models which is the notion of change or transformation (Demil and Lecocq, 2010), and to enhance performance by choosing a new

¹ In this manuscript, the word energy has been used to include different usages that can go beyond the electricity domain. Nevertheless, in most of the cases “energy” involves mainly “electricity” systems.

business model that does things better (Bucherer et al., 2012; Massa and Testa, 2011), a phenomenon studied under the label of business model innovation (BMI).

In this thesis the author defends the following: *in the context of the energy transition, the business model concept is a useful approach to explore, innovate and create novel socio-economic practices in demand response markets, thus developing the flexibility, increasing the robustness and decreasing the environmental impact of current power systems.*

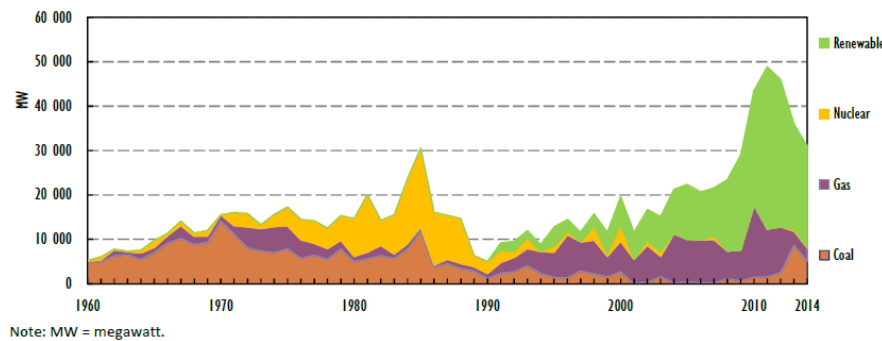


Figure 1 Energy resources share evolution in Europe, sources (IEA, 2016)

It is worth to pointing out that in this context energy system is a complex system and it has been operated for decades by public entities without any real intervention of private parties or customer engagement. Therefore, the author places considerable emphasis the general context and the structure of power systems in Europe as shown in the following subsection.

1.1 The electricity system

1.1.1 Energy system components

The electricity system contains two major components (Figure 2). Firstly, the physical infrastructure represented by generation, transport and use and components; secondly, an organised electricity market based on different marketplaces. The physical infrastructure consists of electricity generators, electricity-transport systems, which are typically subdivided into systems for transmission over long distance and systems for distribution to residential and industrial consumers of electricity. The market consists mainly of the following actors (Erbach, 2016):

- **Electricity generator:** who generates electricity and sell it to the energy suppliers.
- **Electricity suppliers** who purchase the electricity from the generators and sell it to consumers.
- **Consumers** who use electricity and pay monthly fees to suppliers.
- **Transmission System Operators (TSO)**, who are responsible for transporting electricity for long distance and ensuring grid stability and reliability by real time dispatch.
- **Distribution Network Operators (DSO)**, who are responsible for delivering electricity to the consumers and measuring the consumption.
- **Regulators**, who set the market rules and oversee the functioning of the market.

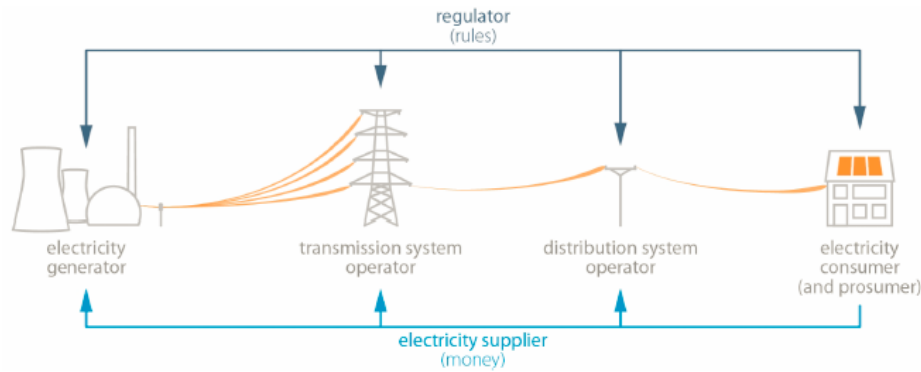


Figure 2 Electricity system main parts, source: (Erbach, 2016)

The electric grid: the electric grid can be defined as a network connecting electricity generators and consumers via the transmission and distribution networks and has two fundamental technical attributes. Firstly, supply and demand must always be in state of balance; otherwise, failures (blackouts) will occur. Secondly, the flow of electricity cannot be controlled as it simply follows the path of the least resistance so that consumers receive electricity from mixed resources (Erbach, 2016). While the main actors in this domain are the TSO and the DSO, there can be other actors involved in the management, maintenance and the contribution to other functions for the grid.

Electricity generators: electricity generators have various sizes starting from small generation systems as Photovoltaic (PV) solar panels (starting from around 1 KW) to large hydro-electric dams, and thermal power stations (Several gigawatts). Generators are rated by their generation capacity which is the maximum power they can produce. They differ according to the flexibility which they can operate. Some generators, such as nuclear power plants have low flexibility and they are suitable for producing a stable amount of electricity over long periods. Other generators, such as hydro-power units have high flexibility, thus they can change production rapidly and adapt to fluctuations in electricity demand and supply.

Transmission networks: transmission networks consist of networked grids of long-distance power lines. The transport high voltage electricity (50 kV – 1000 kV) to reduce losses. These networks are run by transmission system operators at the European level systems operators while transmission grids are operated on a sub-national or national level.

Distribution networks: distribution grids are networks that intermediate the transmission grids and consumers and are managed by distribution system operators. DSOs are usually responsible for consumer electricity metering, communicating the consumption to the energy supplier. Generally, renewable electricity systems are connected to the distribution network.

Balancing supply and demand: the electricity supply must always be equal to electricity demand. Otherwise, the system might face the risk of breaking down. Therefore, non-flexible generators are used to serve as the base load while flexible generators are used to answer to demand peaks.

Due to the demand variations, enough generation capacity must be available and reserved to meet demand at all periods and ensure the security of supply. Balancing supply and demand in the short term is done with the use of primary reserves which can be activated in few seconds, secondary reserves which can be activated within few minutes and tertiary reserves which can be activated within 15 minutes (Erbach, 2016). Often, the TSO is responsible for maintaining the power system balance.

Demand response: demand response is an alternative approach for balancing the grid that involves reducing electricity demand in times of generation scarcity. This often depends on the electricity market where there can be incentives or electricity price variations. Herein, new actors such as energy aggregators and demand response providers contribute to balancing the system by using the demand response approaches.

Balancing injections (supply) and offtakes (demand) of electricity in the grid over quarter-hour is the responsibility of balance responsible parties (BRPs). Shorter-term fluctuations are managed by the TSO who will ask operators to increase or decrease demand. The TSO will pay for these ancillary services and will charge BRP for imbalances (Erbach, 2016). The energy systems are regulated systems and energy policies forms a reference for many new businesses. Therefore, the author, in the next subsection, outlines in broad the current and the future energy policies trends and strategies.

1.1.2 European Policy three pillars

In the 1990s the EU energy policy objectives were represented in the form of a triangle: competitiveness, energy security of supply and environmental sustainability (Figure 3). The competitiveness objective means that electricity and gas markets that are competitive, integrated and interconnected. The environmental sustainability objective involves reducing Greenhouse Gas emissions (GHG) by using less energy and more renewables. Finally, the objective of energy security of supply is mostly about minimising the EU's vulnerability concerning uncertainties with respect to future supply, in particular dealing with oil and gas but, also with EU energy infrastructure (Nuffel et al., 2017).

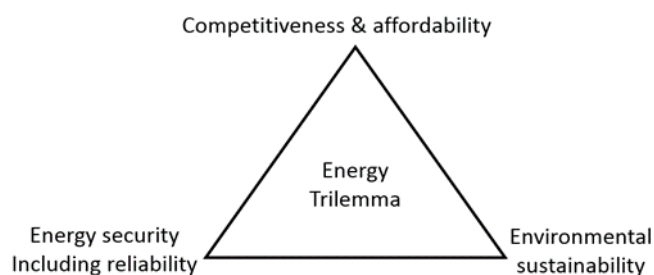


Figure 3 Energy Policy objectives, applied to electricity, source (Nuffel et al., 2017)

These objectives are interconnected and are not interdependent. By increasing renewable energy and energy efficiency, the EU is not only mitigating climate change effects but also moving forward in improving energy security. The same is true for infrastructure investment which will not only promote competitiveness and internal market growth but will

also play a part in greater security of supply through the development of reliable and coherent energy network in Europe.

In 2007 the EU leaders set targets to mitigate climate change effects. In 2008, the 2020 Climate and Energy package was adopted, which is a set of binding legislation to ensure the EU member State to reach 20/20/20 targets. The package sets three key targets are 20% cut in greenhouse gas emissions (from 1990 levels), 20% of EU energy from renewables and 20% improvement in energy efficiency (Table 1).

EU level target	2020	2030	2050	
Greenhouse gas emissions	20%	40%	80% - 95%	Reduction compared to 1990 levels
Renewable energy	20%	27%	55%	% of total consumption
Energy efficiency	20% (not building)	27% (not building)	41 %	Reduction compared with BAU scenario
Electricity interconnection	10%	15%	No target	% of installed electricity production capacity
Smart electricity metering deployment	80%	No target	No target	

Table 1 Summary of key EU target in the short, medium and long term, source: (Nuffel et al., 2017)

According to the EU projections using existing measures provided by the Member State in 2015, emissions are expected to be 24% lower in 2020 compared to 1990 (European Commission, 2016). Regarding the renewable energy, the EU as a whole achieved a 16% share of renewable energy in 2014 (European Commission, 2017). In overall, final energy consumption decreased by 7% between 2005 and 2013 showing significant progress in decreasing energy efficiency (European Commission, 2015). Energy plans are updated by European Commission regularly (European Commission, 2017).

1.1.3 The traditional energy utility model pros and cons

Historically, customers need for electricity has commonly been seen as a product that can be delivered when they want, in any quantity at a reasonable and predictive price. Traditionally, customers have had a passive role, have been considered ratepayers, and have been isolated from market dynamic and externalities. Their role is limited to the voice of their representatives in the legislative and regulatory processes. The main alternative for the grid electricity is the expensive diesel generator (Gimon, 2016). The characteristics of the traditional utility business model, illustrated in (Figure 4), can be explained by the following advantages and disadvantages (Gimon, 2016).

- **Traditional business model advantages:**

- **Cheap electricity:** the pooled purchasing of power allows energy utilities to achieve economies of scale and have a low cost per kilowatt-hour. The big size of power plant brought lower electricity cost to the customers and gave energy utility a negotiation power in the wholesale markets. Its monopoly status ensures access to long term financing.

Nevertheless, this claim can be controverted if certain public expenses are taken into account in the electricity price calculation

- **Sizing and flexibility:** by aggregating customers demand, energy utilities can handle the huge variations in customer load behaviours. This factor ensures customers access to electricity. Once customers hook up to the grid, they will have immediately the amount of electricity that they want. Customers can get the maximum power they need in a fairly, cheap and easy way, even if it exceeds the peak consumption. Finally, grid flexibility refers to the grid capability to adjust and respond in a fraction of second to changes in customer demand which guarantee high reliable product.
- **Other advantages** of the traditional BM are free-of-hassle. Customers do not have to worry about the maintenance. While power plants are polluting, pollution effects are far away from the customers. Moreover, it is considered as a tool for promoting social equity.

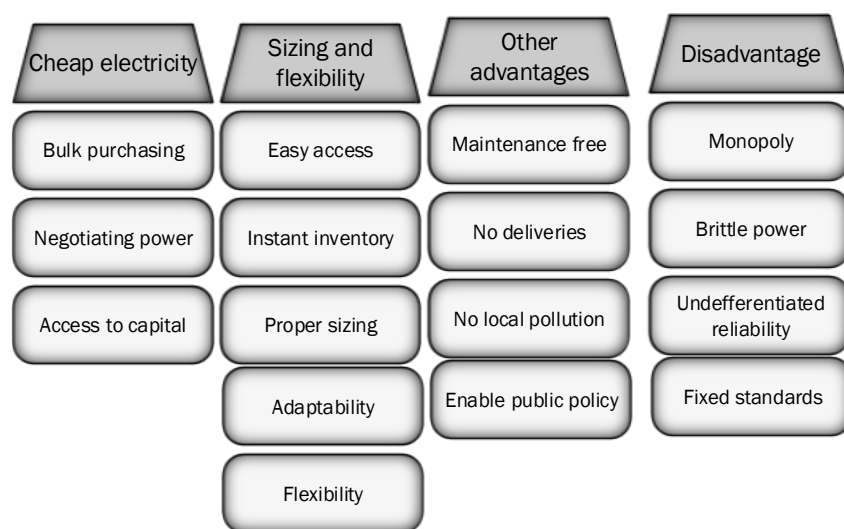


Figure 4 Traditional energy utility model pros and cons, source:(Gimon, 2016)

- **Traditional business model disadvantages:**

- **Monopolies:** most grid users have to deal with a monopoly whatever the status, public-owned one, investor-owned one, or others. Though competition has been promoted on the generation and retailing parts, distribution and transmission is still a monopoly. Customers face limited choices concerning the smart meters and the power systems ignore their capability to be grid flexibility providers.
- **Brittle power:** if a big natural disaster or accident struck our grid, it would go down all at once; This low degree of resilience can cause a high degree of damage if there is a loss of power for several hours or days as the current infrastructure prevents most of the people to get alternatives.
- **Undifferentiated reliability:** reliability has been provided to the whole users at the same level. Some might need higher reliability as their electric appliances might get damaged. Others might prefer to get a lower reliability level for a lower price.
- **Other disadvantages:** energy utility services are limited to people who are in its grid range while remote customers are often excluded.

1.1.4 Area of disruption

The energy sector is facing critical changes that can be described as disruptive changes. Therefore, we need new form of businesses that drive the energy transition. Herein, the question is what form, these new business models they will take and who would take the advantages and transform energy transition challenges into opportunities. To go further with this question, the author discusses the major changes that the energy sector is exposed to (Nillesen and Pollitt, 2016):

1- *Customer behaviour*

Nowadays, customers have trends towards increasing renewable consumption and decreasing their grid dependency; moreover, there is a growth in self-generation. Customers have a little trust in energy utilities (Apajalahti et al., 2015) and energy utilities are suffering in adapting their business model to new customer's needs (Helms, 2016). For example, in Germany, energy utilities are losing their market shares on the expense of renewable energy based on new companies, often installation made by private citizens and farmers (Richter, 2012).

2- *Competition*

Energy transformation creates new opportunities and new roles for companies. For example, in the distributed energy community, new actors can play the role of energy management instead of energy utilities. Engineering and technology companies, such as GE and Schneider Electric which have been working on distributed energy equipment for a long time, will have the advantages of playing a key role in taking part of the energy utility roles. Demand side management services are other key areas where new entrants, such as aggregators work on reducing the industrial and commercial customer electricity bills by shifting their energy consumption to off-peak times. Online service, such as energy monitoring and controlling services are also emerging allowing information technology companies, such as Google to enter the energy sector.

3- *The production service model*

The centralised infrastructure that exists today has long time be a source of strength of the power industry, but it has been proved that it could be a source of weakness regarding the market or future policy. Some changes in the markets (e.g. collapse of the carbon market, cheaper coal prices, etc.) can have a significant effect on the type of power plants. In Europe, over the course of 2012–13 ten major EU utilities announced the mothballing or closure of over 22 GW of combined cycle gas turbine capacity, of which 8.8 GW was either built within the last ten years. Some power plants have been a subject of air toxics standards. The US energy Information Administrative expects about 60 GW of coal generation to shut down between 2012 and 2018 a reduction of about a fifth.

4- *Distribution channels*

In a digital-based smart energy era, the expectation is that the main distribution channel will be online, and the energy retailing main value propositions would introduce on innovative digital platforms to secure the energy automation, own generation and energy efficiency

customer offerings. This new channel might put the incumbent energy utilities out of the markets on expense of online, digital and data management companies.

5- Government and regulation

Energy is by its nature a key economic and political issue. More than in many other sectors, firms in the power sector depend on the political context for their licence to operate. Moreover, public trust regarding their activities is an important factor.

In the next section, the emerging concept of energy market will be discussed focusing on the main types of energy markets and their purposes.

1.2 Energy markets

The energy market design as a concept includes two opinions. On the one hand, “Market purists” support the creation of an energy market in order to remove all policy intervention that distorts market prices. On the other hand and opposite to the competitive market approach, “climate change planners” seek to minimize the financing cost of low carbon generation investments by insulating investors from market risk and introducing instruments, such as procurement auctions for Power Purchase Agreements (IEA, 2016). The objective of electricity markets is to improve the economic efficiency while mitigating the power system operation risk. The market equilibrium should work to balance two opposite objectives: maximize the social surplus and minimize the total operational cost (Chen, 2016). Herein, the market price, such as locational marginal prices and ancillary service market clearing prices align the financial interest of market participants with system and market operation objectives (Chen, 2016). (Figure 5) illustrates the interaction between the market operations and system operations to achieve market equilibrium by responding to dispatch signals and prices. Market participants, such as generation firms, distribution companies, transmission companies and financial players address system operation needs.

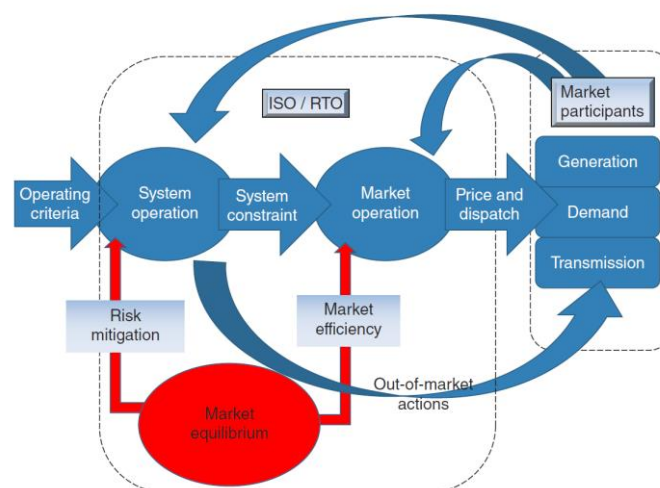


Figure 5 Market and system operation integration, source: (Chen, 2016)

1.2.1 Electricity market risk and benefits

Electricity markets are volatile because of the other vectors, mainly the gas. This issue exposes the high upfront cost of low-carbon technologies to uncertainty. Furthermore, the

increasing share of renewables, such as wind and solar reinforces this uncertainty by pushing the wholesale prices down. However, the wholesale market can reduce energy system complexity through (IEA, 2016):

- The coordination of a massive number of distributed generations locally and nationally.
- Maximising performance (e.g. operation cost reduction)
- Increasing transparency and collective decisions.
- Stimulating innovation in the power system.

Nowadays it is questionable whether it is still viable the energy utility models which are vertically integrated monopolies that are used to perform the coordination of few power plants. With millions of distributed energy resources, this approach seems expired. Exposing generations to market prices would increase operational efficiency. The energy market is needed to send signals for investors when the revenue is high enough to recoup the investment cost.

1.2.2 Electricity Market horizon

The design of the electricity market shows time frame ranging from planning to real-time as described in (Figure 6) and it is divided as following:

- **Capacity markets** are designed to fulfil resources adequacy and make sure that there will be sufficient capacity to meet future peak load plus a reserve margin. They create long-term (3-4 years) price signals that attract investment. Generators and consumers participate in this forward market to reduce the risk of future price changes.
- **Day ahead-market (DA)** allows participants to bid-in demand before each operating day to be met by generation offers.
- **Intra-day markets** are continuous markets to handle uncertainties (e.g. weather changes) after closing the DA market. They are important to respond to renewable generation changes. In Europe, it happens every hour and delivery should be performed after one hour of commitment.
- **Real-time (RT)** market has unit commitment processes that aim at activating a generation unit 2-3 hours look-ahead time. RT markets send dispatch and prices signal to market participants every 5 minutes to balance system load, maintain system reserve and resolve system congestion.

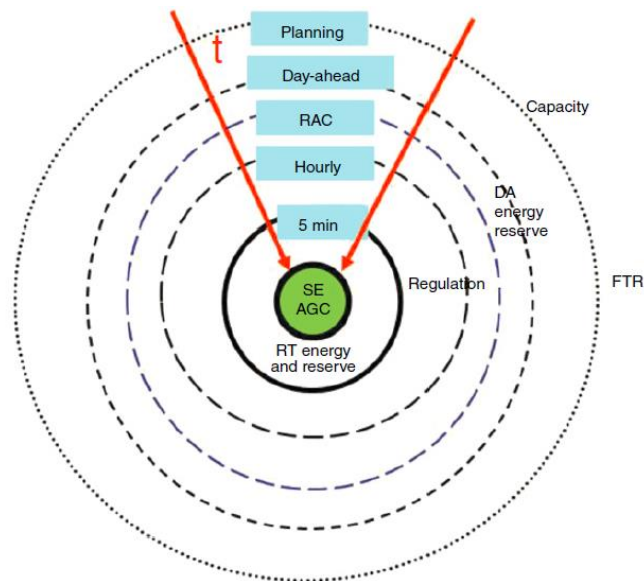


Figure 6 multi-level of market design, source:(Chen, 2016)

1.2.3 Reserve or ancillary market

The power system often is faced with uncertainties in both generation and load which may lead to power imbalances. Therefore, reserves are needed in the system to control normal frequency deviation. Reserves are defined as “*The flexible unused available real power response capacity hold to ensure a continuous match between generation and load during normal conditions and effective response to sudden system changes, such as loss of generation and sudden load changes*”. They can be divided according to the purpose to non-event continuous need and contingency events and can be categorised according to the response time, online/offline status and physical capabilities (Chen, 2016).

For example, in North America, reserves are categories as 30 minutes supplemental reserve, 10 minutes non-spinning reserve, 10 minutes spinning reserve and regulating reserve and so on. Contingency reserves are used to compensate for a loss of generation. The spinning or synchronised reserves are the un-used synchronised capacity (connected to the grid or standby status) and interruptible load, which is automatically controlled, can be available within a set period of time. Non-spinning or non-synchronized reserves are available capacity not currently connected to the grid. Regulating reserves can be used in both upward and downward directions (Chen, 2016).

In Europe, the reserves have three categories: primary, secondary and tertiary control. The primary control is activated within 30 seconds, the secondary within 15 minutes and consists of Automatic Generation Control and fast start units and the tertiary control has a slower response and is used to restore the primary and the secondary control unit back to reserve state (Chen, 2016).

Ancillary service markets are mainly reserve markets designed to support the transmission of electric power and maintain the reliability of the interconnected system. The service includes spinning and non-spinning reserves, frequency control, replacement reserve, voltage support and black start. However, voltage support and black start are cost based and

have no market yet. The ancillary or reserve markets are created to bring the market mechanism for the procurement of reserves on the system, and they are scheduled with energy in the DA markets and/or RT markets.

After clarification of the main key concepts related to the energy transition, the next section will introduce the complementary subject of the thesis, which is the business model.

1.3 Business model

1.3.1 The business model concept

In the past few years, the use of the concept “business model” has increased, taking attention of both practitioners and academics alike. (Figure 7) displays the use of the terms business model in management and business articles and shows its dramatic increase between 1995 and 2018, in parallel with the emergence of the internet and the e-business.

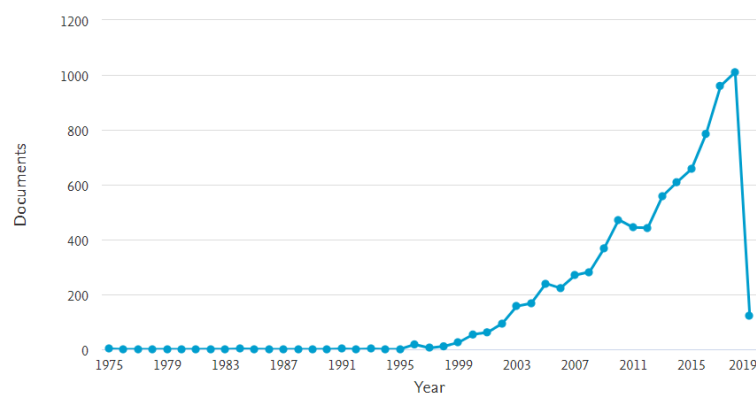


Figure 7 Business model use in articles of Scopus database between 1975 and 2018

Traditionally, each operating firm has a business model that explains the customer types, their benefits, the employed resources and the economic model. However, the advances in the ICT domain has facilitated BM experimentation and innovation and has allowed entrepreneurs and existing firms to organise business activities in entirely new value creation logic.

Scholars have no consensus on the BM definition, which has various conceptualisations that serve the scope of each studied phenomenon (Zott et al., 2011). (Table 2) shows some of the selected definition of business model from the literature. The business model concept may execute several functions including; articulation value proposition, identify a market segment, define the value chain and value network, estimate the cost and profit structure and formulate the competitive strategy (Chesbrough and Rosenbloom, 2002). Business models pave the way for the new technologies to be alternatives in some places of the markets and create value. Therefore, it is considered as a construct that mediates the value creation process. It translates the technical inputs to the economic domains of outputs (Chesbrough and Rosenbloom, 2002). Apart from being a commercialisation device, the business model is an innovative tool that reflects conscious managerial choices and is considered as generative cognitive processes (e.g. analogical reasoning and conceptual combination) that assists managers on an individual level to ideate and design new business models (Martins et al., 2015). Taking into consideration the timing and the dynamic nature of firms, the business model is conceived as “process-based” conceptualisation. Business model as process addresses business model changes, such as the

creation of a new business model and materialisation of a business idea into a new venture, *extension* by adding new activities, *revision* by modifying an existing BM and finding alternatives, and *termination* by abandoning processes (Cavalcante et al., 2011). Examining what could be the components of a business model, Osterwalder (2004) has proposed the business model as a combination of concepts and relationships that express and represent the business model in a simplified manner.

Author, year	Definition	Focus
(Chesbrough and Rosenbloom, 2002)	“The heuristic logic that connects technical potential with the realization of economic value”	Technological innovation
(Magretta, 2002)	“Stories that explain how enterprises work”	Narrative
(Cavalcante et al., 2011)	“An abstraction of the principles supporting the development of a firm’s core repeated processes”	Process
(Martins et al., 2015)	A cognitive structure that consists of concepts and relations among them that organise managerial understandings about the design of activities and exchanges that reflect the critical interdependencies and value creation relations in their firms’ exchange networks	Cognitive
(Zott and Amit, 2010)	The business model depicts the content, structure, and governance of transactions designed so as to create value through the exploitation of business opportunities	System-based
(Morris et al., 2005)	Business model is a concise representation of how an interrelated set of decision variables in the areas of venture strategy, architecture and economics are addressed to create sustainable competitive advantage in defined markets	Entrepreneurship
(Osterwalder, 2004)	A business model is a conceptual tool containing as set of objects, concepts and their relationships with the objective to express the business logic of a specific firm ... allows a simplified description and representation of what value is provided to customers, how this is done and with which financial consequences.	Ontology-based
(Casadesus-Masanell and Ricart, 2010)	“Business model is a reflection of the firm’s realized strategy”	Strategic management

Table 2 Business Model definition from the literature

Foss and Saebi (2017) have reviewed the literature and noticed that three common themes have been implicitly and explicitly expressed among business model conceptualisations. First, business model is a “system level concept” centred on activities and focusing on value and it emphasises a systemic and holistic understanding of how an organisation orchestrates its system (Osterwalder, 2004). Secondly, BM typically occurs in the value network including suppliers, partners, distribution channel (Weill and Vitale, 2002; Zott and Amit, 2010), thus can generate a collaborative mechanisms among the potential parties (Faham et al., 2016). Finally, BM is a new unit of analysis.

Recently, three perspectives regarding business model role and function have been introduced base on business model definition literature review. Accordingly, business model roles are identified as: (I) explaining the business, (II) running the business, and (III) developing the business (Foss and Saebi, 2017). As clarified in (Table 3) each defined role has been associated with a group of terms that are largely used by scholars in the course of describing the business model functions.

Firms can use the business model to explain how an existing or future business is to generate profit. In this regard, BM can simplify, represent and describe the BM for key business actors, such as investors, suppliers, media, customers and partners as well as internal employs. Running the business refers to the operational roles assigned to business models and is associated with defining linkages, processes and structures including managers and external partners. Developing a business addresses the strategic function of the business model. Herein the BM role is a tool to define and develop the firm's strategy (Foss and Saebi, 2017).

Business model functions	Associated terms from the literature
Explaining the business	Abstraction, description, outline, reflection, representation, statement, story
Running the business	Activity system, architecture, framework, blueprint, method
Developing the business	Approach, design, logic, conceptual tool, recipe, set of choices and consequence

Table 3 Business model definition functions categories, source: (Foss and Saebi, 2017)

1.3.2 Business models review

Due to the diverse conceptualisation of the concept business model. The author adopts and draws on the literature review of (Gassmann et al., 2016) to form and outline the business model reviews. This interesting research presents the seven dominant schools of thought on business model each of its theoretical background that explains the business model phenomenon.

1.3.2.1 Activity System School

The activity system defines the business model as a set of interdependent activities spanning firm boundaries. Herein the BM describes the design of transaction content, structure and governance to create value (Amit and Zott, 2001). The transaction content refers to goods or information that being exchanged and to the resources and capabilities needed. Transaction structure points out to the participating parties and the link between them. It also refers to the order of transactions and the mechanisms for enabling transactions. Finally, transaction governance refers to how activities are controlled by the relevant parties, the legal form of the organisation and to the incentive (Amit and Zott, 2001).

By building upon previous work, Zott and Amit (2010) have proposed the activity system perspective, which outlines design elements and design themes (Figure 8). Design elements include the content, structure and governance of an activity system while design themes explain the source of value and consists of novelty, lock-in, efficiency and complementarities.

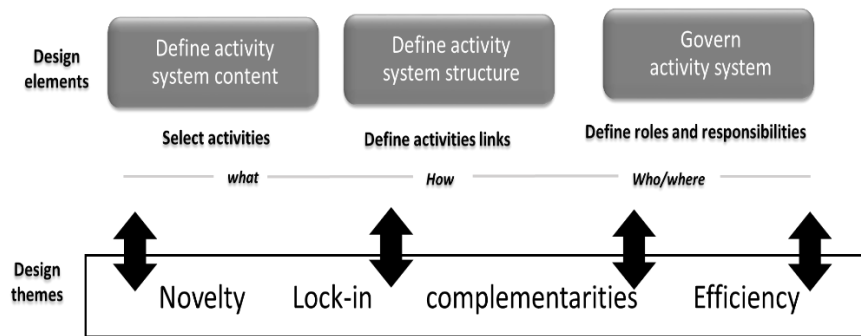


Figure 8 Activity System perspective on business model, adopted from (Zott and Amit, 2010)

1.3.2.2 Process school

This school defines the business model as a dynamic process of balancing revenue, costs, organisation and value. Demil and Lecocq (2010) have emphasised the transformational view which raises the question of “how to change it”. The focus is much on the business model evolution process and how managers can change their business model rather than on the static approach in which BM is a snapshot of the business model components in a specific point of time. The authors have proposed a business model framework called RCOV that consists of three components Resource and Competences, the Organisation and the Value proposition (Figure 9). Resources and competences refer to the knowledge managers develop, organisational structure encompasses the organisation’s activities and the relation with other organisations and value proposition address the question of how and for whom the products and services will be marketed.

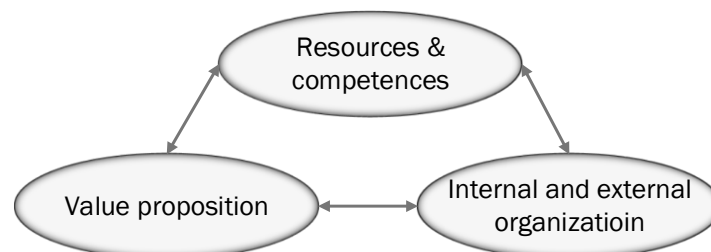


Figure 9 RCOV Business Model Framework. source: (Demil and Lecocq, 2010)

1.3.2.3 Cognitive school

The cognitive school defines the business model as a ‘model’ or the ‘logic’ of how firms do business distinguished by a rather cognitive stance. According to Baden-Fuller and Morgan (2010), BM has the characteristics and fulfils the roles of ideal types. They are exemplars that can be imitated and replicated in other domains. By that, they provide recipes that have been already tried and tested in the world. In view of this, BM can capture the business’s characteristics and its activities in a remarkable and concise and explain firms generic kinds of behaviour which are clearly different.

The successful business firm case can be thought as a standardised representative for a genre of firms that practice a similar kind of business model and offers knowledge of the system on a fee-related-to-success basis. For example, while franchising has become ubiquitous in food outlets, hotels and coffee bars. Often people refer to McDonald’s as a reference for franchising

(Baden-Fuller and Morgan, 2010). In this regard, the analogical notion of a business model as recipes can play an essential role in business model innovation.

1.3.2.4 Technology-driven school

The technology drive school conceives business model as a way to commercialise new technology. This approach is based on two complementary theoretical works (Gassmann et al., 2016). The first one is based on (Chesbrough and Rosenbloom, 2002) whose view on business model is conceived as a spin-off strategies. The second one is based on (Teece, 2010, 2007) who draws on the dynamic capabilities in designing viable business model.

The business model can be seen as mediating structure between technology and economic value that transforms the technical inputs, such as feasibility and performance into an economic output such value, price and profit (Chesbrough and Rosenbloom, 2002). The authors emphasise the role of a business model in capturing value from early-stage technology ventures.

Moreover, the dynamic capabilities approach of (Teece, 2010, 2007) focuses on the creation, integration and commercialisation of a continuous stream of innovations consistent with customer needs and technological opportunities. The dynamic capabilities framework can be described and disaggregated into sensing opportunity, seizing enterprise boundaries and reconfiguring the required assets.

1.3.2.5 Strategic Choice School

The strategic choice school defines the business model as a result of strategic choices. Casadesus-Masanell and Ricart (2010) have distinguished between strategy, business model and tactic. Accordingly, strategy is a high order choice and can be used as a contingent plan to select what business model to use. Choosing a particular business model means choosing a particular way to compete, the firm logic and operation model. Stakeholder values tactics are determined by the business model and different business models give rise to different tactics available for competition and/or cooperation. Therefore, tactics can be described as residual choices open to a firm after choosing its business model. Strategic plans impact the business models components directly and indirectly, thus the two concepts are correlated (Buton, 2017).

1.3.2.6 Recombination school

The business model, by the recombination school, is a recombination of patterns for answering the who-what-how-why question of a business. (Frankenberger et al., 2013) have suggested a framework consisting of four elements namely: value proposition, profit mechanism, customer and value chain. BMs are recognised as archetypes, categorisations or morphologies that employ analogies for creative imitation. The focus is on fusion of and on building on existing knowledge to drive new business models.

1.3.2.7 Duality school

Duality school defines the business model as a requirement for ambidextrous thinking as it does coexist with competing business models. It handles the topic of managing dual business models and balance between exploration (Find new BM) and exploitation (Developing the current BM) (Ireland and Webb, 2009). Dual business model refers to competing with more than one and potentially cannibalising business model in a single market.

1.3.3 Business model decomposition

The business model review shows that this concept is a rich construct that links actors, embeds interdependencies and dynamics. It can be of great interest for managers for visualising and exploring potential opportunities and effectively managing and implementing innovative BMs. Academics have proposed several of tools, such as perspectives, frameworks and ontologies. These tools are associated with three functions (Massa and Tucci, 2013). First, they provide “*reference language*” that foster dialogue, create a common understanding and contribute to collective sense-making. Second, they permit a “graphical representations that simplify cognition and offer the possibility of virtually experimenting. Third, they enable managers to articulate the value of their venture and to get support from external parties so as to gain legitimacy.

In order to have in-depth understanding of the business model concept, the author adopts the work of (Massa and Tucci, 2013) which divides the business model innovation tools into several levels with varying depth and complexity depending on the degree to which the BMs abstract from the reality they aim to describe (Figure 10).

The highest level from reality is the narrative level. The “*Narrative*” perspective defines the business model as a story, a verbal description of how a firm works. These narratives play an essential role in inducing expectation among interested actors about what could be the future of the business. Narrative BMs serve in simplifying cognition, facilitating communication and persuading external stakeholders (Magretta, 2002). The next level is the level where patterns and “*Archetypes*” are observed in the BMs structure. They can be recognised as an ideal example or type. For example, the archetype Premium, used by Lexus, enable firms to put a higher margin price than competitors, usually for a superior product, offering, experience, service or brand. Similarly, the Freemium archetype enables users to have access to free service while charging a premium for advanced or special features. As has been shown that these archetypes have identifying labels, followed by a brief description to be followed and imitated (Baden-Fuller and Morgan, 2010).

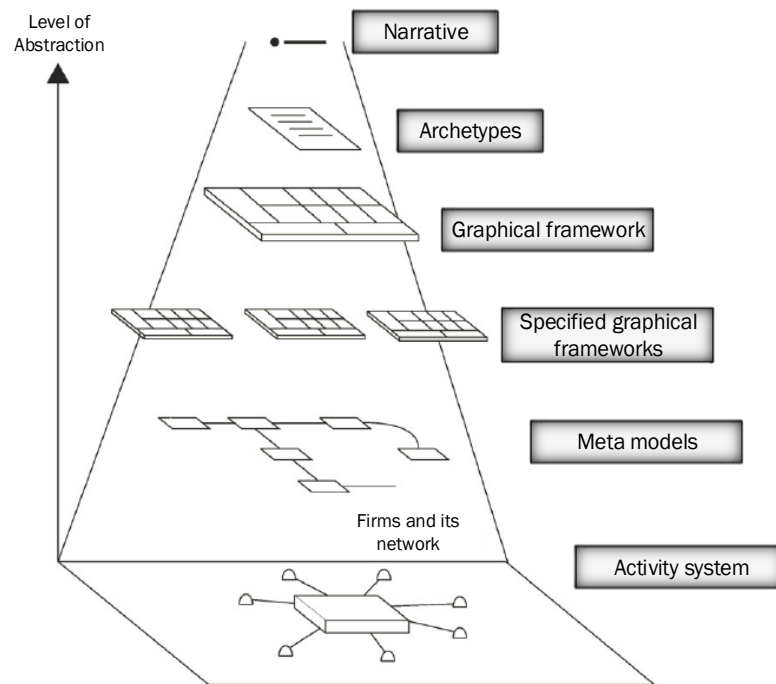


Figure 10 Business model at different levels of abstraction from reality, source (Massa and Tucci, 2013)

“Graphical framework” level gives more details regarding the business model components. By that, managers have the capability to analyse, represent in one picture and manipulate the business model structure. The most popular example is the Business Model Canvas of (Osterwalder, 2004) which consists of nine blocks: value proposition, customer segment, customer channels, customer relationship, key partners, key resources, key activities, revenue stream and cost structure. The next level is where BM has a dynamic notion. Indeed “*Meta-models*” integrate the static and dynamic functions of BM. Dynamic BMs are based on choices and consequences, they represent the architecture of choices and its overall influence on BM behaviour (Casadesus-Masanell and Ricart, 2010). Finally, the activity system perspective level defines a business model as a system of interdependent activities which consists of design elements (Content, structure and governance) and design themes (Novelty, Lock-in, Efficiency and Complementarities).

1.4 Research questions and thesis contributions

This thesis aims at fostering the energy transition by developing a business model tool for new entrepreneurs in this sector. To do so, the thesis draws on the business model theory and the energy transition needs. This intersection between the two concepts results in the following main research question and related sub-questions:

MRQ: How can the business model concept contribute to assisting entrepreneurs in the context of energy transition?

RQ1: What are the emerging business models in the energy domain and how can they be analysed and classified?

RQ2: How do energy start-ups pursue business model innovation?

RQ3 How can the business model concept contribute to the development of innovative demand response activities?

The objective of raising the first question is to review the literature and have an up-to-date data about what has been investigated in the energy business models for energy transition. By that, the author has gained the required knowledge for a deep understanding of the studied field and was able explore various types of energy business models. The second question shifts the focus from the general view towards new market actors “Energy Start-ups”. The reasons for choosing this research question is twofold. First, to enrich the literature about the business model innovation that new market actors, represented by energy start-ups, bring to the energy transition. Second to collect data from the ground and to have a complementary source of data besides the academic data. Finally, the last research question is a result of the intersection between what has been reviewed in the first research question and what has been explored from the empirical data that has been obtained from the second question. Herein, the thesis converges on a specific requirement and focused on the demand response business model.

This thesis contributes to a recent call for more research on business model innovation for energy transition (Hannon et al., 2013; Huijben and Verbong, 2013; Richter, 2013; Wainstein and Bumpus, 2016). It contributes to business model innovation by showing how energy start-ups develop their business models and how they capture value from new market opportunities. It also enriches the concept of demand response and add-value for practitioners by developing a business model tool that can support managers and entrepreneurs in their effort of creating new business models in this domain.

1.5 Research methodology

The research methodology guides the selection and application of suitable approaches and appropriate methods. This thesis research’s methodology consists of four phases adopted from (Blessing and Chakrabarti, 2009): Research clarification, Descriptive study I, Prescriptive study, and Descriptive study II (Figure 11).

In the **Research Clarification**, a literature review has been conducted. The objectives were first to formulate a realistic research goal. Second, to accumulate factors that support and influence the energy business model. Third, to synthesise the finding in an initial description of the existing situation and current business model practices in the energy sector.

The result from the literature review was insufficient in order to develop a business model tool that can support entrepreneurs seeking for new business models. Therefore, a **Descriptive Study I** was initiated. The author conducted fifteen interviews with energy start-ups and investigated their business models.

Then, the thesis research design evolved towards a **Prescriptive Study**. The author decided to employ the acquired experience to create a business model canvas for the energy demand response “Demand Response Business Model Canvas DRBMC”. This tool is based on the assumption that providing a visualisation framework can support entrepreneurs in developing new business models.

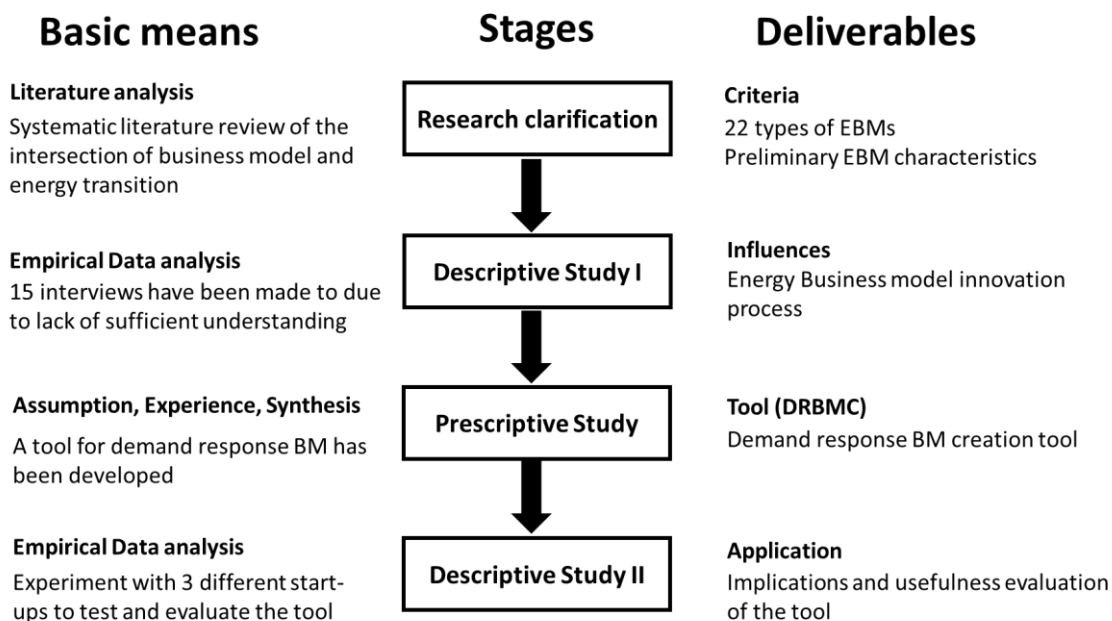


Figure 11 The thesis Design Research Methodology, adopted from (Blessing and Chakrabarti, 2009)

Lastly, in the **Descriptive Study II**, the author investigates the impact of the developed tool to support start-ups in innovating their business model. Herein, the tool has been tested with three start-ups in order firstly to evaluate its capability to be used as a business model tool and secondly to evaluate its usefulness and whether the use of this tool is fruitful and capable of generating new business ideas, exploring new opportunities representing new business models and analysing them efficiently.

1.6 Thesis outline

The remainder of this thesis will be organised as follows:

Chapter 2 attempts to give an answer to the Research Question 1. The chapter goes through a systematic literature review to analyse the diverse energy business models. It proposes a set of BM characteristics and it presents 22 energy business models and eight business model patterns.

Chapter 3 presents an analysis of 15 start-up business models and focuses on explaining how start-ups develop their business model in the frame of energy transition. By that, it answers the Research Question 2. The chapter provides a business model innovation process for energy entrepreneurs.

Chapter 4 aims at answering the Research Question 3 by introducing a business model tool for a specific use in the “demand response” domain. It employs the main findings of Chapter 1 and Chapter 2 and addresses the main challenges for the demand response business model creation process.

The thesis ends with an overview of the main **conclusions** addressing the contributions to the academic field and to practitioners. The conclusion also points out to the discussion of shortcomings of the research, potential future research areas, and provides specific management recommendations.

Chapter 2

2. A systematic literature review of Demand-side management and renewable energy business models for energy transition

2.1 Introduction

Recently, an international effort went into decarbonisation of the energy sector in order to mitigate climate change (DDPP, 2015). In Europe, fuel combustion and fugitive emissions from fuel excluding transport, is responsible for 54% of GHG emissions in 2016 (Eurostat, 2018). Moreover, considerable political efforts have been put into liberalizing energy markets. Since that time, the rules, roles and business models of the conventional actors in the energy sector have been increasingly changing. Energy utilities have been pushed to deliver additional services, such as energy advice rather than to increase energy sales. Competitive market principles are taking the place of the traditional role of energy utilities as public goods providers.

In parallel, the distributed energy resources, such as small-scale renewables, are increasingly expanding, and they depend on a different logic compared with centralized, large-scale power plants. They yield significant benefits regarding carbon emissions and may contribute to reducing losses in energy distribution. However, building decentralized sustainable energy systems requires a high degree of integration of these local, independent small-scale renewables. This shift from a planned system, in which the state decides what and how to produce and who pays, to a competitive and two-sided market can be analysed with help of the business model concept, which defines how to capture value from new markets. The deployment of renewable energy technologies through sustainable business models opens up access to new entrepreneurs to participate in the energy transition.

(Antoncic and Hisrich, 2003) indicate that entrepreneurship is a proactive concept that operates at the organisational boundary and extends current technologies, products, services, norms, etc. into new directions. Noticeably, energy entrepreneurs, who are looking to detect new possibilities emerging from the intersection of sustainability and the energy domain, are contributing to the energy transition by commercializing discontinuous innovations and breakthrough technologies (Elgar, 2011).

Analysing the difficulties of emerging business models in the energy sector requires identifying specific business model characteristics for this sector and analysing the relationship between different stakeholders. Often, business model innovation is introduced by newcomers rather than incumbents who may have difficulties in responding successfully and quickly to disruptive innovations.

(Burger and Luke, 2017) conducted an empirical review analysis that examined the distributed energy business model, and their aim was to support policy makers and regulators. This chapter focuses on emerging BMs in the energy domain, and it aims to understand the structure of entrepreneurship of these BMs. The purpose is to describe an array of business model configurations and to classify them following specific characteristics as well as singular business model patterns.

This chapter is structured as follows: section 2.2 explains the employed methodology. Section 2.3 presents the analytical framework that includes the characteristics of Energy Business Models (EBMs) and a synthetic framework for EBM classification. Based on this framework, section 2.4 shows the results of the systematic review, presenting the identified EBMs classified as eight patterns. Section 2.5 draws the conclusions. Lastly, a concise description of the main chapter's contribution is presented in section 2.6.

2.2 Methodology

The authors conducted a systematic literature review to accumulate evidence across a body of previous research. The systematic review is a way to address a specific problem by summarizing the existing research and presenting it in one single document (Harden and Thomas, 2005). The aim of a systematic review is not to give answers but to report as accurately as possible what is not known about the research question and the status of present knowledge, in a replicable and organised method (Briner and Denyer, 2012). Following (Gough, 2007) methodology, it includes the following phases: identify the research question, define the inclusion and exclusion criteria, describe the search strategy and synthesis.

First, the following research question has been set up to guide the research process: What are the emerging business models in the energy domain and how can they be analysed and classified? This question emerged in response to the increasing need for new business models that accommodate and facilitate the widespread adoption of distributed Renewable Energy technologies and demand-side management (DSM) systems.

The research scope is the energy transition focusing on the electricity field; in some cases, papers about non-electrical subjects, such as the heating systems for small-scale consumers have been included for their BM interest. Therefore, the chosen articles are in the scope of the renewable energy and DSM areas, excluding articles that provide technical solutions or those that tackle policy issues (Table 4).

Searches were done through two electronic databases: Scopus and Business Source Complete of EBSCO. The search strategy was to look for the intersection of two groups of items. The first group includes business-oriented keywords: “social enterprise, innovation, value creation, corporate responsibility, business model, entrepreneur and venture”. The second group is energy-oriented and had six terms: “energy, power, electricity, distributed generation, renewable and energy service”. The time window of the research was between 1980 and January 2018. Searches included the title, abstract and keywords. The intersection of the two previous groups, after excluding oil, fuel, and petroleum-oriented journals and non-English articles, resulted in 981 articles from Scopus and 1370 from EBSCO, including review papers, available book chapters and conference papers. Based on an examination of abstracts, a sum of 229 publications were selected from the two databases. After adding 17 articles from the references and removing the repeated ones, 59 articles were selected that have a significant contribution to the topic of emerging business models for the energy transition. The most frequently appearing journals are Energy Policy (17), Journal of Cleaner Production (13) and Renewable and Sustainable Energy Reviews (5).

After that, a coding process was initiated in order to combine the individual studies. The focus was on the characteristics of each identified EBM. This step included iterative reading and re-reading cycles. A set of codes, which explain the EBMs attributes, were generated and used to create the final characteristics categories. After this step, we used the activity system theoretical framework of (Zott and Amit, 2010) as a unit of analysis. The analysis consisted of codes related to the design themes, such as energy efficiency, product novelty, etc. and codes related to the design elements, such as broader stakeholder involvement, new partnerships, servitization and innovative governance schemes.

Finally, the codes were refined and connected to have a synthetic structure. To shape our analysis and reach a high level of abstraction, subcategories were formed combining both

the EBM characteristics and the results of analysis of activities system framework. Then through discussion and interaction, the authors closed the remaining gaps and agreed on common patterns.

Criterion	Inclusion	Exclusion
Publication type	Peer-reviewed academic journals, available book chapters and conference papers	Other types of articles
Language	English	Any other language
Availability	Available online as full text	Not available online as full text
Research discipline	Management/Business Administration or Engineering	Any other research discipline
Time period	1980 to January 2018	Any other study published before 1980 and after April 2018
Sector	Residential facilities and small-scale commercial and industrial sector.	Specific articles focusing on developing countries.
Relevance	Articles that address (at least partly) business models applied to renewable energy, energy efficiency and demand side management	Articles that provide technical findings and present technological solutions. Articles that tackle policy issues rather than management.

Table 4 Systematic review search methodology

2.3 Analytical framework

2.3.1 Business model

The business model concept refers to financial and organisational aspects, strategies as well as the required resources to reach the markets and the required resources. The term has been intensively used recently, mainly due to changes in communication and distribution channels caused by the Internet.

Business models define the value proposition, the process of creating this value and how both consumers and suppliers capture the value (Zott et al., 2011). Osterwalder, A. (2004) has defined four components that construct the BMs: value proposition, infrastructure, customer interface, and financial viability. The BM fulfils several functions including articulating the value proposition, identifying a market segment, defining the value chain and value network, estimating the cost and profit structure and formulating the competitive strategy (Chesbrough and Rosenbloom, 2002). Therefore, academics, as well as practitioners, are using the business model to analyse, investigate and describe intra-entrepreneurship activities and new venture launching (Baden-Fuller and Morgan, 2010).

Business models extend the boundaries of the firm to reach the external environment, including partners, suppliers and customers (Zott and Amit, 2010). (Johnson and Suskewicz, 2009) have emphasised the role of BM for the whole sector. They showed that in large infrastructure changes, such as the transition from fossil fuels to renewable energy, the BM concept can be a useful tool to support the development of a whole new system instead of focusing on individual technologies. The BMs are defined as integrated parts of a wider socio-technical system that considers the systemic change (Zott et al., 2011). Great technological innovation may fail if insufficient attention is given to the BM design (Teece, 2010). Business

models pave the way for the new technologies to take a place in the markets and create value for them; therefore, BMs are considered a construct that mediates the value creation process and translate the technical inputs into the economic domains of outputs (Chesbrough and Rosenbloom, 2002).

Developing new BMs requires deep understanding of the fundamental customer needs and how the competitors failed to satisfy those needs, considering technological and organisational trajectories. While designing the desired BMs seems the most important, the process of learning and adjusting the BM holds the same importance. Furthermore, estimating the customers and competitors' behaviour changes from initial conjectures makes adopting new BMs go faster (Teece, 2010).

Business models have been recognized as a locus of innovation (Chesbrough, 2007a) and know-how to capture the value is an essential part of BM function (Teece, 2010). BM innovation comes off through three forms: changing the content by adding new activities, changing the structure by linking activities in a novel way, or changing the governance by replacing one or more parties that perform the activities (Amit and Zott, 2012; Zott and Amit, 2010).

Transformation towards sustainable business models (SBM) can be stimulated through the integration of sustainability aspects into firms' BMs (Stubbs and Cocklin, 2008). It includes balancing the environmental as well as social values and adapting specific extensions (Rauter et al., 2017). Environment and society are recognized as external stakeholders and SBMs include sustainability aspects in the value proposition and value creation (Boons and Lüdeke-Freund, 2013). Shifting to an SBM can be more ambitious through changing organisational perspectives from inside-out to outside-in to create value for common goods (Dyllick and Muff, 2016). Some SBMs, such as the product-service system (PSS) or servitization modify radically the way value is created and captured (Bocken et al., 2014; Hansen et al., 2009; Yang et al., 2017). The notion of servitization, which consists of shifting the focus from product to service solutions, may hold a way to reduce environmental impacts and increase competitive advantage (Plepys et al., 2015). Servitization solutions are desirable from a sustainability point of view as they have a high probability of achieving some environmental improvements (Tukker, 2004). PSSs or servitization have been considered as SBMs; therefore, switching towards a service-oriented BM is a challengeable managerial issue and highlights considerable complexity as it is more customer centric (Trevisan, 2016).

In this chapter, the BM conceptualisation of (Zott and Amit, 2010) is used as a framework of analysis that is well-known, rich and has already been employed in the energy sector (Hellström et al., 2015). This framework focuses on business models from a design perspective and is defined as “the content, structure, and governance of transactions designed to create value through the exploitation of business opportunities”. Content refers to what activities should be performed, structure describes how the activities are linked and governance refers to who and where should these activities be performed. Transaction content explains the required capabilities and resources as well as the exchanged goods and information. Transaction structure points out the parties that participate in the exchange and transaction governance refers to legal organisational form, incentive of participants and the way information, goods and resources flow (Amit and Zott, 2001). The activity system is characterized by four distinct themes that outline the value creation drivers: novelty, lock-in, complementarities and

efficiency (Amit and Zott, 2001). Novelty-centred BMs refer to the adoption of new ways of performing the economic transactions. Lock-in centred business models refer to the ability of the firm to attract, maintain and improve customer and partner association with the BM. Complementarities-centred BMs refer to having a bundle of goods together instead of providing each of the goods separately. Efficiency-centred business models refer to the measures that may be taken in order to achieve transaction efficiency through their BMs (Zott and Amit, 2007).

2.3.2 Characteristics of new energy business models

This subsection provides a set of attributes to characterize new BMs in the energy sector. These attributes are issued from (36) academic works that address EBMs. (Table 5) presents these academic works and the attributes chosen by each author. Based on these characterizations, the following attributes have been selected to support the descriptions of the EBMs presented in subsection 2.3.2: Servitization intensity, financing and ownership, the customer's role, decentralization level, flexibility degree, and management and control.

Servitization signifies the service-oriented character of the BM and means selling the functionality of the product rather than the product's ownership. This concept is based on replacing the product with a combination of products and services to change the notion of the value from exchanging to utilization (Mont, 2002). A similar meaning is also expressed by the terms "product-service system", "eco-efficiency service" or "functional sales". In the energy transition context, servitization is correlated with energy services and energy efficiency, and the notion of having a certain savings percentage on the end-user's energy consumption (Plepys et al., 2015). Variations of energy services have been outlined and ranged from basic services such as information and analysis provision to more advanced services, such as activities and performance (Kindström and Ottosson, 2016). These variations can be assessed by the servitization intensity, which characterizes the magnitude of services included in a PSS (Tukker, 2004). Energy service activities include energy management, project design, implementation, maintenance, evaluation and energy and equipment supply while performance refers to savings guarantees, and its remuneration is directly tied to the energy savings achieved (Bertoldi et al., 2006). Furthermore, energy service contracting allows the service provider to sell service provisions, such as lighting levels, room temperature, humidity and comfort (Sorrell, 2005). Recently, servitization has been used to refer to the transformation of the energy utility business model to a service-oriented BM to meet energy transition challenges (Helms, 2016), demand-side management (Helms et al., 2016) and distributed generation (Boston Consulting Group, 2010; Överholm, 2017). Energy utility servitization, is defined as the development of BM from simple commodity suppliers to comprehensive energy solutions that include consulting, installation, financing, maintenance and warranties (Richter, 2012), allows energy utility to decouple energy volume sales from revenue. Solar service firms are new market actors who sell the function of the photovoltaic (PV) solar panel systems rather than the solar panel (Överholm, 2017). Two main offers are developed, the leasing and power purchase agreements (Wainstein and Bumpus, 2016). Frequently, energy BMs with a high servitization intensity have the potential to reduce the environmental impacts of the energy sector (Hannon et al., 2013).

Financing and ownership have been the locus of BM analysis (Frantzis et al., 2008; Kanda et al., 2016; Okkonen and Suhonen, 2010). Ownership can be organised in different ways, such as privately, publicly or private-public partnerships; nevertheless, three main ownership models have been noted in the energy domain: consumer's ownership, collective

community ownership and service-based with company ownership (Juntunen and Hyysalo, 2015; Walker and Cass, 2007; Zhang, 2016).

Renewable energy resources ownership may have an influence on the grid capacity and thus on grid stability and energy supply security. The decisions that owners of renewables may contribute to increasing or decreasing grid balance. Frantzis et al. (2008) have distinguished between customer or/and third-party ownership and utility ownership. The main difference is that in the latter, the energy utility has the full authority to manage and control the renewables production, consequently maintaining grid balance, while in the former, the prosumers have the choice to accept or refuse to contribute to grid balance activities. Community ownership is often considered as a source of income that can be controlled locally and therefore, these kind of investments are more likely to be accepted socially (Walker, 2008). One of the main motivation for developing local supply ownership is to avoid value leakage out of the local economy (Hall and Roelich, 2016).

Financing renewable energy technology is highlighted as a crucial factor for both micro-generation or for large-scale renewable energy technologies. In the former, renewables upfront cost is often described as a barrier that prevents customers from having a clean energy resource and hence outsourcing financing to a third-party in order to remove this barrier (Engelken et al., 2016). In the latter, financing has also been addressed as a barrier because of the long-term investment in the infrastructure assets (Kanda et al., 2016) and the success and failure of the financial configuration is often dependent on the institutional support (Bolton and Hannon, 2016). Alternative financing sources for renewable energy investments emerge from citizen participation in energy cooperatives (Yildiz, 2014), where the financial risk can be mitigated due to local authority investment (Cato et al., 2008). A similar mechanism for collectively fundraising for renewables is through crowdfunding platforms (Vasileiadou et al., 2016).

The next attribute is the *customer's role*. In recent renewable and DSM systems, the relationship with customers has been modified. These changes include the intensification of the customer engagement, delivering new services, providing real-time information and the installation of two-way communication channels (Tayal and Rauland, 2017). The consumer's behaviour, attitudes, tastes and needs are critical factors for the proper running of decentralized systems (Burger and Weinmann, 2016). The user involvement and interaction within the firms occurs not only at the marketing phase but at the design and use phases as well (Tolkamp et al., 2018). Furthermore, multiple roles for consumers are described in the literature: "active" consumers who self-consume green electricity; customers as "financial investors" in renewables; "service users" demanding light, heat, etc. instead of an energy commodity; "local beneficiaries"; project "supporters"; "protestors" and "activists"; "technology hosts"; and "producers" (Walker and Cass, 2007). The customer's role is central in order to reduce the intervention cost in the DSM systems that is defined as the cost of exploring heterogeneous and specific consumption patterns and compensating consumers for participating in demand response programmes (Helms et al., 2016).

Energy systems can be designed by different *decentralization levels*. The smaller production capacity of renewables and their distributed nature create a new decentralized energy market that requires different revenue models. This characteristic can provide solutions for each consumer separately, which implies high cost in comparison with one-size-fits-all solutions. It includes a strategic shift from big to small, from commodity to service, from

wholesales to a customer-orientated strategy and from long-term planning to a more flexible planning (Burger and Weinmann, 2016). Developing local projects based on distributed generation creates local jobs and income, improves social fairness and equity, reduces carbon emissions, enhances air quality and reduces fossil fuel dependence (Hall and Roelich, 2016). The locally grounded, collectively shared, participatory and politically supported community renewable might lead to a high level of participation (Süsser et al., 2017). In the case of local entrepreneurship, the emphasis is on the importance of who is participating and for whom participation is performed as well as where the value is captured (Real et al., 2018). Often local entrepreneur assemblies are based on mutual trust (Süsser et al., 2017). Decentralization refers to the position on the distribution network and the transfer of energy from the production site to the consumption site, in which the ownership of this network and proximity between production and consumption play a critical role in determining the business model (Juntunen and Hyysalo, 2015; Walker and Cass, 2007).

Flexibility degree refers to the “ability of power systems to utilize their resources to manage net load variation and generation outage, over various time horizons”, and net load is defined as load minus supply from intermittent resources, such as wind and solar (Boscán and Poudineh, 2016). Flexibility can be stimulated either from consumption’s valuables or from generation’s valuables by coupling them with timing service (Helms et al., 2016). The decentralized generation is not just developing sources of renewable energy but also a way of local balancing. The end-user flexibility and the active management may be used to strengthen the stability of the grid (Gordijn and Akkermans, 2007; Schleicher-Tappeser, 2012). Trading flexibility services are important to have a reliable power system (Boscán and Luis, 2016). Flexibility has three main functions, which affect three different electricity market users (Boscán and Luis, 2016). First, the “integration of intermittent resources”, which has an influence on market balancing and is managed by a TSO. Second, the “congestion management” in the electricity network, where a DSO captures flexibility benefits and benefits from low congestion. Third, market players, such as aggregators, suppliers and balancing responsible parties are concerned about obtaining cost-efficient outcomes by leveraging “portfolio optimization”.

Management and control are worth pointing out in this context, as who takes the responsibility of maintaining and keeping the hardware working is of great importance (Kanda et al., 2016). Management consists of three pillars: operation, control and governance. Many factors affect this characteristic, such as the proximity of the technology to the consumption’s site (Juntunen and Hyysalo, 2015), as well as the contract, the partnership and the legal form (Bolton and Hannon, 2016; Okkonen and Suhonen, 2010; Walker and Cass, 2007). It should be noted that the operation and control are key activities that aim also to optimize grid balance and electricity trading service and to provide maintenance to the co-owned infrastructure (Facchinetti and Sulzer, 2016). Operation and control are prerequisites in order to handle the fluctuation of renewable energy production and grid balance (Frantzis et al., 2008; Helms et al., 2016).

Energy communities are entities whose members themselves govern and manage the renewable projects. The governing model is subject to who runs, influences and is involved in developing these communities, members’ commitments and their shared vision (Van Der Schoor and Scholtens, 2015; Walker and Devine-Wright, 2008).

Characteristic	Definition	Reference
Servitization intensity	Generating value from the shift from selling energy as a commodity to a comprehensive energy service solution.	(Bertoldi et al., 2006; Facchinetti and Sulzer, 2016; Helms, 2016; Helms et al., 2016; Loock, 2012; Overholm, 2015; Överholm, 2017; Richter, 2012; Sorrell, 2005; Wainstein and Bumpus, 2016)
Financing and Ownership	Generating value from innovative partnerships and alliances in order to scale-up renewable energy projects.	(Bolton and Hannon, 2016; Cato et al., 2008; Coughlin et al., 2011; Frantzis et al., 2008; Juntunen and Hyysalo, 2015; Kanda et al., 2016; Okkonen and Suhonen, 2010; Vasileiadou et al., 2016; Wainstein and Bumpus, 2016; Walker, 2008; Walker and Cass, 2007; Yildiz, 2014)
Customer's role	Generating value from better consumer integration and participation in the energy transition as co-producer or co-participator.	(Burger and Weinmann, 2016; Helms, 2016; Strupeit and Palm, 2016; Tayal and Rauland, 2017; Tolcamp et al., 2018; Walker and Cass, 2007)
Decentralization level	Generating value from the small-scale, large number of energy distributed generations.	(Bolton and Hannon, 2016; Facchinetti and Sulzer, 2016; Hall and Roelich, 2016; Hannon et al., 2013; Helms et al., 2016; Juntunen and Hyysalo, 2015; Richter, 2013; Süsler et al., 2017; Walker and Cass, 2007)
Flexibility degree	Generating value from improving the flexibility of the power system through flexible consumption and generation assets.	(Behrangrad, 2015; Boscán and Luis, 2016; Boscán and Poudineh, 2016; Gordijn and Akkermans, 2007; Helms et al., 2016; Matusiak et al., 2015; Schleicher-Tappeser, 2012)
Management and control	Generating value from innovative distributed generation asset management including controlling, operating and governing.	(Bolton and Hannon, 2016; Facchinetti and Sulzer, 2016; Juntunen and Hyysalo, 2015; Kanda et al., 2016; Okkonen and Suhonen, 2010; Van Der Schoor and Scholtens, 2015; Walker and Cass, 2007)

Table 5 Energy business model characteristics

2.3.3 Energy business model framework

We chose a systematic literature review approach to identify the emerging EBMs for energy transition and their characteristics. Consequently, a set of six characteristics were identified: servitization intensity, financing and ownership, the customer's role, decentralization level, flexibility degree, and management and control. To analyse the outlined EBMs more precisely, we employed a well-established business model conceptualisation of an activity system (Amit and Zott, 2001; Zott and Amit, 2010), which consists of three design elements (content, structure and governance) and four design themes or sources of value (novelty, lock-in, complementarities and efficiency) (subsection 2.3.1) (Table 6). Furthermore, it gave us an exhaustive and representative frame. The combination of the addressed EBMs characteristics and the activity system conceptualisation resulted in our analytical framework, which has been used as a tool to cluster the EBMs in distinct patterns in (Figure. 12).

Design elements	Content	Which activities are performed in the energy value chain?
	Structure	How the energy value chain is linked and sequenced?
	Governance	Who should perform the energy activities and where?
Design themes	Novelty	Adopting innovative content, structure or governance
	Lock-in	Building in elements to retain energy business model stakeholders and consumers
	Complementarities	Bundle activities to generate more value
	Efficiency	Reorganise activities to reduce transaction costs

Table 6 Activity system (adapted from Zott and Amit, 2010)

The results are structured in four parts following activity system design themes or sources of value: novelty-oriented EBMs, lock-in oriented EBMs, complementarities-oriented EBMs and efficiency-oriented EBMs. Each part includes the number of patterns, and each pattern is supported by EBMs from the literature review.

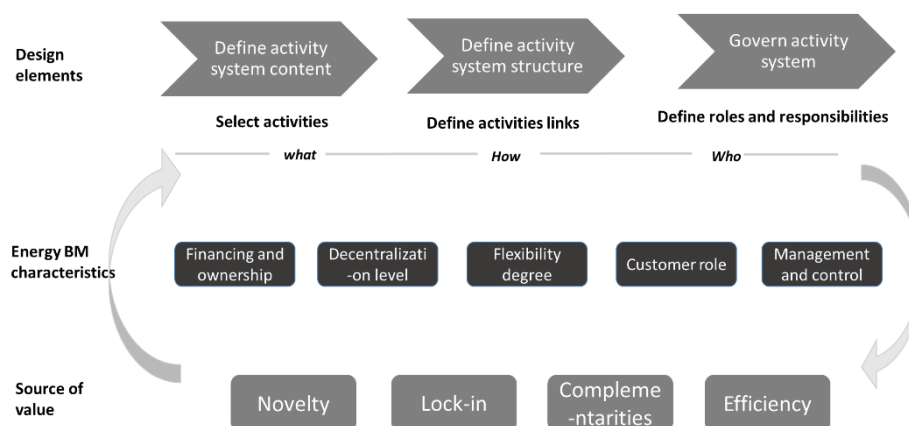


Figure 12. Integration of energy characteristics within activities system framework

2.4 Results and discussion

Based on the literature review and activity system conceptualisation (Zott and Amit, 2010), this section outlines a set of distributed electricity and demand response business models. Each business model has been analysed separately using characteristics defined in subsection 2.3.2. Then, they have been classified according to two parameters. First, the source of value: novelty, lock-in, complementarities and efficiency; and second, regarding how the value is created: content, structure and governance (Amit and Zott, 2001). As a result, the classified EBMs have been clustered forming eight patterns presented in (Figure 13). For simplicity and conceptual clarity, the clustering shows the independency of the patterns, but in some cases, there can be an overlapping between two or more patterns. The following subsections analyse each pattern and the EBMs within each pattern, following the four BM themes.

Business model elements / Business models themes	Content (What activities should be performed?)	Structure (How should be linked and sequenced?)	Governance (Who should perform the activities and where?)
Novelty (Adapting innovative content, structure or governance)	Going green		Building energy community
Lock-in (Building in elements to attract and keep customers)		Offering functionality	
Complementarities (Bundling activities to generate more value)		Optimizing grid operation Cross-selling	Acting locally
Efficiency (Reorganizing activities to reduce transaction costs)		Running platforms Scaling-up	

Figure 13 Energy Business Model patterns

2.4.1 Novelty-oriented energy business models

In this subsection, two patterns are identified that have novelty as sources of value creation. This novelty is manifested in different innovation forms and rooted in one or several activity system design elements. In the content element, the fossil fuel energy is replaced with renewable energy resources: in most of the EBMs identified, PV solar panels. These EBMs have been grouped in a pattern named “Going Green”. The second pattern is the “Building energy communities” and is related to two activity system design elements: in the structure element, new organisations based on the co-participation form are addressed, while in the in the governance element, the addressed EBMs are based on shared resources and governance.

2.4.1.1 Going Green

In this pattern, innovation occurs mainly by replacing the energy fossil fuel with renewable energy resources, and, therefore, the innovation is mainly rooted in the content of the BM rather than in the structure or in the governance. Two energy business models are identified within this pattern: the “utility-side renewable energy” and the “prosumer”.

In the “utility-side renewable energy” model, the fossil fuel resource is replaced with renewable energy, but the organisational structure of the BM remains the same and renewable resources are integrated vertically. The infrastructure consists of small numbers and large-scale plants owned by the utility-side. The new product is green electricity offered as a commodity that is embedded in a centralized network and distributed to the end-user. The energy utilities adopt renewable energy and extend their value proposition by adding on new renewable energy sources to satisfy customers’ demand for renewable energy (Richter, 2013).

The second identified EBM is the “prosumer” EBM, where the customer becomes an active individual consumer. Prosumers have both roles, the producer and the consumer. This EBM has been identified mainly in small PV systems, which are owned and hosted by the customer. The generated electricity is fed in the grid according to regulated feed-in tariff rates or it is self-consumed. The customers are driven by governmental incentives, such as income tax reductions during the first years and the feed-in tariff. The incentives secure income and eliminate the price risks (Strupeit and Palm, 2016; Zhang, 2016). Scholars have different terms for this EBM, such as “Local producer”, “Zero Generation PV” and “customer-owned” (Frantzis et al., 2008; Gordijn and Akkermans, 2007; Huijben and Verbong, 2013). The customer creates the value through small-scale owned distributed generation. The energy utility role is passive and limited to providing interconnection and net metering. In this EBM, the installer firm plays a key role in customer adoption of the PV systems. Usually, installers are local firms, which depend on the network of producers and wholesalers to obtain technical knowledge on these new systems (Karakaya et al., 2016). However, in some regions these local firms are facing challenges, such as diminishing feed-in tariffs for PV, declining adaptation rates and decreasing installation profitability (Karakaya et al., 2016). In this EBM, the customer partly replaces the fossil fuel utility-based electricity with their own renewable energy resource and becomes a prosumer.

2.4.1.2 Building energy communities

This pattern refers to the deployment of energy communities, allowing multiple participants to invest and/or benefit directly from the energy produced by a shared system. Participants benefit by owning or leasing a portion of the system or by purchasing kWhs of

renewable energy. The range of power of the installations within this pattern is from a few kW to a few MW and the installation is administered by a third-party or an energy utility.

In this pattern, the EBMs have a community model that differs from the financial and the governance model. Depending on the EBM, the customer can finance the project as a shareholder or by a loan. Moreover, the customer will have a different decision capacity depending on a share-based community or a cooperative community. Walker and Devine-Wright (Walker and Devine-Wright, 2008) illustrate two dimensions concerning community based EBMs for renewable energy. First it may range from being “open and participatory” to be “closed and institutional” according to who runs, influences and is involved in developing of the community. Second, the outcomes and benefits of distribution differ e.g., locally, nationally, etc. Energy communities have a diversity of meanings that can be transferred to different forms depending on local contexts. These communities can be social enterprises funded by public institutions or initiated by a public-private partnership, an energy utility or a locally owned cooperative.

Equity and distribution of cost and benefits are critical factors in these EBMs. Moreover, the involvement of local people in project development contributes to increasing the project acceptance, facilitating the development of local renewable energy projects and promoting positive beliefs and actions about renewable energy (Walker and Devine-Wright, 2008). The local entrepreneur’s role is essential in employing the social interaction and collectively creating local values (Süsser et al., 2017). A high level of involvement is required, especially in the renewable energy projects where the entrepreneurial venture is linked to many other stakeholders (Cato et al., 2008). Developing these EBMs includes many social and economic benefits. Community shares create local income, maintain local control, and contribute to load stability through load management systems. Moreover, these projects have often a lower capital cost and have faster local authority approval (Wainstein and Bumpus, 2016). In some cases, renewable systems are embedded in communal micro-grids, known as community renewable energy networks, employing a bidirectional flow of information on efficient grid control (Tomc and Vassallo, 2015).

Four EBMs have been identified within this pattern: utility-sponsored communities (USCs), special-purpose communities, energy cooperatives and local white labels. Energy utilities take part in a specific EBM within this pattern, which is the “utility-sponsored community” BM. The USCs are BMs developed by energy utilities that create a community usually associated with a wind or solar project. The utility usually focuses on citizens that will be impacted by the project as well as local entrepreneurs and investors. The main motivation is to increase the public acceptance of the projects and the community members are usually invited to participate as shareholders; nevertheless, without a cooperative status, members of the community have little power in the governance structure, as even grouped their shares represent a small part of the project.

A specific configuration of this EBM is the Utility-Sponsored Community Solar (USCS) BM, which is developed by utilities in the form of community solar with a size range from 2 MW to 20 MW. USCSs target new market segments including multi-family homes and residential rooftops that are not suitable for hosting on-site PV systems. It has been found that USCS is an opportunity for utilities in the U.S., which face shrinking revenue on expenses of residential solar PV (Funkhouser et al., 2015). USCSs maintain an energy utility relationship

with the consumers, satisfy consumers' demand for renewables and diversify utilities' energy resources. USCSs can help energy utilities to retain their customers as no significant changes in the customer's behaviour and practices are required. USCS has a meaningful economic return and customers realize the benefits through a fixed solar rate or a shared investment return. USCS has potential advantages for the utility including economies of scale, reduced line loss, and reduced transmission and distribution cost. Solar programmes improve the utility planning by better integration of solar power (Funkhouser et al., 2015). This BM addresses novelty by grouping customers in communities and allowing them to invest and have shares. Furthermore, the location of assets is closer to the consumption points in comparison with the traditional centralized BM. However, the control and governance of the activities is handled by energy utilities.

The second identified EBM is the Special Purpose Entity (SPE), which is based on investor-owned companies with strong policy incentives. The main motivation of SPEs is to profit from Investment Tax Credits (ITCs) (Coughlin et al., 2011). In this BM, the members have to raise the capital, negotiate contracts with owners and the site host, set up legal and financial processes for sharing benefits and manage the operation of the business (Coughlin et al., 2011; Funkhouser et al., 2015). The renewable electricity is generated by private investors in a community form, and the governance of the BM is under the members themselves. SPEs contribute to social fairness and equity by increasing access to participation mainly in solar energy projects, especially for those who can't install solar PV systems on their rooftop homes due to financial issues, unsuitable roofs, ownership issues or physical conditions, such as shading.

The third EBM identified within this pattern is the energy cooperative model. These cooperatives conduct business activities along the energy value chain including generation, distribution and trading. It has been found that an energy cooperative BM presents a complex phenomenon and combines technological and social change where social factors, such as participation, trust and conflicts management are essential. The motivation of citizens to engage in an energy cooperative is based on the desire to influence the local policy or the ownership model of these companies, which are based on democratic principles rather than voting schemes proportionate to equity shares. Moreover, this membership model can lead to active participation of consumers (Yildiz et al., 2015). In the energy cooperatives, citizens are customers as well as key partners; they take part of the governance and finance part of the capital to generate local and green electricity (Küller et al., 2015). However, the traditional BM elements and structure are unsuitable for representing the energy cooperative BMs (Dilger et al., 2017). Three types of energy cooperative BM based on members' roles have been proposed (Dilger et al., 2017). First, the "investor type", which is a market-oriented EBM, does not serve members' needs directly (the generated electricity feed-in the grid); members are investors, and they are motivated by return on investment. Second, the "hybrid type" consists of members who are both investors and customers and offers members purchases (e.g., electricity), cooperatives regard their members as customers and strive to serve and satisfy their needs beyond the return on investments. Third, the "prosumer type" is a member-centred BM in which members are fully integrated, and the value proposition is exclusively designed to satisfy members' need directly. Moreover, in some cases, cooperatives have their own distribution network Infrastructure.

Lastly, the local white label EBM has been identified within this pattern. This EBM refers to an organisation that does not hold a supply licence and usually works on local scale. It is often based on intermediating and encouraging energy community generations to supply electricity to local people through a partnership with a licensed supplier. The local white label has the potential to link local supplier with a local customer, thus allocating cost of local generation to local customers (Hall and Roelich, 2016). This pattern attracts customers who do not trust big utilities, are looking for renewable energy and prefer consuming local electricity.

These four EBMs can be combined with the active participation of a public entity, habitually a municipality where different kinds of interactions between sustainable entrepreneurs and public authorities exist (Gasbarro et al., 2017). Indeed, given the large-scale, capital intensity and social function of energy projects, the presence of local public authority and the political nature of the system is a prominent issue. The local authority and its political framework may play an important role in managing the financial risk; therefore, trade-offs between risk and political control are greatly influenced by the commitment of political actors to environmental or economic goals (Bolton and Hannon, 2016). Municipalities are usually exempt from taxes, which reduces production cost; the assets are under municipality ownership or may be shared by local electricity company. The municipality secures loans without collateral costs, and the consumer, who is the municipality, controls the heat service and has the power of decision-making (Okkonen and Suhonen, 2010).

These kinds of projects aim to launch renewable energy systems on public buildings or lands and are often initiated and run by environmentally driven volunteers. These EBMs are often used to implement renewable energy systems described as “*a way of implementing renewable energy technologies, emphasising themes of self-sufficiency, local determination, engagement and empowerment*” (Walker, 2008). Public authorities can look for public-private partnerships based for example in the “associative entrepreneurship” concept, which combines entrepreneurship and mutualism dimensions (Cato et al., 2008).

In some special purpose entities, the local authority presented by a municipality initiates a fully licensed supply company working locally and linking generation and consumption in a specific geographical area; tariff fairness and demand side service are the main advantages of this model (Hall and Roelich, 2016). In other cases, a municipal Energy Service Company (ESCO) provides energy efficiency service in return for revenue where the value is maximized when demand reduction is maximized; this BM presents energy efficiency as a service with the engagement of new actors, such as municipalities (Hall and Roelich, 2016). In these last cases, the main benefits are the empowerment of the locality in the decision-making process and the increased citizen participation. The mission of ESCOs may be promoting sustainable development; in this case, ESCOs have strong ties with local authority and are an autonomous organisation, compete with incumbents, are able to take risks on new technologies, and are integrated in the sustainability policy framework of the local authority (Bolton and Hannon, 2016). Gasbarro et al., (Gasbarro et al., 2017) have pointed to the systemic nature of energy transition that involves a broad nature of actors, institutions, material artefacts and knowledge and explored the opportunity related to the interaction of new technologies, public governance and entrepreneurial dynamics. The authors have shown sustainable entrepreneurs can adopt different strategies to engage with public authority. These are according to system level action (meso and micro) and degree of interaction (being part of a policy framework).

2.4.2 Lock-in oriented business models

In this subsection, one pattern is discussed: offering functionality, which includes three different EBMs.

2.4.2.1 Offering functionality

In this pattern, energy service providers offer energy efficiency measures or renewable energy systems through a solution not based on product ownership transfer. The value creation includes services, such as financing, installation and maintenance. Consumers' roles are passive and similar to the conventional role.

Three EBMs have been identified within this pattern: the energy service company the third-party BM and the customer-side renewable. In these EBMs, the financial partners are crucial (Wainstein and Bumpus, 2016), and the combination of products and services is built on alliances between manufacturers, installers, and insurance firms and can lead to great potential to improve sustainability (Överholm, 2017).

Energy service companies provide energy services that reduce energy consumption using more efficient energy systems. These services include financing, controlling and maintaining the equipment. ESCOs, assume most of the financial and technical risk, provide bespoke and holistic energy services and create environmental and social benefits. Moreover, the relationship with customers is close and long-term (Hannon et al., 2013). ESCOs have a unique financial model; however, it is regarded as time consuming because of the investment procedures and the long payback period, and, furthermore, consumers have a weak knowledge of ESCO offerings (Pätäri and Sinkkonen, 2014). ESCOs may take a private company legal form and promote economic growth with local authority partnerships. In this case, ESCOs have long-term contracts with local authorities based on operational autonomy driven by a council's bill reduction and fuel price risk mitigation, which limits customers' risk but also limits the BM to mature and proven markets (Bolton and Hannon, 2016).

The third-party EBM is often linked to the PV technology and therefore is often cited in the literature as the third-party PV BM. The PV systems are installed on the roofs of the customers' houses, and customers pay a fixed price per kWh of the direct use of the PV system for a long period (more or less 20 years) thanks to the power purchase agreement. In other cases, customers are involved in a leasing contract and pay a fixed amount per month for the usage of the PV system (Huijben and Verbong, 2013; Zhang, 2016). The third-parties control and own the PV system, bearing the financial risk and reducing complexity for the consumers. Other stakeholders, such as energy utilities assume the role of a facilitator for PV market diffusion in this case (Frantzis et al., 2008). Customers have an immediate reduction of up to 10-20%, a predictable cost of electricity over 20 years and a lower upfront cost. Moreover, the learning and scale effect enable the firm to lower the transaction cost associated with incentives, grid connection, permits and installations (Strupeit and Palm, 2016). This EBM has been defined as an intermediary PSS model, where consumers locally produce electricity, while providers sell functionality, keep ownership and responsibility and seek PSS components optimization (Överholm, 2017). The core logic beyond the BM innovation stems from strong financial partnerships to get large-scale capital; stimulating demand by aggressive sales and downstream partnerships and vertical integration of the value chain to minimize costs. Important sources of revenue could come from the tax credits that are offered in countries, such as the USA by the federal ITC. However, it requires a large tax liability, which can be obtained from financial

institutions partnerships (Wainstein and Bumpus, 2016). The application of this EBM by energy utilities has been described by Richter, M. (Richter, 2013) as “customer-side renewable energy”. This BM delivers renewable electricity as a service and provides a customized solution that fits with different types of customer requirements. The customer is engaged by hosting the generation system, the infrastructure consists of large numbers of small-scale generations closed to the consumption points and the benefits are shared between customers and energy utilities based on long-term contracts (Richter, 2013). In the servitization of the utility BM, the value is created by intangible assets, such as informational, organisational and human capital. The infrastructure is centred around the customer, the value proposition is heterogeneous and customized, and the revenue model is based on small-scale and expense intensive sales generated from services (Helms, 2016).

2.4.3 Complementarities-oriented energy business models

In this subsection, we discuss how complementary products and services are offered in new business models in order to capture the value from energy system changes. These EBMs have been grouped into three patterns: optimizing grid operations, combining value proposition and acting locally. In the optimizing grid operations pattern, Demand Response (DR) services are combined with the consumption and renewable generation devices in order to optimize the energy system efficiency. In the combining value proposition pattern, renewable energy systems are sold together with products coming from other sectors; these products include prefabricated homes or electric vehicles. The latter can be used as power sources for grid balancing, power sinks for load flexibility and storage devices. Lastly, the acting locally pattern contains different EBMs focusing on matching local generation with local loads.

2.4.3.1 Optimizing grid operations

In this pattern, the sources of value creation are based on complementary services for load and generation management looking to optimize grid operations often related to the distributed renewable energy resources and/or the customer’s consumption configurations. The core feature of this pattern is its association with timing, what is called “timing-based” activities. These activities aim to increase the flexibility of energy supply or demand through ICT infrastructure. It is a “coupled service” that couples timing as a service with supply valuables (e.g., large power plant) or/and with consumer-based valuables (large or small demand) (Helms et al., 2016). In this pattern, three EBMs are presented: demand-response, virtual power plant, and active management of distribution networks.

The demand response EBM looks for mechanisms to change end-users’ usual consumption shapes. This modification is especially interesting when facing high wholesale prices or when system reliability is jeopardized (Albadi and El-Saadany, 2008). Changing the user’s consumption shape can respond to changes in the electricity prices over time. It also refers to induced lower electricity consumption use through incentive payments, at times of peak demand.

Demand response value creation involves activities of identifying, activating, connecting and communicating with consumers. These activities usually focus on large-size small numbers of consumers (e.g., industrials), which entails lower transaction and intervention (consumer disruption) costs than handling small-size large-number consumers. To induce lower electricity consumption in the case of large-size consumers, incentive payments are largely

used, while small-size consumers can be invited to modify their consumption shape by changes in the electricity prices over time or by other techniques.

Even if the demand-response EBM focuses on actors that offer flexibility in energy consumption, the generated value propositions can be for different stakeholders, such as system operators, generation actors, distribution stakeholders, retailers or load stakeholders. The Demand Response Provider (DRP) creates value for the System Operator (SO) by adjusting the demand profile to maintain generation load balance and reduce peak hours. Moreover, energy consumption modification can have an impact on the spot electricity price (Behrangrad, 2015).

The DRP can create value for generation stakeholders by creating a desirable load profile, which increases their operation efficiency. DRP can also offer services to transmission and distribution actors by reducing consumption in congested zones, thus helping to delay or reduce investment in the infrastructure (Poudineh and Jamasb, 2014). Concerning the retailing stakeholders, the DRP uses its competences to modify the consumption shape of a retailer to reduce its procurement costs. Lastly, DRP creates value for load stakeholders by shifting the electricity load when the kWh prices are high (Behrangrad, 2015).

The second BM is the “Virtual Power Plant” (VPP); herein, the provider aggregates a combination of high numbers of small-scale generation units e.g., Combined Heat and Power (CHP) and renewable energy resources in order to generate a sufficient capacity, enabling producers to participate in the energy market and gain fees from their flexibility, often complemented with consumption management (Helms et al., 2016). Prosumers shift part of the demand to lower price periods and sell the generated renewable energy when prices of the electricity market are high or consume when the prices are low. The prosumer has a lower electricity bill and the SO has higher available capacity during peak hours (Gordijn and Akkermans, 2007).

The share of renewable energy resources and distributed generations, which are connected to the grid, is growing. This growth requires from the distribution grid either to be flexible or be extended by reinforcement. While the latter is temporary and not cost-efficient, the former depends on the efficient use of the existing network and creating value from activating user flexibilities of both generators and consumers, in what is called active management of the distribution network. This concept is defined as a system in place to control a combination of distributed resources, in which DSOs have the possibility of managing the electricity flow and generators take some degree of responsibility for system support through a connection agreement (D’Adamo et al., 2009). The DSO is responsible for the distribution network operation. In this EBM, the DSO provides voltage management services to the renewable energy resources, and the generators profit from this service by maximizing their connected capacity and generated electricity (Gordijn and Akkermans, 2007). The aggregator can also provide this service by aggregating and limiting commercial and industrial consumers’ maximum power consumptions during congestion periods. This service maintains the voltage within the DSO network capacity and prevents voltage variation risk (Rahnama et al., 2017).

This EBM includes ancillary service; even if habitually utilities have provided these services to maintain grid stability and security, new companies have emerged with an original EMB that can be classified within the active management of the distribution network.

Lastly, an innovative activity that is currently being developed includes the installation of energy storage systems, which is a key activity to balance the intermittency of renewable energies. Based on these activities, innovative BMs have been developed, which has allowed early stage companies to make a place in the energy value chain (Behrangrad, 2015; Müller and Welpé, 2018).

2.4.3.2 Combining value propositions

In this pattern, the energy products and services that emerge from the energy industry are provided as add-on products/services to the original product and integrated within other products from different sectors. Two EBMs have been identified within this pattern: the vehicle-to-grid or home EBM and the cross-selling of PV systems EBM. These EBMs build original combinations between the mobility sector and the demand response services as well as the construction sector with renewable energy systems.

In the “vehicle-to-home” EBM the aggregation of the electric vehicle is embedded in the management of other loads in the home. In the “vehicle-to-grid ” EBM, a commercial intermediary manages and aggregates the battery loads of a large number of connected vehicles at the same time in order to have a sufficient tradable capacity (Weiller and Neely, 2014). In both cases, a demand response service is combined with retailing electric vehicles.

In the cross-selling of PV systems EBM, a product or service based on renewable energies, such as PV solar panels is sold with prefabricated homes, providing more value than having each product be sold separately (Strupeit and Palm, 2016). The advantage of this combination is that the PVs are 10% cheaper than the market price as the inclusion of the PV systems in the mortgage of the established house selling process lowers the transaction cost of PV (Strupeit and Palm, 2016). Moreover, this solution is often more aesthetic as PV systems are better integrated than add-on solutions.

2.4.3.3 Acting locally

In this pattern, the complementary service of demand response is organised locally in order to create and capture the value of load balancing locally. DR value proposition is related to cheaper power use, matching local generation with local loads and systems benefits to infrastructure providers (Hall and Roelich, 2016). Three EBMs are proposed, first the e-balance EBM, then, the local pool and sleeve EBM and lastly, the Energy hub.

The e-balance EBM aims at locally balancing consumption and production in an intelligent and effective manner in order to enhance the reliability and efficiency of the low/medium voltage energy grid levels; it acts as a platform based on ICT and citizens’ behaviour (Matusiak et al., 2015). The value creation is enabled by automated DR that shifts the load of local consumers to periods when there are inexpensive energy prices, pooling local generation and employing smart metres to net off the local supply at a virtual metre point (Hall and Roelich, 2016). In the U.K, this EBM is enabled by a third-party supplier in which the local suppliers community does not have to obtain a full license (Hall and Roelich, 2016). This matching of demand and local supply has the opportunity to enhance the profitability of the local suppliers (Hall and Roelich, 2016).

Second, in the “local pool and sleeve” EBM, the local aggregator pools a group of local generations and then supplies the energy to a consumer or consumers. In the UK, the “License

Lite” enables this EBM to supply local electricity directly to local consumers without passing through the wholesale market and to avoid national balancing charges (Hall and Roelich, 2016).

Finally, the Energy Hub EBM refers to a local energy system that mediates multi energy carriers (electricity, thermal and chemical energies) that optimize energy management and integrate energy conversion and storage units. It primarily guarantees energy supply and demand match through internal flexibility and energy market participation (Facchinetti and Sulzer, 2016).

2.4.4 Efficiency-oriented energy business models

Two patterns are defined in which efficiency is the major source of value: scaling-up and running platforms. In the former, the business logic lies behind the economies of scale and the implementation of distributed generation at customers’ sites. In the latter, the online platforms that establish a direct link between various energy market parties are discussed, such as the peer-to-peer energy trade, and renewable crowdfunding.

2.4.4.1 Scaling-up

In this pattern, the firms generate economies of scale by aggregating supply, as in the case of the first EBM, the network model of a large company, which is taken from the heat supply sector. In the second EBM, economies of scale are achieved by aggregating demand, as in the collective buying of PV solar panel systems.

In the first BM, a network model of a large company, the provider’s value creation enables a low-cost unit of heat supply due to its several operation units. Economies of scale in the fuel supply (e.g., biofuel, wood chips, etc.) are the core of the value creation. Customers, such as municipalities can lease the required infrastructure, such as the heat plant and the distribution network to the provider, which is also operating the heat production. While the major benefit is the cost efficiency, the supply of foreign fuel might have an impact on the local and regional economics (Okkonen and Suhonen, 2010).

In the “collective buying”, the second EBM, an organisation, provides a service of buying, installing, and maintaining the PV system on the customer sites or it only arranges the installations. In both cases, the subscribers benefit from availability of information, such as selection of suppliers, price bargaining, insurance, etc. (Huijben and Verbong, 2013). The efficiency improvement arises from the lower cost of demand aggregation, complexity mitigation from reducing technological risk and making information available for a large number of subscribers. The value creation is improved by the joint value maximization and strong bargaining condition.

In this pattern, the main tasks are outsourced to a third-party who has the experience, the required knowledge and efficient resources. The service oriented-business model and the aggregation of demand or supply enable decentralized generations to create cost efficient value. As a result, ownership, financing and controlling may be outsourced to a service provider, as in the case of heat generation or perhaps not as in the case of PV collective buying.

2.4.4.2 Running platforms

Digital and advanced technologies are increasingly transforming the electricity value chain, transforming the way electricity firms create, deliver and capture value (Shomali and Pinkse, 2016). In this pattern efficiency gains are generated by making transactions more transparent and fast, simplifying the processes and increasing the availability of information.

The emergence of online platforms in the energy sector is driven by the increased volatility of renewable generation, end-user new role complexity and the introduction of ICT (Weiller and Pollitt, 2014). Herein, three EBMs have been identified that are based on digital interaction for their value propositions: the peer-to-peer EBM, the crowdfunding for renewable energy EBM and the electricity-balancing service platform EBM.

The first EBM, the “peer-to-peer”, consists of a software platform that plays an intermediate role between commercial consumers and the distributed generation where consumers can choose their energy mix and compare the different tariffs (Hall and Roelich, 2016). The direct link between consumers and generation constructs a more efficient way of satisfying demand without passing through the wholesale market.

In the second EBM, the “crowdfunding for renewable energy”, is described as an organisational innovation form used by people who are networked and pooled. The main purpose is to raise funds and finance renewable energy projects collectively and thus to scale up renewable energy projects and transform the energy and the financial regimes (Vasileiadou et al., 2016).

Lastly, the electricity balancing service platform EBM is a matching platform between suppliers who cannot predict their renewable energy generation and consumers who participate in the energy demand side management and are vulnerable to real-time electricity price volatility. It aims at providing demand response service to electricity suppliers and reducing consumers’ bills by optimizing and managing the household electricity (Weiller and Pollitt, 2014).

The running platforms pattern enables new services in which the BM activities are organised for a more efficient, sustainable and lower cost. Such platforms foster the emergence of new markets for energy trading, fundraising and load balancing. In these EBMs, new parties are linked in peer-to-peer relationships. The flexibility of load can be enhanced by high transaction speed and real-time access to data. Consumers and small generation stakeholders have access to the energy market and can participate in demand response platforms. Herein renewable generation and demand response become more dependent on granular and decentralized resources.

2.4.5 Synthesis of the review

In subsection four, 22 different EBMs have been presented clustered in eight patterns. (Table 7) lists these EBMs and summarizes the characteristics for each EBM.

EBM patterns	Energy business model	Servitization intensity	Financing and ownership	Customer's role	Decentralization level	Flexibility degree	Management and control
Going green	Utility-side renewable	Commodity-oriented	Energy Utility	Consumer	Centralized (big scale renewable)	Supply side	Energy Utility
	Prosumer	Commodity-oriented	Customer	Prosumer	Very decentralized (on customer side)	Not considered	Consumer
Building energy community	Utility-sponsored community	Commodity oriented	Energy Utility and customer	Prosumer/ Financial investor	Decentralized	Supply side	Energy Utility
	Special purpose entity	Pooling resources	Investors	Financial investor	Local energy resources	Not considered	Investors
	Energy cooperative	Pooling resources	Members	Prosumer/ Financial investor	Local energy resources	Not considered	Members

	Local white label	Commodity-oriented	Energy Supplier	Local consumer	Local energy resources	Not considered	Energy Supplier
Offering functionality	ESCO	Service-oriented	ESCO	Service user	Very decentralized (on customer side)	Demand side	ESCO
	Third-party ownership	Service-oriented	Solar service provider	Technology host	Very decentralized (on customer side)	Not considered	Service provider
	Customer-side renewable	Service-oriented	Energy Utility	Technology host	Very decentralized (on customer side)	Supply side	Energy Utility
Optimizing grid operation	Demand response	Service-oriented	Not considered	Demand response service provider	Organised nationally	Demand side	Automated and/or consumer
	Virtual power plant	Service-oriented	Not considered	Flexibility trader	Decentralized energy resources	Supply side	Automated and/or producer
	Active management of distribution network	Service-oriented	Not considered	Local producer	Local energy resources	Supply side	Distributed system operator
Combining value proposition	Vehicle to home/ grid	Service-oriented	Not considered	Demand response service provider	Decentralized energy resources and consumption	Demand and supply side	Automated and/or consumer
	Cross-selling PV systems	Commodity-oriented	consumer	Prosumer	Very decentralized (on customer side)	Not considered	Consumer
Acting locally	E-balance	Service-oriented	Not considered	Demand response service provider	Local consumption	Demand and supply side	Automated and/or consumer and producer
	Local Pool and sleeve	Service-oriented	Not considered	Consumer/producer	Local energy resources	Supply side	Automated and/or producer
	Energy Hub	Service-oriented	Not considered	Prosumer	Local energy resources	Demand and supply side	Automated, consumer and/or producer
Scaling-up	Network model of large company	Service-oriented	Customer or service provider	Service user	Local energy resources	Not considered	Producer
	Collective buying	Service-oriented	Not considered	Prosumer	Very decentralized (on customer side)	Not considered	Service provider
Running platforms	Peer-to-peer	Service-oriented	Not considered	Consumer/producer	Decentralized energy resources	Not considered	Service provider
	Crowdfunding for renewable energy	Service-oriented	Not considered	Investor/prosumer	Decentralized energy resources	Not considered	Service provider
	Electricity balancing service platform	Service-oriented	Not considered	Demand response service provider	Decentralized energy resources and consumption	Demand and supply side	Service provider

Table 7 Energy business model characteristics

The patterns of business models are identified and classified following four sources of value creation: novelty, lock-in, complementarities and efficiency. (Table 8) shows the variety of value sources related to EBMs.

The novelty-driven BMs can be explained in two patterns: going green and building an energy community. In the going green, the renewable energy has been adopted by the main market actors, such as incumbents or directly by a small market niche of consumers, so-called pioneers. This adoption does not bring about any other major changes in the organisational structure and is about new technologies. While in the building energy community, the renewable energy is employed in an organisational structure that is new in the energy sector

and where new connections between participants (e.g., members, local authority, etc.) are created. Additionally, those novel connections have been governed using democratic and local decision-making methods (e.g., energy cooperatives). Thus, we extended the building energy community model to novelty in BM governance.

In the building energy community model, the renewable energy resources have been introduced in the decentralized form of communities that are suitable for customers who are not able to install PV on rooftop homes. Herein, in addition to the adoption of renewable technologies, customers are co-participators in the value creation and they may have shares and own portions of the assets. In the case of energy cooperatives, the value proposition is more about creating social and environmental benefits locally, focusing on small-scale and decentralized energy projects and capturing the value through collective ownership and self-governance. The BMs focus on social issues, such as promoting access to products/services and employment.

In the lock-in driven BMs, one pattern is identified: offering functionality. It enables new value proposition, in which renewable energy technologies are proposed as a service by creating a comprehensive solution including a package of services. The value is created through intensive partnerships and alliances and developed around a sustainable concept (Överholm, 2017). Innovation here can be allocated to the organisational level where structural and cultural changes occur in the business practices (Boons and Lüdeke-Freund, 2013). This pattern shows that EBM are redesigned with a complete new value proposition and replace the commodity-oriented electricity of energy utility with a new configuration of product-service system (Reim et al., 2015).

In contrast to transactional offerings and product-centre BMs, providing energy services indicates a long-term and close relationship. The responsibility of the provider for the energy resource necessitates regular maintenance, consumption measures and price information. Furthermore, the service-oriented BM resources are more intangible assets-based and are foremost human resources based and information intensive. In this regard, the lock-in value source is embedded in the BM structure design element.

The complementarity-oriented patterns, namely, optimizing grid operation, combining value propositions, and acting locally, are presented as EBM categories that are based on complementary products/services that support the expansion and growth of renewable energy technologies. The demand response service, if it complements consumption and production activities, can improve the efficiency of both consumption as well as production. Active management of the distribution network can also improve and foster the integration of renewable energy and increase the distribution quality. In a similar vein, renewable energy resources and demand response can be used as complementarities within other sector to be provided with other products/services, such as in the case of demand response in electric vehicles and the case of solar PV systems in prefabricated homes. Even though these patterns apparently seem based on new content, such as ICT technologies, in fact they rely mainly on a network of stakeholders at the energy grid level (e.g., DSO, TSO, aggregator, retailers, consumer and producers, etc.). For that reason, the value creation is greatly based on innovative design elements of structure. The acting locally pattern is embedded in the design elements of governance as it is steered and managed by local actors and the benefits are directed to local actors.

In these patterns, the value flows from the consumers to the energy system and is captured by many stakeholders. The decentralized values, which are created by a high number of participants, are aggregated and employed to better stabilize the electricity grid. The innovation is triggered by technology (Boons and Lüdeke-Freund, 2013), as new technologies (ICT and renewables) are employed in new business models (e.g., demand response). Combining value proposition patterns creates value through the intersection of energy technologies and other sectors. Firms tend to engage with a specific set of BMs, what are called dominant BMs in the industry, but this pattern shows that innovation is fostered through the applications of energy business models within another domain or industry. In the acting locally pattern, the value is locally organised and directed to local actors. Energy has been used as an undifferentiated commodity. In this pattern, locally produced energy has been a key resource to compete in the local market.

In the last pattern, the efficiency-driven BM, two patterns are found: running platforms and scaling-up. In the former, efficiency is achieved from using online platforms in order to have efficient transactions, such as energy trading or fundraising. This integration of the Internet with energy operations, such as billing, trading, monitoring, measuring and managing appliances opens up plenty of opportunities and new ways of value creation (Amit and Zott, 2001). In the latter, efficiency is obtained through economies of scale, where resources, such as fuel or demand for PV panels are aggregated.

Design themes	Design elements	Content (What activities should be performed?)	Structure (How should be linked and sequenced?)	Governance (Who should perform the activities and where?)
Novelty (Adapting innovative content, structure or governance)		Green electricity Selling PV solar panels	Non-rooftop solar customer Fixed prices	Local decision-making Self sufficiency Local job Governing mechanism: trust Low capital cost Local authority approval Social acceptance sustainable development Tariff fairness
Lock-in (Building in elements to attract and keep customers)			Scale effect Learning experience New market segments Sell functionality Bespoke solution Customized solution Secure long-term income	
Complementarities (Bundling activities to generate more value)			Enhance system reliability Enhance system adequacy Market performance benefits Cross-selling Low transaction cost	Local electricity match Local energy multiple-resources
Efficiency (Reorganising activities to reduce transaction costs)			Demand aggregation Supply aggregation Reduced complexity Bargaining cost Large transaction volume Information availability Large network size Access to renewable resources Transaction speed Real-time load management Link new parties Efficient electricity market price	

Table 8 Value sources of Energy Business Models

2.5 Conclusion

The EBM framework that is suggested in this chapter fills an important gap in the literature as it presents the various business models that deal with demand-side management and renewable energy resources. Although many scholars have studied the emerging business models in the energy sector, little attention is paid to providing a framework that shows the similarities and differences across the business models. The proposed framework distinguishes between the business models based on their innovation in the activity system business model conceptualisation (Zott and Amit, 2010). Based on this framework, 22 different EBMs have been presented clustered in eight patterns.

The results show that diffusion and commercialisation of distributed renewable energy and demand-side management services are fostered by innovation in the business model content, structure and governance. Innovative content EBM refers to the replacement of fossil fuel with sustainable energy resources. Innovative structure EBMs are driven by collective initiatives, joint value creation, cross-selling, intermediate platforms and product-service systems. Innovative governance EBMs are driven by economic, environmental and social values and democratic management, transparency, local value creation and the engagement of public actors.

Our main contribution has been to emphasise the different business model logics that have been employed in order to push energy transition forwards and to point out that novel business models are emerging in the energy market driven by environmental and social values, and exploiting renewable energy resources. The motivation beyond this chapter supports the belief that the shift from unsustainable to sustainable energy systems will require a deep understating of how the values are created in each of the defined patterns.

This chapter illustrates that the emerging business models present new values in the power system. In the energy generation side there are the sales of local renewable electricity, solar PV panel lease, and collective renewable energy generation.

On the transmission and distribution side, there are values that aim at optimising the operational cost of the grid by shifting or reducing consumption during peak hours. Herein, the energy entrepreneurs employ different resources and creating new relationships between the market actors, for example, the EVs, VPP, local balancing service between local generation and local consumption, peer-to-peer and balancing internet platform.

Furthermore, new activities in the energy value chain, which have been identified in the literature, can be based on one or several EBMs presented in this chapter. Some of the presented EBMs are more likely to be combined as they offer interesting synergies. This is the case for example of activities where the consumer becomes a prosumer, not only owning renewable energy systems but also being an actor in the demand response systems. This combination offers interesting possibilities for EBMs, such as the virtual power plant.

Lastly, the proposed framework can be used for ideating new business models, which is a task that newcomers to the energy sector are looking for and face. Since newcomers are driven by technologies rather than by business models, the proposed patterns assist managers in innovating by combining several EBMs or patterns, by changing the characteristics of specific EBMs, by removing or adding design themes, or by bringing new configurations into the design elements. Furthermore, our framework can be used as a starting point for analysis and

development of existing EBMs and for reducing complexity and drawing a comparison between different potential alternative EBMs within specific patterns or even between the distinct patterns. Finally, the chapter provides insights on how to design new business models for entrepreneurs who seek to build non-existent business models.

The EBM framework can be used to invent new business models by manipulating and exploring the different possibilities of employing one or more of the proposed characteristics, adopting specific patterns, or by changing the design elements or selecting different design themes.

2.6 Summary of the major contribution of Chapter 2

- The motivation beyond this work is to support the belief that the shift from unsustainable to sustainable energy systems will require a deep understating of how the new values are created using the business model as an analytical device.
- This chapter aims at exploring of the business models that are contributing to the transformation of the energy systems.
- To achieve this goal, a systematic literature review has been done. The scope was limited to renewable energy technologies and demand-side management. The search is done using two databases EBSCO and Scopus, searching for article on the intersection of business models and energy terms (e.g. renewable energy, distributed generation, demand response, etc.).
- A set of attributes that describes the energy business models are identified: servitization intensity, financing and ownership, the customer's role, decentralization level, flexibility degree, and management and control.
- The activity system perspective on business model has been used for mapping the identified energy business models.
- As a result, 22 business models have been identified in the literature. These business models are grouped into eight patterns: going green, building energy community, offering functionality, optimizing grid operation, cross-selling, acting locally, running platform, and scaling-up.
- This chapter shows the similarities and differences between the emerging business models and points out that novel business models are emerging in the energy market driven by different values and employing different business model logics.
- Since newcomers are driven by technologies rather than by business models, the proposed patterns assist managers in innovating by combining two business models, by changing the characteristics of specific business model, by removing or adding design themes (e.g. efficiency, novelty), or by bringing new configurations into the design elements (e.g. new form of governance).

Chapter 3

3. Describing the energy start-up business model innovation process: insights from practical case studies

3.1 Introduction

While existing organisations have a more and less broad goal and a predefined direction, start-ups have several possible directions as they move forward. As a matter of fact, very often start-up business models are built from scratch through novelty in the proposed value, the way the value is created or captured. Examining the start-up business model is of great theoretical and practical importance because this kind of organisations is usually able to create distinctive BMs that are built upon a deep linkage with customers. They often operate in market niches that are undiscovered or untested by incumbent firms (Mahadevan, 2004). Understanding how firms differ is a critical challenge for both theory and practice, thus creating a BM framework that can describe and explain the innovation activities is a prerequisite for expressing and unveiling how firms differ in a competitive sense.

Typically, entrepreneurs can be recognised as pioneers in bringing new technological innovation to the market. However, with the rise of companies, such as Amazon, it has been found that other types of innovation can be created by having a different configuration of business model resources, economic model and offerings (Chesbrough, 2007b). Technology-based start-ups can be understood as a “*new venture where know-how and advanced technological discoveries are capitalised and exploited through new products and services*” (Klofsten, 1994). Recently, it has been found that business model can support sustainable innovations (Boons and Lüdeke-Freund, 2013). Entrepreneurs might come up with new paths and solutions with a design rooted in the local needs rather than based on centralised assumptions by large institutions about what should be done. Start-up business models might combine the social, environmental and economic values to create a business model for sustainability (Belz and Binder, 2017).

Environmental benefits are an essential aspect of energy business models for sustainability, which can contribute to environmental issues and the deterioration of natural resources. Entrepreneurial business models have the potential to slow down natural resources deterioration and even improve the ecosystem by capturing new market opportunities that address ecological values besides economic values (Cohen and Winn, 2007). Sustainability-driven entrepreneurs recognise environmental and social issues as opportunities that need to be captured (Belz and Binder, 2017). One of the challenges that entrepreneurs face is their inability to internalise all innovation elements. Therefore, making linkages with external actors is a core objective in order to obtain the required resources and capabilities (Keskin et al., 2013).

In this chapter, the focus is on the particular field of business models. This chapter analyses a sample of energy start-up business models. In general, start-ups have greater potential to innovate than the existing companies. This is mainly because of their agility and the failure of the incumbent firms to effectively exploit the technological change. Incumbent firms have difficulties in perceiving and enacting new business models once these technological changes occur (Chesbrough and Rosenbloom, 2002). This struggle, to change the business model by incumbent firms, has been addressed by referring to the difficulties that energy companies have in providing energy efficiency services by (Apajalahti et al., 2015) and has been outlined by indicating the challenges of energy utility asset transformation towards a service-provider business model (Helms, 2016). While these large companies seem to be slow movers, by looking at energy start-ups, new business models can be discovered. Överholm (2017) has described the intermediary business model that is created by ventures in the solar service industry. These new ventures provide solar panel systems as part of a service offering

instead of selling the solar system as a product, Okkonen and Suhonen (2010) have presented the growth of small-scale heat energy production business models and have described the business model architectures and their earning logics.

As has been mentioned above, start-ups may be technological-based firms in which know-how and advanced technological discoveries are exploited through new products and services. However, start-ups might not deploy an advanced technology, rather they tend to introduce of fundamentally different business models in an existing industry or market, a phenomenon called Business Model Innovation (BMI) where firms do not discover new products or services, but simply redefine what an existing product or service is and how it is provided to the customer (Markides, 2006) (e.g. Amazon, Dell). The objective of this chapter is to describe energy start-up business models, their types of innovations and their added value in term of sustainability.

Besides the first criterion of having a novel technology or new business model, all the selected start-ups contribute implicitly or explicitly to sustainability by adding ecological values. Themes, such as energy efficiency, renewable energy resources, energy optimisation and grid security, have were used as references during the selection phase. The conducted analysis addresses these ecological values and their impact on the energy system. On the contrary to unsustainable business practices, the studied start-ups strike a balance between optimal product and service performance (e.g. low cost) and improved social and environmental effects (producing renewable energy, cut energy consumption, reduce energy cost, etc.).

Another important criterion is that all the addressed start-ups have gained credibility from the InnoEnergy. They have all passed the InnoEnergy selection process and are accepted in their support program. This is a hugely important criterion because this legitimacy validates the selected cases. InnoEnergy is a co-creator organisation facilitating product sales commercialisation and industrialisation. Though the selected start-ups are all related to the context of energy transition, they work in different fields: renewable energy, energy efficiency, demand response, clean transportation and storage systems. The start-ups are all established in Europe and come from five different countries.

In order to analyse start-up business models, a theoretical framework has been identified, which is based on business model innovation literature. The analysis includes three main dimensions: opportunity exploration, business model seizing and impact. Based on the work of (Schneider and Spieth, 2013) who conducted a systematic literature review on business model innovation from the perspective of firms, two main theories were used, dynamic capabilities and strategic entrepreneurship. On the one hand, dynamic capabilities perspective is the ability of an organisation to purposefully adapt an organisation's resource base and build competences and achieve a competitive edge in a dynamic and changing environment (Teece et al., 1997). On the other hand, strategic entrepreneurship embeds efforts to explore as well as exploit opportunities (Ireland and Webb, 2009).

Identifying of market opportunities has been described as a complex process (Ardichvili et al., 2003), requiring entrepreneurial actions and relying on factors, such as prior knowledge, motivation, feasibility and desirability assessments (Mcmullen and Shepherd, 2006). Consequently, and first of all, the focus was on explaining how these entrepreneurs have recognised market opportunities. Following that, the value creation logic was represented in a simplified structure by dismantling the business model to its most basic elements: value

proposition, market segments, growth model, capabilities and cost-revenue model (Afuah, 2018). The value proposition element highlights the novel values offered by these start-ups and addresses either emerging needs, such as the need to integrate renewable energy resources in the distribution grid, or a market opportunity, such as using an advanced software to build energy management systems. The market segment describes the customers of these start-ups and their needs. Apart from energy consumers, energy system operators and actors, such as energy utilities and grid operators are new customers for these new business models. The growth model outlines some planned strategies to achieve continuous development. Substantially, firms deploy physical, human and organisational resources and a business model is based on specific configuration of these resource (Mezger, 2014). Thus, firms use specific capabilities to exploit these resources and generate revenue.

The result of this chapter is based on empirical data and the investigation of multiple real-life cases from the energy sector. The author carried out semi-structured interviews asking about the business idea, the business model development, the value creation logic, the resources used, sustainable impacts and the economic model. The interviewing approach was useful approach to obtain qualitative information and expand on and clarify closed responses.

Only a small amount of research has described the venture business model in the energy sector (Overholm, 2015; Överholm, 2017) or new entrepreneurship business models (Huijben, 2015; Okkonen and Suhonen, 2010; Wainstein and Bumpus, 2016). Even less is known about the business model innovation of energy start-ups, their value creation logic, capabilities or the added value in term of sustainability. In fact, while policy makers are trying to reform the current energy system towards sustainability and are seeking competitive energy market with new entrants, it seems that pursuing a business idea commercially is a complex process that needs to be described to better understand it. Using the business model of these new start-ups as a unit of analysis, the chapter tends answers the following question:

How do energy start-ups pursue business model innovation?

The rest of this chapter is organised as follows: Section 3.2 outlines the context of research and introduces the entrepreneurs' commercialisation process phases, development from an idea to a business model. It also explains where the identified energy start-ups come from and provides a brief description of each case. Section 3.3 presents the theoretical framework that has been used in the business model analysis. This framework is based on the literature of business model innovation and has three main phases. It begins with *opportunity exploration*, describes the start-up *business model seizing* and finished with *business model impact*. The methods used are outlined in section 3.4, including the research approach applied, the selection of case studies and data analysis. Section 3.5 presents and discusses the result, the development of an energy start-up has been described in a proposition of business model process which consists of three dimensions and a set of elements. The results also describe the types of business models extracted from the empirical data. Section 3.6 is the conclusion section 3.7 summarises the chapter's contribution.

3.2 Context

3.2.1 The entrepreneurial commercialisation process

Entrepreneurs initiate a process in which there are several phases of development from an idea to commercialised product-service. Huang et al (2018) have investigated the process for commercialising and transforming ideas into products or services. Four major focus levels

are identified: knowledge (technology and science), product (product and service), resources, and organisation and strategy (business model management) (Figure 14). In the knowledge level, firms focus on obtaining the scientific knowledge necessary to commercialise the product; the product phase is about developing the product; the resources level focus is on allocating the internal resources and finding the required external resources while in the strategy level, strategic plans are put for further growth. Along this process, several milestones are marked: research, scope, customisation, product, business model formation and launch. Key resources in each stage are required and are accumulated in order to push the process to the next stage. Such resources are academic knowledge, industrial knowledge, customer perception, recognition, market information and suppliers (Huang et al., 2018).

The academic research has been divided into six areas of research cover the whole process of product commercialisation (Huang et al., 2018). The first area is the technology readiness level in which the objective is to develop mature technology. The firm focuses on the knowledge and product level and improves its knowledge through technology's tests.

New product development is the second area that follows technology readiness in which the firm's focus is still on knowledge and product level. However, herein the scope is defined, and a prototype is made, tested and modified in an iteration process until the final product is made.

The third area is the open innovation and is an area of building trust and sharing resources between different players in the ecosystem. This process overlaps with product development area as it starts from the technology stage and ends at the application stage. The main goal is to get the required resources to complete product development.

Supply chain area is about engaging suppliers in the new product development process during prototyping. It aims at optimising the integration of the required materials; thus, it overlaps with open innovation as suppliers are key resources for new product development.

Innovation ecosystem is the area where the focus shifts to the strategic level and in which the developer should co-evolve with suppliers and complementors to successfully launch the product.

Finally, in the business model area, a firm formulates its strategy in order to sell the developed product/service. There is a clear overlapping with innovation ecosystem and supply chain as the relationships with supplier, partners and competitors should be defined.

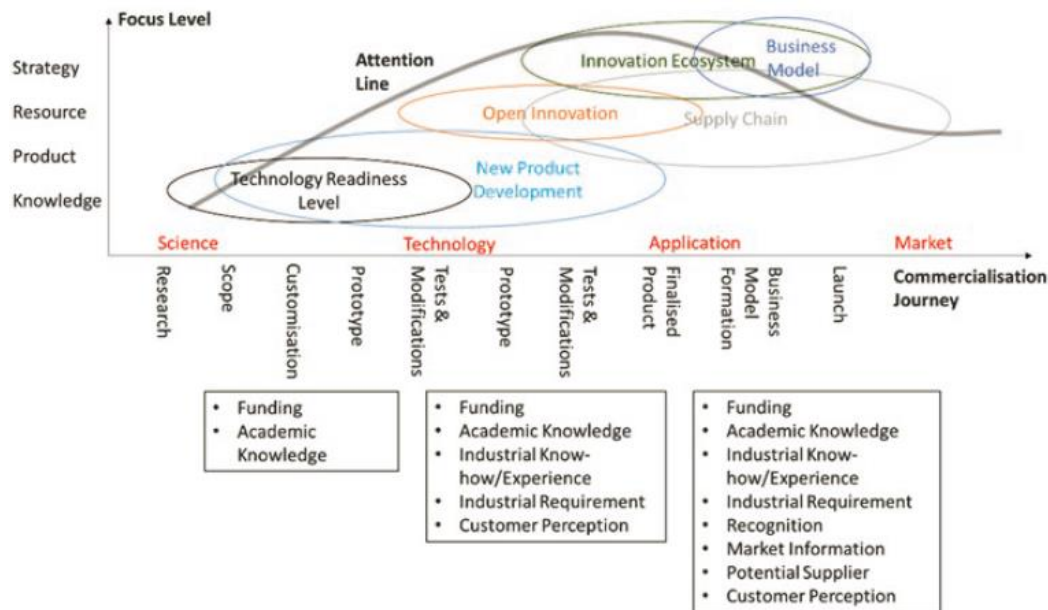


Figure 14 Commercialisation process framework source: (Huang et al., 2018)

3.2.2 Energy Entrepreneurship in Europe

In order to catch up with the last BMI practices in the energy sector, the author got involved in the InnoEnergy network through their Ph.D. school program. The main mission of InnoEnergy is to connect people from across the continent to create new, commercially attractive technologies, bringing together knowledge and experience, wherever in Europe it is located. Their vision is to encourage cooperation between industry, academia and research – as well as innovators and entrepreneurs. In their scope, they have working areas related to energy storage, smart grid, renewable energy, energy from chemical fuel, clean coal and gas technology, energy efficiency, smart electric grid and nuclear power.

During the last two years of the Ph.D., the author has followed several courses within InnoEnergy. Some courses were about particular real-life energy problem, such as the case of the ski resort in the Alps “Station de Chamrousse”. This resort lacks the sufficient power capacity from the grid as the electrical grid has not been reinforced recently; thus, the resort lacks power during the peak of energy consumption. Another course was about energy economics and market design, and an impressive course was about energy entrepreneurship. Moreover, InnoEnergy gave the author the possibility to exchange with the start-ups that have been accepted in the InnoEnergy entrepreneurship program.

The major activity was conducting interviews about the BMIs. The author has selected 40 start-ups in the following domains: renewable energy, demand-side management, and ecological transportation. After the first feedbacks of the selected start-ups and taking into account their availability, 15 start-ups were chosen to be interviewed.

In the following subsection, the author introduces a brief description of each interviewed start-up.

3.2.3 Cases description

3.2.3.1 Enie.nl

Enie.nl started in 2013 as a solar panel supplier offering solar PV panels for sale in the Netherlands. In 2017 the start-up added another BM and started to rent solar panels and proposes the PV panel as a service, adding complementary services, such as initial investment support, maintenance and insurance have been delivered. The customer pays just a monthly fee based on the energy that is produced. So, if there is no energy production, the customer does not pay anything as they only pay for the amount that is really produced and the price they pay is always a little bit lower than utility electricity prices.

3.2.3.2 EP Tender

EP Tender, initially, offers a range extending service for Electric Vehicles (EV) using trailers that can be attached to EVs. This start-up was found in 2012 in France. Besides its primary service, the BM includes many other applications linked to the trailers: It can be used as a virtual power plant, a mobile charger, as rescue recovery service for a car that runs out of juice. It can be used as a zero-emission genset in places where there is no power or where there is a big event.

3.2.3.3 Eneida

The Portuguese start-up, Eneida, was found in 2012, before that it was a R&D department in its mother company, specialised in the development of industrial smart sensors and wireless network. The start-up offers a service of optimising the operation condition of the Low Voltage (LV) network. Their customers, the DSOs, benefit of speeding up the entry of EVs, renewables and at the same time increase the quality of the service, energy efficiency and assets productivity.

3.2.3.4 Energy Pool

Energy Pool is the first independent aggregator in France and was set up in 2009. The start-up offers two interrelated and interdependent value propositions for two distinct customers. First, it offers demand response service for energy system actors, such as TSOs, DSOs and Energy Utilities. Second, it monetises the load flexibility of large industrial plants (e.g. steel plant).

3.2.3.5 Stimergy

Stimergy was born in 2013 in France. Stimergy reformulates the datacentre as a distributed collection of computing units interconnected by optical networks. Each unit, named "digital boiler", consists of several high-performance servers that deliver hot water. Each digital boiler on average enables to cover 60% of the hot water energy needs of a residential building.

3.2.3.6 Nnergix

Nnergix was found in 2013 in Spain, and it offers power and weather forecasting service applied to the electricity market and especially for the renewable energy generation. It provides its customers with upcoming electricity production for the next hours and days so that they can take decisions based on that forecasting in the short-term. Electricity traders who make delay transaction in electricity markets use this information to trade and take the best strategies for their cost optimisation.

3.2.3.7 Steadysun

The French start-up, Steadysun, which was set up in 2013, offers similarly to Nnergix a forecasting service for the production of solar power plants, for horizons time ranging from a few minutes to several days. However, the start-up's technology is a combination of physical modelling and mathematical modelling.

3.2.3.8 Cloud Energy Optimizer

Cloud Energy Optimizer is an IT service provider that delivers a building management system with additional information. The proposed solution can better control the climate management system. It was found in 2016 in the Netherlands. The developed self-learning software reacts 24 hours ahead and uses the heat capacity of the building to be as pleasant and energy-efficient as possible. By efficiently dealing with the available energy sources and continuously considering the weather conditions, the variation in the supply of solar and wind energy as well as energy prices, the system reduces the consumption of natural gas as much as possible. Cloud Energy Optimizer can achieve significant savings on the energy bill without sacrificing comfort.

3.2.3.9 Coturnix

Coturnix was set up in 2016. It has developed a software-based solution that offers predictions about building energy behaviours. The solution is embedded in buildings management systems. Through future energy need predictions, the French start-up is able to reduce and optimise building energy consumption.

3.2.3.10 Beeyon

Beeyon, which was born in 2017 in Ireland, has developed a technology that enables datacentre's managers to monitor and manage the datacentres in terms of business key performance indicators and metrics in addition to the conventional metrics, such as kilowatt-hours per rack per server. The customer can identify energy-saving actions that allow all stakeholders in an organisation to analyse what is happening in the datacentre.

3.2.3.11 Solable

Driven by an ambition to change people unsustainable consumption practices and global environmental issues, Solable, which was found in 2014 in France, offers a shower water heater device that reduces the hot water expense by 90% and the residential power invoice by 40%.

3.2.3.12 EPC Solair

EPC Solair was found in 2010 and offered a mounting system designed for PV panel on flat roofs. The French start-up's solution is designed for commercial and industrial roofs that can carry a little weight and are exposed to sealing problems when the roof is drilled to install classical mounting systems.

3.2.3.13 Helioslite

Founded in 2013 in France, Helioslite designs and sells tracking devices for photovoltaic solutions. Customers have benefits of getting more energy out of the solar PV panel, thus reducing the energy cost.

3.2.3.14 Gulplug

Gulplug found in 2016, emerges from a big corporation in electric equipment (Schneider Electric). The French company, with its first innovation "Save it yourself", offers to industrial customers, a box with sensors, connected to a monitoring platform which is able to significantly

reduce the machine consumption without any impact on the production lines operations. With the second innovation “Selfplug”, the start-up has designed magnetic electrical plugs that can be used to charge the EVs or industrial robots automatically.

3.2.3.15 Sylfen

Sylfen is a French start-up, launched in 2015, currently doing a pilot project to test its storage technology. Through its hydrogen-based battery and the energy hub concept, customers would benefit from a significant reduction in the consumed energy bill. However, the start-up still encounters two significant challenges. This value creation requires not only that the electricity produced from renewable to be cheaper than the one from grids, but also the energy storage unit combined with renewables to be cheaper than the energy consumed by the grid.

After the introduction of the main cases, the next section will draw on the academic literature on business model innovation in order to constitute a theoretical framework. In this chapter, this framework will be used as an analytical framework.

3.3 Theoretical framework

In order to develop an appropriate business model framework for energy transition, the author draws on the BMI framework developed by (Schneider and Spieth, 2013) that is evolved from a literature review on BMI and limited to individual firm’s perspective.

3.3.1 The BMI framework

The Schneider and Speith (2013)’s framework is based on three broad theoretical perspectives: resource-based view, dynamic capabilities and strategic entrepreneurship (see Figure 15). Resource-based View (RBV) emphasises internal firm resources used to achieve sustained competitive advantages. According to RBV, firms can be considered heterogeneous because they have heterogeneous resources (Barney, 1991). Secondly, the dynamic capabilities

perspective highlights the firm's ability to integrate, build and reconfigure both internal and external competencies to sustain its competitive advantage in a volatile changing environment (Teece et al., 1997). Lastly, strategic entrepreneurship addresses the firm’s ability to identify new market opportunities and to exploit them (Ireland et al., 2003).

To sum up, the RBV theory poses the question of how to employ the firm's existing resources while the dynamic capabilities are questioning of how to develop the firm's existing resources and finally strategic entrepreneurship addresses the question of how to explore and exploit opportunities.

The adopted framework distinguishes between two different conceptualisations: business model development and business model innovation. The first one is rooted in resource-based view and dynamic capabilities theories and represents the firm's response to the changing environment by making minor and continuous changes to innovate the BM, herein the dynamic nature of the business model should be maintained to deliver competitive advantages. The second conceptualisation is based on strategic entrepreneurship. According to the authors, firms need to explore the potential opportunity in its environment and turn uncertainty to potential sources of opportunity even if the current BM is working and well-established.

In this chapter, the focus has been directed to both dynamic capabilities and strategic entrepreneurship because of their appropriateness to new venture creation and the selected case studies. On the one hand, the dynamic capabilities theory emphasises the purposefully adaption

of an organisation's resources and competencies; thus, the innovation that is willing to be a driver for sustainable energy transition can be analysed by investigating the reconfiguration of the new venture resources and competencies. On the other hand, strategic entrepreneurship theory stresses on opportunity exploration and exploitation. Herein, studying opportunity exploitation in the energy sector can dramatically transform some traditional businesses into more sustainable and ecological businesses. By capturing the opportunities derived from technological, social and economic changes, entrepreneurs can renew the energy system by integrating these changes into their business models.

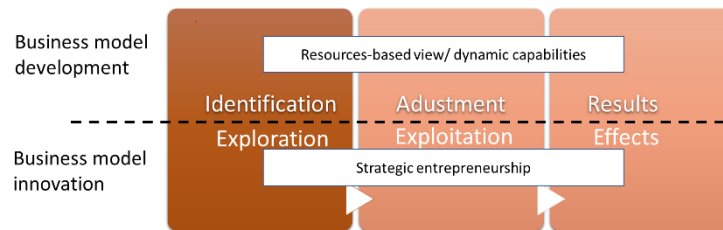


Figure 15 business model innovation integrated framework, source (Schneider and Spieth, 2013)

By adapting to the energy sector, the abovementioned business model innovation framework (Figure 15), the author will introduce in the following subsections the employed framework to analyse the energy start-up business models.

3.3.1.1 Dynamic capabilities

BM can be explained by internal variables, such as resources and capabilities and more precisely through organisational and managerial capabilities. Firms and especially start-ups can launch and develop their business models with slight entrepreneurial and managerial skills. This prerequisite demand can be described through dynamic capabilities framework which can be disaggregated into three functions: (1) sensing opportunity and threats, (2) seizing opportunities, and (3) managing threats and transformation (Teece, 2007) see (Table 9).

Dynamic capabilities	Description
Sensing opportunities and threats	Conducting research activities, assessing customer need expressed and latent, understanding technological possibilities, structural evolution of industries and market, suppliers and competitor's response.
Seizing assets	Selecting product and technology architecture, selecting target customer, revenue model, selecting partners, capturing co-specialization, effective communication and recognising non-economic factors.
Managing threats/transformation	Managing co-specialization and knowledge management, incentive alignment

Table 9 Dynamic capabilities framework, source (Teece, 2007)

The dynamic capabilities theory defines BM as a configuration based on distinct resources and competencies that are able to change the BM (Mezger, 2014). However, managerial skills to allocate resource efficiently are different from entrepreneurial skills which are more associated with identifying and exploiting a new business opportunity. Recently dynamic capabilities business model framework has employed in investigating the organisational and managerial capabilities for business model innovation for sustainability

(Inigo et al., 2017). Mezger (2014) has proposed a capability-based BMI conceptualisation framework that consists of three dimensions: sensing, seizing and reconfiguring see (Figure 16).

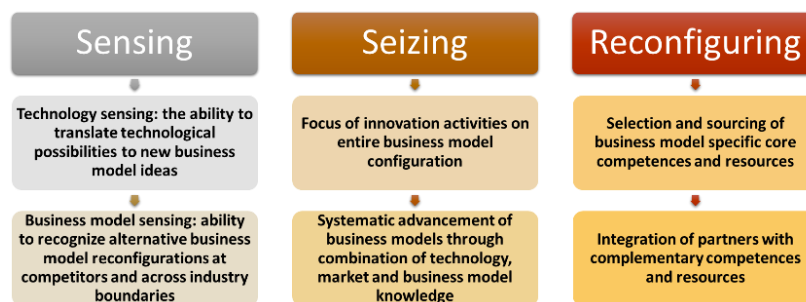


Figure 16 Capability-based conceptualisation of business model innovation, source: (Mezger, 2014)

3.3.1.2 Strategic entrepreneurship

Strategic entrepreneurship is still an emerging research field, and its first academic work is cited in (Hitt et al., 2001) in the *strategic management journal*. Strategic entrepreneurship focuses on the intersection between the individual upstart-focused entrepreneurship and strategic management, with an attempt to link opportunity-seeking with advantage seeking (Foss and Lyngsie, 2011).

Strategic entrepreneurship is defined as “*integration of entrepreneurial (e.g., opportunity seeking behaviour) and strategic (e.g., advantage-seeking) perspectives in developing and taking actions designed to create wealth*” (Hitt et al., 2001). The integration of strategic and entrepreneurship can be identified in six domains including external networks, resources and organisational learning, innovation and internationalisation (Hitt et al., 2001).

External network refers to actors, such as suppliers, customers and competitors among others. Networks can be the sources of information, resources and credibility (Hitt et al., 2001). By networking, start-ups can discover and create new alliances in their network that can provide them with a proper distribution networks and marketing capabilities. Intangible resources can be more important than tangible resources as it is difficult to imitate them. Reputation can be an important intangible strategic resource that gives access to resources (e.g. financial capital), making advantages of information asymmetries and provides customers with selection criteria. Start-ups lack this positive reputation because of their novel products. However, they can gain legitimacy by establishing an alliance with well-established firm and using narratives as a widely accepted market place activity. Knowledge is another intangible resource embedded in the human capital that helps organisation to change and it can be generated by learning. The entrepreneurial strategy is associated with the creation of new products and services and commercialise them. This can be realised through the creation of integrative capabilities and shared knowledge among the other firm’s resources, avoiding learning traps and using knowledge acquired from partners to enhance the technological distinctiveness (Hitt et al., 2001). An entrepreneurial mindset is required to a successful implementation of strategic entrepreneurship and is associated with knowledge and the ability to rapidly sense, act and mobilise, even under uncertainty conditions (Ireland et al., 2003). Entrepreneurial mindset. The shared values and beliefs that shape the firms' structure constitute the organisational culture and the effective entrepreneurial culture facilitates the firm’s effort to manage resources effectively

and balancing between opportunity-seeking and advantage-seeking behaviour (Ireland et al., 2003).

The successful use of strategic entrepreneurship embeds efforts to explore as well as exploit opportunities. Exploration activities refer to creativity, experimentation and new knowledge and it is associated with long-term outcomes. In contrast to exploration activities, exploitation activities are focusing and efficiency-based and are associated with competitive advantages enhancement. Herein the uncertainty is small (Ireland and Webb, 2009).

Thereby, it is essential and practically suitable to integrate strategic management in the venture business model where start-ups are exposed to uncertainty and seek for a new source of value creation (Zott and Amit, 2010).

3.3.2 Opportunity exploration

In this subsection, the aspect of opportunity exploration will be discussed. Starting with opportunity as an entrepreneurial state of mindset and its correlation with uncertainty. Then exploration entrepreneurial opportunity types and finally focusing on some environmental opportunities drivers by illustrating the current market imperfections.

3.3.2.1 Entrepreneurial Opportunity

Every new venture starts with a new idea. However, ideas and opportunities are distinct. Every opportunity has an initial idea, ideas are necessary but not sufficient condition for opportunity emergence. Sufficient conditions are related to an aggregation of evidence of economically viable model, market potential and the ability to sustain growth and competitive advantages (Dimov, 2007). Opportunity can be seen as the progress along a continuum ranging from initial insight to an entirely shaped idea reading, initiating and operating a business (Dimov, 2007). Dimov (2007) studied the entrepreneurial opportunity and their gradual development. The study emphasises that entrepreneurial opportunity is related to a series of insights rather than to single insight. The series of insights reinforcing, modifying or contradicting each other act as one entity to resolve the uncertainty issue. The study also shows that social influences continuously affect the entrepreneurial opportunity by directing attention, providing new information and interpretations, reinforcing beliefs etc.

Any venture is created upon an entrepreneur's actions, and the entrepreneur acts on the possibility of pursuing an identified opportunity. These actions are inherently uncertain because they are made to deal with future issues, such as potential opportunity or threat. The degree of uncertainty can be reduced by the novelty of the value proposition (e.g. new product, process, or business model).

Uncertainty takes the form of doubt which prevents actions as it undermines the entrepreneur's beliefs regarding the importance of the perceived opportunity, the capability of being feasible and its usefulness to fulfil some need (Mcmullen and Shepherd, 2006). By adding a new construct to the perceived uncertainty, such as knowledge and motivation, the entrepreneur's understanding of the preventing role of uncertainty can be adjusted (Mcmullen and Shepherd, 2006).

Based on organisational literature, (Milliken, 1987) proposed three distinct types of uncertainty (state, effect and response). In the state uncertainty, the administrators perceive the environment as unpredictable which can be expressed by the question of "What is happening out there". On the contrary, effect uncertainty is the inability to predict what the nature of the

impact of the future environmental changes will be to the organisation and can be embedded in the question of "How will it impact me?". Finally, response impact is the inability to predict the consequence of the response choice and can be simplified by posing the question of "What am I going to do about it?" (Mcmullen and Shepherd, 2006).

Entrepreneurial actions can be seen as the outcome of less perceived uncertainty. Conversely, the unperceived opportunity can be explained by the subjectivity of value, imperfect knowledge, asymmetric beliefs and differences in entrepreneurial alertness (Mcmullen and Shepherd, 2006). Thus, entrepreneurs who act, tend to see the objective reality of the market opportunity and see a more accurate picture than others. Entrepreneurs act because they "know" what to do. Furthermore, entrepreneurs tend to escape the ignorance and paralysis produced by uncertainty (Mcmullen and Shepherd, 2006).

Entrepreneurial actions are conceptualised in two stages namely: "*Attention stage*" and "*Evaluation stage*". The conceptualisation tackles the entrepreneur's belief regarding recognising an environmental stimulus as a market opportunity, the feasibility of the opportunity to be enacted and fulfilment of some personal desire from the successful exploitation. In each stage, knowledge and motivation are considered. Knowledge is related to the amount of uncertainty and motivation is related to the willingness to bear uncertainty. Intrinsic motivation is related to desire for independence, innovation, personal achievement and it is a significant factor in the entrepreneurship process (Dimov, 2007). An entrepreneur who acts in the attention stage has a certain degree of domain-specific knowledge "Prior knowledge" that enables him/her to acknowledge third-person opportunity. In contrast, people who do not know enough about the technological changes, tend to ignore environmental changes. Besides knowledge, motivation is the second factor that is required to recognise the environmental changes (e.g. technological changes) as an opportunity for someone. Motivation, in this context, refers to the personal strategy for assessing whether the entrepreneur's opportunity represents an opportunity for someone else?" (Mcmullen and Shepherd, 2006). Once an entrepreneur admits that a third-party opportunity exists, he/she would pass to the second stage.

In the second stage, the question is what to do and why to do it. Regardless of the constructed knowledge and motivation, there is still doubt whether it is feasible (can be achieved) and desirable (capability of fulfilling the motivation). Hence, the entrepreneur's recognition of third person opportunity does not mean he/she has the knowledge and motivation necessary to exploit it ?" (Mcmullen and Shepherd, 2006).

Besides knowledge and motivation, the social network is an essential factor, and the denser the entrepreneur's network is, the higher his/her attention or alertness will be to the potential of the opportunity success (Ardichvili et al., 2003). In addition, the personality traits and creativity of the entrepreneurs are essential in the opportunity development process.

3.3.2.2 Opportunity type

Opportunity recognition includes three distinct processes (Ardichvili et al., 2003). Firstly, sensing or perceiving either a market need or an underused resource. Secondly, recognising or discovering a fit between the market need and specified resources. And thirdly, the creation of a new fit between needs and resources in a new form of business concept. Hence, the market opportunity can be defined by having value to fulfil "Value sought" and the capabilities and the resources (value creation capability) to do that (e.g. intellectual, human,

financial etc.). Therefore, the types of opportunities that can emerge are shown in a matrix of four opportunity types (Figure 17).

		VALUE SOUGHT	
		Unidentified	Identified
VALUE CREATION CAPABILITY	Undefined	"Dreams" I	Problem solving II
	Defined	Technology Transfer III	Business Formation IV

Figure 17 Opportunity type, source (Ardichvili et al., 2003)

The "Dreams" opportunity type is an opportunity where both the problem and the solutions are unknown. It is associated with artists, designer and inventors who push a knowledge or a technology into its limit or in a new direction. In the "Problem solving" area, the market need is identified, but capabilities are undefined. It is related to information search as well as to research and development, and it aims at finding solutions to an addressed market need. The "Technology transfer" has defined capabilities but unidentified market needs, such opportunity type emphasises finding application for the discovered technology. Finally, in "Business formation" both the capabilities and the market needs are identified, and it involves matching the capability and market need in an appropriate business model that can create, deliver and capture value.

3.3.2.3 Opportunity and business model

Identification of opportunity for new business model is fundamental. The evolution of new technologies leads to opportunities for new business models. However, new business model do not necessarily require new technologies (Markides, 2006). BMI questions the existing assumption regarding the current market as well as industry business practices (Jolin, 2016) and search for novelty (Bucherer et al., 2012). Firms can identify new opportunities if they are able to capture the know-how of the emerging technology and technological changes and associate them to BM components. Another aspect that can support managers in opportunity recognition is the analysis of the competitors or the other industries BMs (Mezger, 2014). The assessment and evaluation of other business models can generate new business model ideas.

Sensing threats and opportunities refer to the capability of the managers to recognise megatrends in their working environments including technological changes, market evolution and customer needs. However, most emerging trends are hard to be recognised and seen, as sensing new opportunity involves scanning, creation, learning and interpretive activities. Detecting new opportunity can be facilitated by two factors, firstly having different access to existing information and secondly getting new information and new knowledge. Herein, managers accumulate and filter information from the business ecosystem, then would transform the created conjectures into hypotheses that can be updated as more clear evidences emerge (Teece, 2007).

Sensing or creating new opportunity is rooted in the cognitive and creative mindset as well as it is grounded in the organisational processes. While the former is associated with the process of scanning, monitoring, assessing and interpreting external and internal technological

developments, the latter is related to the capability of the manager to raise arguments and discussion, making sense of the obtained information and synthesis and information updates (Teece, 2007).

Inigo et al. (2017) have identified the key process in the sensing phase in which firms have developed radical BMI for sustainability: (I) open dialogues with disruptive environmental and social stakeholders (II) focusing on socio-technical systems, sustainability challenges and collective solutions and (III) search for new technology to transform the markets for sustainable development.

3.3.2.4 Opportunity and sustainable entrepreneurs

In this subsection, the author discusses the origin of the entrepreneurial opportunity for sustainability and their contribution to slow environmental degradation. Incorporating environmental aspects in the firms activity has been addressed in a range of environmental requirements and environmental initiatives (Zhang and Zwolinski, 2017). However, in opportunity exploration phase, four market imperfections that contribute to environmental degradation have been identified. These imperfections can be used as a source of entrepreneurial opportunities by addressing environmental and social challenges (Cohen and Winn, 2007).

Inefficient firms: from an economic point of view, efficiency aims at reducing economic waste, and it does not explicitly take into consideration the efficiency gains in using natural capital. Others, such as eco-efficiency refer to minimising of both economic and environmental waste simultaneously in order to reduce the natural resource usage, minimise the associated cost and increase the profit.

Externalities: externalities exist when costs or benefits are not accurately reflected in the product and service prices due to industrial or commercial activities effects on other parties. Externalities might be positive and negative. For example, when a homeowner remodels his/her house and concurrently improves the surrounding landscape, herein the positive externalities are the benefits that the neighbour would get from the visual improvement. On the contrary, negative externalities could be the pollution's impact on the surrounding crops released by a nearby factory.

Flawed pricing mechanisms: because the conventional economics theories are based on the assumption that natural resources are infinitely plentiful, the free markets failed to account for the true value of the exhaustible natural resource, consequently many natural resources are underpriced and undervalued. An entrepreneur might anticipate a more accurate market price that generates an opportunity in which the demand curve for the new technology become competitive with existing technologies.

Imperfectly distributed information refers to a situation in which information is not equally distributed between parties. Asymmetric information occurs when one party in a transaction has superior information compared with another. For example, in the energy sector, imperfect information is that when people have no idea regarding their energy consumption, the price variation during the day or the different cost benefits of the alternative energy resources.

3.3.3 Business model seizing

According to the dynamic capabilities theory, business model innovation has three dimensions; sensing, seizing and reconfiguring. Business model seizing is a phase that follows opportunity sensing and exploration. This includes transferring the idea into a viable and valuable BM. Herein, a new value proposition is proposed which involves changing several components of the BM, such as new marketing concept and a new combination of product-service (Mezger, 2014). In this phase, firms also define their unique ways of value creation. Herein innovation might be a result of a novel configuration of resources, activities and capabilities (Fjeldstad and Snow, 2018). Accordingly, business model seizing can be explained in two main contributions. First, the identification of business model components and second by the value configuration.

Firms might innovate through modularisation of content (e.g. offering pages rather than a book), customisation of content (e.g. online learning platform), using meta-information (related advertisement to the core topic), reproduction and distribution of content in different channels and on different devices (websites, applications, etc.). Besides the business model knowledge, understanding customer preference is essential (Mezger, 2014).

There is a limited understanding of the organisational design in comparison with the technology design; therefore, design a proper BM might embed considerable mistakes. Seizing opportunity addresses the capability of developing new product, service or process. It also improves technological competencies and complementary assets by selecting an appropriate BM (Teece, 2007). Setting the enterprise boundaries includes the innovation protection, nature of complementary resources and industry development phase. Firms also require to integrate the upstream, downstream and external capabilities (Teece, 2007). Seizing and the development of new BMs have been associated with new start-ups rather than incumbents. Incumbent firms rely on already established routines, assets and strategies that serve existing technologies; thus they face many difficulties in coming up with radical innovation (Teece, 2007).

Inigo et al. (2017) have presented three processes in the seizing phase of the radical BMI developments for environmental sustainability. First, the adoption of system-based transformation approach in which the involved actors are aware of the sustainability challenge. Second, paying attention to the intersection of sustainability and customer goals in which active customer role is a key dimension in the development of sustainable BM. Third, the implementation of inter-partner learning and co-creation.

The next subsections, the author illustrates the development of the two main aspects of business model seizing. First, the identification of business model components and second analysing the value configuration.

3.3.3.1 Business model component

An important theoretical perspective approach is the business model as interrelated components of a system that constitutes the firms' backbone. This perspective provides a shared understanding of the business model concept by identifying and distinguishing between the different BM's elements or components. Chesbrough and Rosenbloom (2002) are one of the first scholars who studied BMs, through their paper about Xerox's technology, they emphasised the BM role in creating value from early-stage technology venture. Accordingly, BM is used to commercialise novel technology, intermediates the technical and the economic domain and consists of six functions: value proposition, market segment, value chain, cost structure/ profit

potential, value network and competitive strategy. One of the most prevalent business model framework that defines business model components is the business model canvas (Osterwalder, 2004). This framework is based on ontology perspective and consists of four components: value proposition, customer interface, infrastructure management and financial aspects. These components are dismantled into nine distinct blocks: value proposition, key activities, key resources, key partnerships, customer relationship, market channels, customer segment, revenue stream and cost structure.

According to (Johnson et al., 2008) the value proposition is a key component and it explains the “job to be done” for the customer and precision is one of the success attributes of it. Furthermore, precise customer value proposition contributes to overcoming some customer barriers, such as wealth, access, time and skills. Johnson et al. (2008) have proposed an additional three components which are key resources, processes and profit formula.

From entrepreneurship point of view, Morris et al (2005) have constituted a BM conceptual framework for a new venture. Accordingly, new venture BM differs from other corporation’s BMs in that it emphasises entrepreneur’s ambitious aspirations, which is the relationship between the firm and entrepreneur’s career and life and its influence on the enterprise objectives. While previous work has only focused on the value proposition, the customer, internal processes and competencies, this framework adds "competitive strategy" component in order to translate and reflect the core components into a sustainable marketplace position. Furthermore, a sixth component which tackles venture scope, growth and entrepreneur’s ambition is also considered.

According to (Afuah, 2018) the organisation’s business model is “set of activities for building and using resources to generate, deliver and monetize benefits to customers” and the Business model structure is a framework that consists of five components which are the value proposition, market segment, growth model, revenue-cost model and capabilities. (Table 10) shows some of business model components identified in the literature.

Author(s), year	Business model component
(Chesbrough and Rosenbloom, 2002)	Value proposition, market segment, value chain, cost structure/ profit potential, value network and competitive strategy.
(Osterwalder, 2004)	Value proposition, key activities, key resources, key partnerships, customer relationship, market channels, customer segment, revenue stream and cost structure.
(Morris et al., 2005)	Value proposition, customer, internal competencies, external positioning, economic model and personal/investor factor
(Johnson et al., 2008)	Value proposition, profit formula, key resources and key processes
(Afuah, 2018)	The value proposition, market segment, growth model, revenue-cost model and capabilities

Table 10 Business model component review

3.3.3.2 Business model Value configuration

The value chain analysis is a useful frame to understand the value creation logic in some firms cases. However, some novel business models have been created upon different logics that cannot be explained by the value chain concept. Recently and in order to capture the value creation essence of these new firms, Fjeldstad and Snow (2018) have suggested to link the process of business model building and the typology of *chain-shop-network* of value configuration. The concept of value configuration can be traced back to (Stabell and Fjeldstad, 1998) who has proposed the “Value configuration analysis” which consists of three distinct generic value configurations namely: value chain, the value shop and the value network. According to the author, the value chain models the activities of a long-linked technology, while the value shop models, firms where a value is created by mobilizing resources and activities to resolve a particular customer problem, and the value network models firms that create value by facilitating a network relationship between their customers using a mediating technology.

In the value chain configuration, which is the first value configuration, the value creation is a process of transforming inputs into a product which is the medium for transferring value between the firms and the customer. This model named "long-linked value creation technology". The process includes independent activities, such as manufacturing, storage and selling, marketing etc. that are coordinated together. The value is represented by the product which can either be adapted to the market or be differentiated. The customer value is either in the activities cost reduction or in the performance improvements. The value creation process needs to be disaggregated into activities to a better understanding of the competitive advantages. The activities are defined as "*the building blocks by which a firm creates a product that is valuable to its customers*". Three distinct independencies between the activities are identified: pooled, sequential and reciprocal (Stabell and Fjeldstad, 1998).

The second value configuration is the value shop configuration which is based on mobilising resources and activities to resolve a specific customer problem. This value creation relies on intensive technology characterises by being related to value information asymmetry which refers to the variation in the level of information between the client and the firms. This variation is the main reason for the customer to approach the firm. Another attribute is the dealing with unique cases and providing more or less standardised solutions which require expertise (e.g. Hospital service) (Stabell and Fjeldstad, 1998).

The “Value network” is the third value configuration and is defined as “*firms that can be modelled as value networks, rely on a mediating technology to link clients or customers who are or wish to be interdependent*” (Stabell and Fjeldstad, 1998). While customers are distributed in space and time, the mediating technology enables new forms of exchange relationship. The role of the firms is to provide a networking service. In order to have a deep understanding of the value network, Stabell and Fjeldstad (1998) have explained the logic of the value creation (e.g. banks and insurance companies).

In the value network configuration, firms provide networking services and link different actors, thus organise and facilitates exchange between customers. Linking can be direct where customers are in direct interaction (e.g. telephone service) or indirect where customers have no direct relationship, but they are linked indirectly through a common pool (e.g. retailer banking) (Stabell and Fjeldstad, 1998). Firms are “*Mediators*” that seek customers who complement each other and deny who are not. While the relationship's form between customers might take

supplier-customer relationship, for the firm, they are all customers. Service value is a function of "*positive network externalities*" in which adding more customer on one side, affects the customers on the other side. The initial phase of networking service development is characterised by high-cost service and low value. Value is derived from "*service, service capacity and service opportunity*". Customers receive value even if they are not indeed involved in the mediation service (e.g. pay subscription for access). Mediators charge customer separately for "*linking opportunity*" and "*actual use*". Customer pays a subscription fee as a commitment to servicing potential customer requests then they may pay for the actual usage (e.g. pay per unit) (Stabell and Fjeldstad, 1998).

"*Mediation activities are performed simultaneously at multiple levels*". in order to overcome a potential random demand for mediating services; activities should be performed concurrently. Simultaneous nature of the activities transfers their independence from being sequential to reciprocal. In other words, any failure to synchronise the activities may lead to system collapse. "*Standardization facilitate matching and monitoring*" (Stabell and Fjeldstad, 1998). Putting standard measures enables mediator to match compatible customer and effectively maintain and monitor the interaction between them. In the "*Distinct life cycle phase of rollout and operation*", firms in the initial phase might follow "give away strategy" in which free of charge service or equipment is proposed as a rollout phase. After that and once the mediator has a scale and is able to effectively and concurrently performs, he/she starts to charge for the membership, service and equipment in a potentially long-term return (Stabell and Fjeldstad, 1998).

3.3.4 Business model impact

Business model innovations have effects or outcomes (Wirtz et al., 2016) which can be on the individual firm's performance, the industry and market structure levels, and the firm's capabilities (Schneider and Spieth, 2013). A novel business model can have significant impacts on dominant industry logics (Överholm, 2017); they can influence and change the surrounding ecosystem (Hellström et al., 2015). BMI contributes to sustainable businesses by creating sustainable value in the value proposition, the way the value is created or captured (Bocken et al., 2014). Business model affects the firms performance and designing a novel BM has a positive impact on the entrepreneurial firm's performance (Zott and Amit, 2007).

Reconfiguration, which is the third phase of dynamic capabilities perspective, is necessary to sustain profitable growth by creating routines that increase operational efficiency in a stable environment (Teece, 2007). Herein, BMI is a continuous and ongoing process based on building new competencies and organisational renewal (Teece, 2007). Applied to BM theory, reconfiguration refers to the firm's capability to adapt and build up new valuable resources and competencies that are associated with the new BM. Firms evaluate and select BM content and activities and might replace some conventional resources and re-allocate their positions in the value chain (Mezger, 2014).

Some factors are identified in the asset's reconfiguration phases for sustainable BMI development, such as forming a creative and disruptive sustainability-oriented team, collective decision-making and adopting an integrated approach in dealing with sustainable innovation.

Three factors have been considered in the BMI impact. The first of is the competitive advantage which is highly associated with firm's differentiation degree and represents barriers for rivals to imitate the business. Secondly, innovativeness degree is taken as one of the BMI

impacts, as BMIs have a different degree of innovation, such as radical and moderate (Bucherer et al., 2012). Sustainability contribution is the third factor and is a critical factor as all the selected cases deliver various sustainable values.

3.3.4.1 Competitive advantages

Business model improvement can make a significant difference in creating competitive advantages (Mitchell and Coles, 2003). Business model changes can bring various types of competitive advantages, such as lower prices based on lower cost, more desirable product, more choices and information and close relationship (Mitchell and Coles, 2003). Creating competitive advantages contributes to more product-service sales, higher profitability and greater cash flow.

Porter outlined three primary strategies that can achieve competitive advantages (Porter, 1985). They are cost leadership, differentiation and focus. Cost leadership refers to provide reasonable value at a lower price. One of the ways to lower the prices is by improving operational efficiency. Differentiation means the capability of the firm to provide better benefits than its rivals. This can be achieved by providing a high-quality product, or by some complementary service, customisation, etc. Finally, focus refers to choosing one market segment and serve it either by using cost leadership or differentiation.

3.3.4.2 Innovation degree

BMI is identified as "the discovery of a fundamentally different BM in an existing business" BM innovators do not discover new products or services, but they give new definition to the already existed product or service and figure out a new way to provide it". For example, Amazon did not discover bookselling (Markides, 2006). Two features distinguish the BMI, it attracts different customers, and it requires a different value chain from the established and current competitors. The challenge with BMI is not limited to the development of new ideas, but it is instead re-deployment and re-usage of existing resources and capabilities to develop a new form of value creation (Schneider and Spieth, 2013).

BMI can be distinguished from disruptive technological innovation as well as from radical product innovation. Disruptive technological innovations are processes that expand over time and tends to be associated with the replacement of the incumbent by new entrants (Markides, 2006). BMI does not support such an extreme position as it is associated with a new way of competing in the business usually grows quicker than the market, but it fails to overtake the traditional way of competing. Radical product innovations are innovations that create new-to-the-world products and tends to disrupt prevailing consumer habits and behaviours in a major way (Markides, 2006).

The types of BMI are either radical or incremental. The incremental BM is built upon existing BMs in particular industry while the radical BM is more characterised by its discontinuity to both industry and market on the industry level (Bucherer et al., 2012). Bucherer et al. (2012) have categorised the degree of innovativeness of BMI, which falls into four groups. Firstly, "incremental BMIs" are different BM in the respective industry; however, no discontinuities occur. For example, a BMI that offers additional or tailored services. Secondly, "Industry breakthroughs" refers to a discontinuity in the industry; however, the introduced changes for the customer are incremental (e.g. multiple applications BMI). Thirdly, "Market breakthrough" BMI brings discontinuous changes to the market while the changes for the respective industry are rather incremental (e.g. create new market segment). Finally, "radical

BMI" are characterised by discontinuous changes in both market and industry (e.g. new to the market and industry).

3.3.4.3 Sustainability impact

In this subsection, the sustainability aspects represented by social and environmental values created and captured by the studied start-up business models are discussed. The literature that examines the intersection between sustainability and business model has recently emerged. According to (Stubbs and Cocklin, 2008) sustainability business models address economic, social and environmental aspects in defining the organisation's purpose, take in consideration stakeholders need rather than giving priority to shareholders' expectations, promote environmental stewardship, such as renewable resources, comprise structural changes on the system level (e.g. goods transportation). Sustainability need to be incorporated in the company's management systems (Mabrouk, 2015). Three streams of innovation identified in a literature review conducted on SBM: technological innovation, social innovation and organisational innovation (Boons and Lüdeke-Freund, 2013). Technological innovations are considered devices that commercialise clean technologies, organisational innovations seek to implement alternatives to neoclassical economic worldview by bringing structural and cultural changes to the organisation, and social innovations refer to organisations that maximise social profit and create social value.

Furthermore, the mechanisms and solutions, which these SBM innovation groups might have, are categorised in archetypes (Bocken et al., 2014). The technological innovation, which refers to technical innovation components, such as product redesign for sustainability, has three archetypes: *maximise material and energy efficiency*, *create value from waste*, *substitute with renewables*. The social innovation which includes social innovation components, such as changing consumers' offerings or behaviour, has three archetypes: *delivering functionality*, *adopt stewardship* and *encourage sufficiency*. Finally, the organisational innovation which embeds organisational innovation changes, such as increase corporation social and environmental responsibility consists of two archetypes: *repurpose for society/ environment* and *develop scale-up solution* (Table 11).

Sustainable Business mode archetype	Description
<i>Maximise material and energy efficiency</i>	Mitigate environmental impact of an industry by reducing the demand for energy and resources
<i>create value from waste</i>	Waste elimination by turning waste streams into valuable input
<i>Substitute with renewable</i>	Addressing resources constraints associated with non-renewable resources and current production processes
<i>Deliver functionality</i>	Provide services that satisfy user's needs without having to own physical products
<i>Adopt a stewardship</i>	Proactively engaging with all stakeholders to ensure their long-term health and well-being
<i>Encourage sufficiency</i>	Solutions that actively seek to reduce consumption and production

<i>Repurpose the business for society</i>	Prioritising delivery of social and environmental benefits rather economic profit maximisation through close integration between the firm and local communities
<i>Develop scale up solution</i>	delivering sustainable solution at a large scale to maximise benefits for society and the environment

Table 11 Business model for sustainability archetypes adopted from (Bocken et al., 2014)

3.3.5 Business model framework for energy transition

In general, new firms are considered as innovation pioneers in offering radical solutions to the challenge of sustainability. However, only a few studies address the business model framework that represents and describes their essential elements. Herein, a primary BM framework has been constructed from the literature which will be used to analyse the collected data from fifteen interviews with energy start-ups in Europe (Table 12).

Business model Phase	elements	Description
Opportunity exploration	Opportunity sensing & evaluation	What is the prior knowledge of the technology or the domain? What are the motivation and strategic plans to realise the observed opportunity? To what degree the final product matches the customer's needs?
	Opportunity type	what are defined and undefined capabilities and what are identified or unidentified of customer needs?
	Market imperfections	What are the market imperfections in terms of their failures to fulfil environmental and social needs?
Business model Seizing	Value proposition	What benefits do customers perceive in the firm and its products and service?
	Market segment	What market segments do the firm address?
	Revenue-cost model	How does the firm make a profit?
	Growth model	What is the firm doing to keep growing profitably?
	Capabilities	What are the firm's capabilities (resources and activities) for driving the value proposition, market segments, revenue cost model, growth model and building other capabilities?
Business model impact	Competitive advantage	How does the firm create competitive advantages?
	Innovativeness degree	What is the innovativeness degree of BMI?
	Sustainability impact	What is the sustainability impact of the firm?

Table 12 Business model framework for energy transition

3.4 Methods

3.4.1 Selection of case studies

Given that BMI is a recent term with no consensus on its definition. The author draws on an exploration of the actual practices that are implemented in energy start-ups to provide solid insights. A multiple-case study approach has been applied. A case study research aims to explore, describe and explain events as they actually happened (Yin et al., 1985). A multiple case study analysis has been conducted and a business model framework as single unit of analysis has been used. This explorative approach deepens and gives profound understanding

for each case and its context as well as the detection of commonalities and difference across cases. The multiple case study analysis consists of fifteen cases of start-ups in the energy field.

The selection of case studies is based on the concept of theoretical sampling rather than random sampling (Eisenhardt and Graebner, 2007). First, the energy domain was selected to control similar factors and having the same context: Fifteen case studies in the clean energy technology specialised in renewable generation and demand-side management, e.g., energy efficiency, demand response, energy storage and electric vehicles. For decades, the energy sector was one of the most stable domains dominated by public service actors where there was no competition. However, based on renewable energy technologies and information technologies, customer's preferences have been changing, new needs have arisen, and an abundance of novel business models are emerging. Although most of the conventional energy utilities are still dominating the energy markets, renewable energy based business models and demand-side management business models arise and gain importance. Previous research has addressed the new business model in the framework of energy transition (Huijben and Verbong, 2013; Kanda et al., 2016; Wainstein and Bumpus, 2016).

By scrutinising start-ups within the Innoenergy network and based on research case selection criteria, 34 requests of the interview have been sent. 19 of them did not accept to participate because of different reasons, such as confidentiality, and 15 have accepted to participate. All the selected cases are European start-ups that propose an innovative energy solution in the following countries: France, the Netherlands, Spain, Ireland and Portugal. All the selected start-ups have followed a rigorous selection process for 15 months to participate in Innoenergy.

Two main sources for data collection were employed. First, primary information was gathered from explorative interviews. Most of the interviews were conducted with the start-up's founder. A semi-structured guideline has been used, and all the interviews were recorded and transcribed (Table 14). The interview includes fundamental questions about the business model main activities (See Appendix). To ensure having comprehensive data, secondary information was collected from start-up's publications, websites, published articles and videos. All information was integrated to obtain robust and reliable information, to mitigate information bias and reduce subjectivity (Yin, 1989).

List of interview questions
What did bring the business idea?
How did you identify the opportunity to start your business?
When did you start developing your business?
Can you describe your business model?
How would you characterize and categorize your business model?
What is the value proposition of the company?
How do create value to the customer?
How is profit distributed, and to whom? What is the economics model of the revenue?
Do you generate value beyond profit? If so, what kind of value?
How do you describe your relationships with suppliers, customers, partners?
How would you describe the market environment you are operating in?
What would you consider your most important processes and/or inputs?

What are the strengths of your company? How do you react to changes and challenges? Competitive advantages?
What knowledge did you and your co-founders bring to your venture?
What are the sustainability impacts of the company?
What need to be done in the future?

Table 13 List of energy start-ups interview's questions

3.4.2 Data analysis

The first step in examining the collected data was to perform a content analysis using the inductive approach. Content analysis is a method used to make replicable and valid inferences from data to their context in order to obtain categories or concepts that can be used to build a model (Elo and Kyngäs, 2008). Excerpts in the transcripts that represent, describe or explain the start-up business models, business model innovation and development, components related to sustainability are searched and highlighted. In the second step, a deductive and pattern-matching approach has been used to match the identified excerpts and the proposed framework (Hyde, 2000). The patterns from the excerpts are compared to the predictions of the constructed framework from business model innovation theory. This comparison permits to examine if the cases' data matches the constructed framework. An iterative alternation of induction and deduction processes are proceeded for refining the outcomes. Finally, a list of business model characteristics that distinguish the energy start-up business model innovations has been identified.

Case	Number of employees	Domaine	Founded in	Foundation date	Interviewees	Length of recording
Enie.nl	35	Solar energy	The Netherlands	2013	Co-founder	41:09
EP Tender	6	Electric vehicle	France	2012	Founder and CEO	50:04
Eneida	19	Electrical Grid	Portugal	2017	Co-founder and CEO	21:44
Energy Pool	100	Demand response	France	2009	Head of Strategy, Legal and Public Affairs	41:11
Stimergy	7	Datacentre & Energy Efficiency	France	2013	Commercial and administrative assistance	44:01
Energix	8	Renewable prediction	Spain	2013	Co-Founder & Business Development Manager	40:10
Steadysun	19	Renewable prediction	France	2013	Global Head of Sales & Marketing	21:32
Cloud Energy Optimizer	2	Buildings energy management	The Netherlands	2016	Founder and CEO	26:23
Coturnix	2	Buildings energy management	France	2016	Co-founder and president	48:13
Beeyon	8	Datacentre energy management	Ireland	2017	Co-founder and CEO	38:03
Solable	2	Water heater	France	2014	Founder	35:53
EPC Solair	10	Solar PV mounting systems	France	2010	Co-founder and Director	35:04
Helioslite	3	Solar PV tracker	France	2013	Co-founder and General director	41:44
Gulplug	5	Machine energy management	France	2016	Project engineer	45:32

Sylfen	6	Hydrogen batteries	France	2015	Marketing and communication responsible	39:02
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Table 14 Cased studies description and data collection

3.5 Results and discussion

The results include, firstly, the analysis of the start-ups BMs using the identified framework, which consists of three dimensions: opportunity exploration, BM seizing and BM impact. Secondly, the business model innovation process of energy start-up has been introduced. Finally, twelve types of EBM are proposed.

3.5.1 Energy business model opportunity exploration

3.5.1.1 Opportunity triggers in the energy sector

Many stimuli can trigger opportunities in the energy sector. According to (Mcmullen and Shepherd, 2006) entrepreneurs that start an entrepreneurship process, are first driven by an attention to a potential opportunity which can be explained by entrepreneur prior knowledge and his/her motivation. Secondly, they are driven by a positive assessment of desirability and feasibility. Therefore, Energy entrepreneur's attention and motivation are analysed (Table 15).

The cofounders of Enie.nl have an experience related to solar PV market, market regulation and customer segmentation. At the beginning of the start-up, they started by selling PV panel systems. After that, they create a new BM based on leasing. Their main motivation was driven by fighting against climate change by providing renewable energy to customers who want to have solar PV systems but cannot afford the investment cost.

The founder of EP Tender wanted to accelerate the EVs expansion by increasing their efficiency. He was driven by his motivation of finding a solution to the limited range of EVs because, for him, conventional cars cause noise and air pollution. His ambition is to enable EVs to reach their full potential in terms of occasional long-distance trips.

The Founder of Solable is a creator of several companies and is motivated by common, significant and worldwide ecological problems of energy and water scarcity. Stimergy founder has been inspired by an incident of an air conditioning breakdown in the server room. This emergency incident motivated him to find a solution to that incident that can replace the air conditioning with an alternative that would be more efficient. Beeyon's co-founders were motivated by mitigating the amount of energy consumption that the datacentres consume and the continuous multiplication of the datacentres around the world.

From the examples mentioned above, the main attention of the studied cases can be partially explained by their motivation to find a solution to ecological and environmental issues. Each has its own domain knowledge that directly or indirectly contributes to opportunity recognition.

In some other cases, the attention is not triggered by an ecological problem but rather by a golden market opportunity. The co-founders of Nnergix have recognised that the existing market solutions for renewable energy predictions are not accurate, adding prior knowledge related to energy, weather and electrical markets. EPC Solair's co-founders have tapped on the economic opportunities in the solar PV market, specifically providing a mounting structure for PV plant on a flat roof. Their long experience in the market allowed them to discover that there are no apt solutions for the French commercial and industrial buildings with a flat roof to mount

solar PV plants. Stimergy founder, after an incident in the server cooling systems in a datacentre, wanted to employ a more efficient cooling system to the datacentres.

Energy entrepreneur's attention has been captured by technological potential. This was the case of Sylfen and Steadysun; these two start-ups emerged from big research labs in France. Helioslite's main goal was to design a tracking system to High Concentrated PV modules, what was at that time a new technology. Gulplug is a spin-off from Schneider Electric and is driven by finding commercial applications to the developed technology based on a magnetic electric plug. The foundation of Cloud Energy Optimizer and Coturnix was driven by advancement in the software and data process technologies that can be used in the Building Energy Management systems.

Another group of entrepreneurs has captured its opportunity from paying attention to energy system actors' problems, such as DSO, TSO, energy utility, etc. What motivated and inspired the Energy Pool founder is the offer that he got from a French energy utility to be paid in return for shutting down his aluminium plant during a permanent electrical grid jeopardise. Eneida co-founders, have been asked directly by a Portuguese DSO to develop a smart monitoring system for low voltage network as they were facing issues related to electricity distribution quality and a threat represented by the expansion of renewable energy technologies and EVs charging stations that are connected to the distribution grid.

Additionally, it has been noticed that one of the prerequisites, besides the attention and the motivation, is having an ambition. The ambition of Enie.nl was to make solar panel accessible and available for most of the people in the Netherlands.

The Eneida co-founder has the ambition to be the leading IoT platform for the low-voltage network, Energy Pool founder wanted to expand internationally, and now the company is operating in six countries. The Coturnix, as well as Solable founders, think globally, the target was to make changes on the world level in order to maximise the sustainability impact.

Case	Prior knowledge	Quote
Enie.nl	Experience: related to solar PV market; regulation, subsidies and customer segments Motivation: sustainability and climate change Ambition: to attract the mass customer	<i>"We help them to become more sustainable because in the Netherlands a lot of people are willing to switch to more sustainable ways of energy, but they're not really want to invest four five six thousand Euros" Enie.nl</i> <i>"At the beginning of the solar energy market, there is quite new people are willing and able to invest four, five, six thousand that are those innovators that are willing to do the investments. But our ambition to shift a lot of people to renewable. If you and I want to shift to solar energy. I do not know if we want to invest four five six thousand euros. I think we can also find other ways to spend that money. So we wanted to create a model that makes it to the really low profile to switch to solar energy by making it from initial investment to a monthly fee so this really easy for a consumer to switch so that it is really accessible for a lot of people in the Netherlands. That was a goal and not only focusing on the two or three percent of the Netherlands that is able to invest in solar panels" Enie.nl co-founder</i>
EP Tender	Experience in finance and assets management Motivation: noise and air pollution of cars Ambition: thinking globally	<i>"I sat down in a chair in my garden and I heard the cars passing in the street. I thought it would be so nice if in 10 years' time half of these cars would be electric and with far less noise. So it really started with my own personal interest of having less noise in my garden" EP Tender founder</i> <i>"There are 1 billion cars. today 0.1% are electric. And there has been many attempts, but I think this time is the right attempt. So I think we will have an increasing percentage of electric cars in the 1 billion cars in the market" EP Tender founder</i>
Solable	Experience: Large experience, creator of 10 prior companies Motivation: climate change and water scarcity Ambition: thinking globally	<i>"From my view which is important in the world is to help people to sustain correctly. So in this goal, we began to talk about water because water is one of the biggest problems now in the world and at the same time we have worked also on energy and we achieved a big enhancement in energy" Solable</i> <i>"So if you realize that the gain if you can scale one day at the world size, it's a real revolution. It is about, in France to give an example, we have got about fifty-eight nuclear reactors. If everybody in France uses in its building our Innovation, which is called La douche, I think we could close about 8 to 10 of those nuclear reactors.</i>

		<i>The rules are very simple that our Innovation must touch the world, of course, their targets must be more than 1 billion people" Solable co-founder</i>
Ennergix	Experience: energy, electrical market and meteorological field Motivation: service improvement Ambition: going international	<i>"There was a lot of improvement margin for that service, and we knew that from a customer, we knew a company which has that need of better forecast. So we knew that there was a market there because that company says: you can improve that service because now in the market we do not have providers with enough quality. So if you can do that, you will help us, and then other many companies would need and require that service. So let us say that someone in the market identifies that opportunity and we believe in him." Nnergix co-founder</i>
EPC Solair	Experience: engineer in microelectronics and business administration Motivation: product improvement	<i>"I started in this business working for a German company in 2009 and 2010, and I see an opportunity working on this business. I was a sales manager for France for this German company, and I saw for Industrial and commercial businesses, there is today no good solution. So I decided to start something directly dedicated to this business because I was in this business for another company." EPC Solair co-founder</i>
Beeyon	Experience: computer science, computer architecture programming, innovation and entrepreneurship Motivation: increase of datacentre numbers and their energy consumption	<i>"And by chance, I met a group from Sweden that was a visiting Dublin and one of the participants in the trade Mission by chance, I spoke to him, and he mentioned that the energy management of data centres was very difficult. And it was something that we had considered and I was not aware at all of what was the problem in data centres, but he said it was a major issue and we found it was a growing problem and challenge for the digital industry and we had a solution for that challenge. He thought that there would be a good business opportunity." Beeyon co-founder</i>
Energy Pool	Experience: managing aluminium plant Motivation: add-value to the electrical system (system reliability) Ambition: going internationally	<i>"The CEO as director of a big industry plant was called by EDF and EDF ask him how much would he claims for to stop the production of in of its industry just to reduce energy for the network in the system and so he was completely lost because he didn't know how much the cost to shut down his plant, but he immediately think that this service could have a value for the electrical system. Therefore he decided to set up a company which its mission was with consistent in organising that and in offering the opportunity to Industrials to provide the flexibility for the system." "energy pool is French demand response aggregator having from the beginning the ambition to expand internationally. So that is why we are now working in six countries including Japan turkey UK Belgium." Energy Pool Strategy director</i>
Eneida	Experience: R&D on the smart sensor, industrial wireless network for the energy sector Motivation: add-value to the electrical system (low voltage network) Ambition: to become a leading international company	<i>"On one hand, we have the needs from the DSOs, the needs to have visibility about what is happening there, because of the low carbon technology that is coming in and increasing of demand. Increase the expectation of the quality of service. On the other hand, you have the technology that allows them to do this. As we come from this area that does this, we think it would be very interesting to develop and offer this solution." "We want to be the leading IoT platform for optimising the low-voltage Network." Eneida co-founder</i>
Helioslite	Experience: areas of renewable energy, electronic control devices and project management & finance Motivation: an innovative solution for High Concentrated PV modules Ambition: going internationally	<i>"The idea was to bring novel Innovative solution to a problem, and that problem was tracking devices for high concentrated PV modules." Helioslite co-founder</i>
Cloud Energy Optimizer	Experience: in electronics and data acquisition systems, peak shaving, metering and billing, LED streetlight Motivation: service improvement	<i>"Nowadays these computers act as they are on an island. They do not know, they are not steered from outside, and they do not know what is the weather tomorrow, so these computers do not look to the weather, and they do not know if it is tomorrow 30 degrees or minus 20." Cloud Energy Optimizer founder</i>
Coturnix	Experience: research on information technology, business and sales Motivation: service improvement Ambition: thinking globally	<i>"The main part of the older software that is piloting the buildings today is based on the analysis of the past data, and we analysed the future of data. Of the consumption of the building because we predict that data and we select the best way to reduce energy based on the future." "I created go Coturnix with the dream that using Coturnix of the five billion of a square meter in the world even free of charge could reduce of by 2% the CO₂ in the world and it is my concern today" Coturnix co-founder</i>

Sylfen	Experience: R&D in a big research lab Motivation: commercialised hydrogen storage technology Ambition: accelerating energy transition	<i>"Sylfen is born as a spin-off from the CEA in Grenoble, so the CEA is the Commissariat à l'Énergie atomique is a French technological Institute which has developed very advanced knowledge in the field of hydrogen technology. It's a worldwide leading technology, but in that field competing against Japanese laboratory or other Europeans and Americans as well, and they have made some breakthrough development in this technology about three years ago now and based on this promise the head of the fuel cells department at CEA decided to create Sylfen in order to both industrialized this technology and to commercialize this into a fully ready to be used system dedicated to go to market" Stimergy</i>
Stimergy	Experience: engineering Motivation: finding an efficient solution Ambition: Expand over Europe	<i>"The founder is working - already! - in a start-up. He is responsible for a server room. One day, the air conditioning of the room breaks down. It was 40 degrees inside, and he found it crazy that he needed to spend energy to cool servers. So he looked for a way to recycle that energy" (Lemoniteur, 2016)</i>
Steadysun	Experience: research lab Motivation: commercialising renewable energy forecast technology	<i>"The company was technology-driven. So the idea came from a scientist. The idea was sitting a lab so it could be at the Forefront of the technology and application need." Sale director</i>
Gulplug	Experience: a spin-off from Schneider Electric Motivation: Introducing new technology: magnetic plug	<i>"This second offer is a magnetic plug. This is why our name is Gulplug it a semantic plug, we developing this product for our client which are working on automobile and Robotics." Gulplug project engineer</i>

Table 15 Reducing opportunity uncertainty factors

3.5.1.2 Market imperfections of Energy business model

The analysis shows that several cases address at least one of the market imperfections (See subsection 3.3.2.4) mainly related to ecological concerns (Table 16). Regarding the energy inefficiency, Stimergy has recognised an opportunity in the wasted heat of the datacentres. The firm has designed and combined two closed-loop systems in which the wasted heat of one industry is converted into a new product for another industry. Solable has designed a new water heater system that recovers the wasted heat in wasted water and re-injects it in the pure cold water. Helioslite increases the efficiency of the PV panel, in terms of the generated electricity, by replacing the fixed axe of the PV panel base with a dynamic one that follows the sun orientation during the day.

Concerning the second market imperfection (Imperfect distributed Information), it has been found that imperfection in the distributed information is a considerable issue in the datacentre industry. One large sector of the datacentre industry is called colocation where a company will rent space in a datacentre, and they would install their hardware into the space they rent. The way the datacentre, who is renting the space, charges for that space is by charging for the electricity that the colocation tenant wants to use. So, companies have to enter into an agreement where they reserve the right to use a certain amount of energy. Companies may estimate 10 kilowatts capacity for the servers' equipment and reserve 10 kilowatts. Even if they do not use it, they have to reserve 10 kilowatts for their IT equipment that they wish to put into the colocation datacentres. Then, they pay for what they use. The problem is that companies, the tenants who are putting in their equipment into the datacentre, they tend to overestimate quite substantially the amount of energy that they think they need and that means they are paying for energy that they are never going to use. What Beeyon does, it allows such tenants to accurately determine what their power consumption is, and then reserve what they need plus or minus like maybe 20 or 30 per cent. Whereas at the moment they could be reserving a hundred per cent more energy than they need. So they are paying a lot more for the right to have the energy to their IT assets. So that one-way Beeyon saves companies money in terms of allowing them to determine actually what they need. Beeyon also even, when companies are just paying

for the energy that they are using, identifies servers which are idle which are not contributing to any productivity in the datacentre, even when they are non-productive. They are still consuming much energy, and also they have to be cooled and causing a sizeable cooling overhead. So Beeyon analyses what is the performance and what is the cost in terms of energy consumption of the assets and those assets which are not forming the only maybe 5%.

Miss distribution of information as market imperfection has also been observed in the Low Voltage (LV) of the distribution network. The problem is that DSOs normally work with a capacity that is below the capacity they can use because of missed information regarding the real-time used capacity in the network. However, giving the DSO the ability to know the load that is being used in real time, Eneida enables them to use, by the same level of risk, a higher capacity. This real-time information over the exploited capacity can also be used to manage the load owners, to manage photovoltaic installations, and to aggregate heat pumps in order to offer the DSOs the possibility to implement demand-side management. This optimisation of the capacity usage would decrease or delay the investment in new capacity in terms of transformers or cables for example. Eneida's BM enables higher capacity available in the network and management of the loads by using more loads into the network for the same level of capacity. Eneida, through the combination of smart sensors and IT platform, enables DSOs to have visibility over what is happening in low voltage network in real-time and offer accurate visibility over the electrical capacity.

Cloud Energy Optimizer co-founder stresses on the lack of data that the current building management systems are using for their energy management.

"Nowadays these computers act as they are on an island. They do not know, they are not steered from outside, and they do not know what the weather tomorrow is, so these computers do not look to the weather and they do not know if tomorrow will be 30 degrees or minus 20." Cloud Energy Optimizer founder

The start-up addresses this issue by integrating more information, such as real-time kWh prices, the number of people in the room, sun shining orientation, that are contributing to improving the buildings' consumption patterns.

Coturnix works on changing the behaviour of the building by importing information related to future potential buildings' behaviours. For example, if there is an event like the final world cup of football in Europe, everybody would rush to the supermarkets between 5 p.m. To 7 p.m. To get the ice cream, beers and everything to have a good moment with their friends. So that between five and seven o'clock in the supermarket, they would open all the freezer, and this would make a significant peak in energy consumption. Coturnix aims at identifying those events and analyse people behavioural patterns. By predicting them, Coturnix can change the setup of the freezer from (- 22) to (- 50) between the 2 p.m. and 4 p.m. when the sun is rising and when PV panel systems deliver the maximum of the energy of photovoltaic energy. So that customers can use that flow of energy, solar energy, into the freezer to store energy in the ice. You do not have to start, and you avoid the energy Peak.

Herein Steadysun and Nnergix provide information about future renewable energy production that contributes to reduce the associated risk with renewable energy trade, thus renewable market penetration.

"We provide them with the upcoming electricity production for the next hours and days. So our customers can know that information and make decisions based on that forecast for the short-term forecast" Nnergix co-founder

Gulplug uses smart sensors to collect data on electrical energy consumption so that the energy manager has all the data consumption on a web platform. The customer can recover all the data, monitor, analyse the machines' performance. Additionally, predictive maintenance service is provided.

Regarding the third market imperfection “Flawed pricing mechanisms” three BMs address this potential opportunity. Enie.nl offers solar PV panel for free, and in return, it generates income from the electricity that the consumers are producing. The firm offers competitive prices which allows the customers to make savings on their energy bill. Herein, the firm assumes that in the near future the conventional energy utility prices (fossil and coal energy power) will continuously go up, while the electricity prices from the solar panel will be the same. Therefore, there will be a more significant future margin compared to the current market price.

EP Tender offers extended range service for EVs assuming that there would be a massive increase of the EVs market share due to the price declining of EVs and the increase of gas and diesel prices. Sylfen, through its novel hydrogen storage, it anticipates an increase in the energy utility electricity prices which makes hydrogen storage economically viable.

“So it is a chronic difference that will be levelized because cost of energy in Europe is being levelized, the cost of energy in France is increasing a lot to catch up with the cost of Germany and Denmark for instance. So the trends are to be; basically, the more expensive energy is from grids, the better our technology will get return on investment” Sylfen Marketing director

“Externalities” is the fourth market imperfection in which one case has been identified. Energy Pool has outlined two externalities caused by the current business practices, the coal, gas and diesel generators that Energy Pool’s business model avoids. First, using demand response rather than generation for grid balancing, contributes to avoiding additional network infrastructure and reinforcement. Second, using demand response during the peak times reduces the need for peak hour generation units, such as diesel generator and coal, thus avoiding their carbon emission.

Finally, the result shows that a fifth market imperfection named “inappropriate regulations” can be added. Suitable regulations represent an important factor as the regulatory nature of the energy sector has great influence on the design and operation of the business model. Usually regulations are adapted by the start-ups which comply with the existing regulations; however, in some cases, start-ups can influence and enforces changes in the regulatory system. For example, Enie.nl has realised that the existing regulations do fit into their ambition of making solar panel accessible for all. However, the start-up demanded a legislative change. After one year of court debate, the start-up managed to get permission for implementing their desired BM and managed to change the regulations for their favour. Regulations have been recognised as BM sub-component that should be considered as part of the market in the context of large-scale environmental technology system (Kanda et al., 2016).

“It was forbidden by legislation to put solar panels on the roof of the consumer if I am the owner of the system. So that was the main barrier. We created some special agreement with those parties, and now the law allows us to do this” Enie.nl co-founder

Market regulations changes can bring opportunities to businesses. This is the case of Energy Pool which started after changes in the regulations. This change allows to aggregators to participate in the energy market. Coturnix finds opportunity in the regulations that force buildings to reduce energy consumption by 2020.

"At the beginning because they (TSOs) believe buying flexibility or buying demand response is it's difficult to assess and they consider that aggregators are selling them not product. But at the same time if the rules are well designed this risk does not exist anymore, and we can see that RTE is now quite happy with demand response, they found the right balance in the rules to allow demand response to participate and by integrating aggregators in the market" Energy Pool Strategy director

"There are new regulations that are coming, and they are very interesting for us because in France there is a regulation that has been set up that oblige all the buildings over 2000 square meters to decrease their energy consumption by 20% before 2020. So it is a very good opportunity for us, as you can imagine" Coturnix co-founder

Case	Market imperfections	Identified opportunity
Stimergy	<u>Inefficiency</u> : overconsumption of the datacentres and having outputs as heat waste	Combination of two closed loop heat systems from two different industries
Solable	<u>Inefficiency</u> : overconsumption of shower water heaters and have heat as a waste	Heat Recovery
Beeyon	<u>Imperfect distributed Information</u> : absence of granular measures for datacentres servers energy consumption	Greater visibility over datacentres energy consumption
Energy pool	<u>Externalities</u> : the current business model for grid balancing and grid security requires grid reinforcement investments and release carbon emissions.	Avoid network reinforcement and carbon emission
Eneida	<u>Imperfect distributed Information</u> : absence of measures regarding the real-time capacity of different parties in distribution network.	Detailed information about the condition and operation of critical grid assets.
Gulplug: save-it-yourself	<u>Imperfect distributed Information</u> : absence of measures and information representation about industrial machine real-time consumption	Showing industrial equipment's consumption data
Cloud Energy Optimizer/ Coturnix	<u>Imperfect distributed Information</u> : current building energy management systems lack information regarding weather forecast, energy prices, occupancy and future events impact.	Integrated environmental information into the energy management of buildings.
EP Tender	<u>Flawed pricing mechanisms</u> : the current prices of cars fuel do reflect the true cost of natural resource degradation.	Anticipating an increase in car fuel price
Enie.nl	<u>Flawed pricing mechanisms</u> : current energy utility electricity prices do reflect the true cost of natural resource degradation <u>Inappropriate regulations</u> : current regulations restrict the diffusion of renewable energy technologies	Anticipating an increase of the conventional energy utility prices based on fossil fuel. Changing local legislation to develop a new business model
Sylfen	<u>Flawed pricing mechanisms</u> : the current energy utility electricity prices do reflect the true cost of natural resource degradation	Anticipating an increase of the conventional energy utility prices based on fossil fuel.
Nnergix and Steadysun	<u>Imperfect distributed Information</u> : absence of accurate prediction about renewable energy technologies production	Accurate prediction of renewable energies production and reduction of fluctuations risk.
Helioslite	<u>Inefficiency</u> : the fixed axe of PV solar panel restricts the system energy production	Decrease energy yield of solar PV panel

Table 16 Sustainable entrepreneur and environmental market imperfections

3.5.1.3 Opportunity types and related energy business models

In this subsection, the type of opportunity, which has been earlier presented in (subsection 3.3.2.2), is discussed in light of the available understudied BMs (Figure 18). The author analyses each start-up's opportunity according to four types of market opportunities: *technology transfer*, *problem-solving*, *dreams* and *problem solving* (Ardichvili et al., 2003).

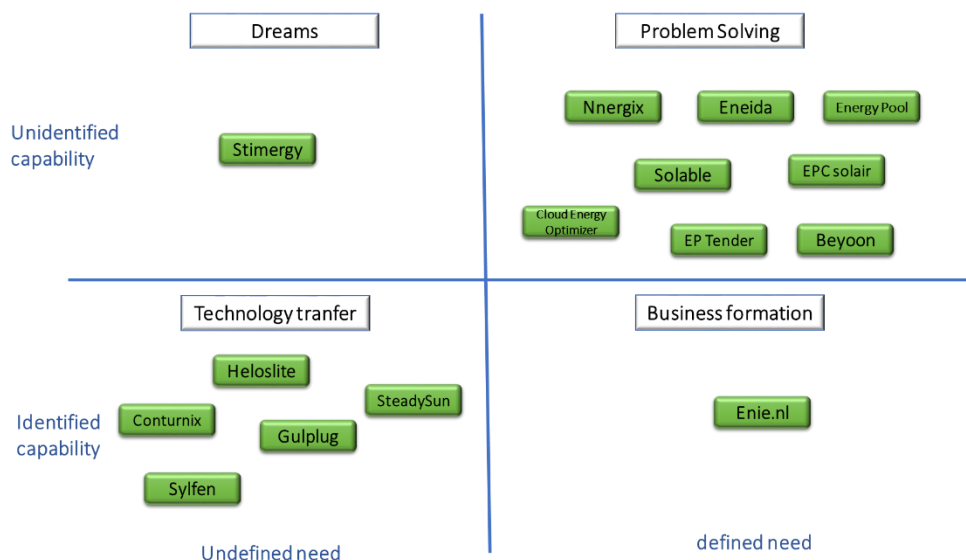


Figure 18 Type of opportunity of the studied cases

a. Technology transfer

In the technology transfer, entrepreneurs have defined capabilities, but unidentified market needs, such opportunity type emphasises finding applications for an invention or discovered technology. The cases analysis shows that five business models have the opportunity type of technology transfer: Heloslite, Steadysun, Sylfen, Gulplug, and Coturnix.

Firstly, the PV tracking device of Helioslite was initially designed to be installed in High Concentrated Photovoltaics (HCPV) projects; however, the HCPV market has never been materialised. Therefore, the entrepreneurs have searched and found another application that is in the small-scale projects and PV farms. The analysis shows that two opportunities have emerged from research and development labs. The first one is SteadySun which is a spin-off from the CEA and INES laboratories (National Institute of Solar Energy). Their BM is created based on a technology that combines the satellite image and meteorological models to predict renewable energy production. The second one is Sylfen which has also been emerged from the CEA in France to commercialise and industrialise the hydrogen battery applications. While the technology is well defined, the application relies on factors, such as electricity prices and renewable energy production. Currently, it has two main applications: on buildings level and district level.

Apart from research and development labs, the start-ups Gulplug, which is a spin-off from Schneider Electric, has introduced a novel approach to plug electrical resources and is based on a magnetic plug that can be used for several applications, such as charging EVs and robotics.

The Founder of Coturnix wanted to employ big data in the building energy management system and integrate future data prediction with this software. He has observed that the current software of building energy management system makes predictions based on past data and past consumption pattern; it does not take in consideration future data predictions.

b. Problem solving

In the "Problem solving" area, the market need is identified, but capabilities are undefined. It is related to information search as well as to research and development, and it aims at finding a solution to an addressed market need. In this opportunity type, eight business models are addressed: Could Energy Optimizer, Energy Pool, Eneida, Nnergix, Solable, EP Tender, Beeyon, EPC Solair that are classified in three types of problems:

- **Problem related to grid operation**

The first kind of problems is the energy system actors need such as TSO, DSO or energy utility. These actors have been recently facing issues related to grid security, grid balancing, electricity quality, EVs charging and new renewable installations connection. In the cases, it has been found that Energy Pool main customer is the Réseau de Transport d'Electricité (RTE) (The France TSO), Eneida main customers are DSOs of Portugal and Nnergix provides services for DSOs, TSOs, BRPs.

Regarding Energy Pool opportunity recognition, the process started when the founder, an aluminium plant owner, has been asked by the energy utility to shut down his plant operations because of a network electricity shortage. At that time, he realised that there was a growing need to network balancing service and decided to capture this opportunity and be a flexibility service provider. The founder of Eneida was also working close to the DSO who explicitly expressed its need for low voltage optimisation service.

The growing shares of renewable energy resources and EVs charging infrastructure that are connected to the LV network created a need for real-time monitoring and managing service. The Nnergix founder has been asked to improve the existed market solution for providing renewable energy prediction service. He realised that this could be an opportunity as one customer explicitly showed his interest and as renewables technologies have been increasingly expanding. The fluctuation nature of renewable energy resources created the need for a predictive service that can enhance the operation cost of such market actors, such as energy trading companies, TSOs and DSOs.

The above analysis shows that some opportunities are recognised from the interaction with the energy system and market actors. Herein, the social context plays a key role in providing information and resources, supports and shapes entrepreneur ideas (Dimov, 2007). Another important factor is information availability (Haynie et al., 2009). Entrepreneur's interaction with energy system actors makes information about system or market issues available. The analysis also shows that new opportunities contribute to increasing efficiency and effectiveness (Haynie et al., 2009). Energy entrepreneurs may add value to the transmission and distribution efficiency, improve energy trading effectiveness and decrease the risk of renewables' fluctuations.

- **Problem related to new market actors**

The second kind of the identified problems is the need of new market actors who engage in businesses related to renewable energy generation, local energy supply, etc. For example, Nnergix provides service for energy trading companies who sell their electricity in the market and are working in a strictly regulated environment.

- **Problem related to unsustainable consumption**

Finally, the third kind of problems is related to the unsustainable consumption patterns. Herein, entrepreneurs seek to improve the energy efficiency, shift to renewable energy, etc. Solable founder is motivated to find solutions for growing, common and worldwide problems (e.g. water and energy scarcity). He has realized that about half of the household energy expenses is for hot water usage, thus his focus was on the need for reducing water heater energy consumption.

Similarly, EP Tender was inspired by a common and growing problem of the pollution impact of cars and the limited range of EVs. On the contrary, the founder of Beeyon was not aware of the energy management issues and the need to be more efficient until he met someone who works in this sector. The opportunity was tailored to a specific problem. EPC Solair founders were working closely to the PV markets, and they saw that the existed PV mounting system solutions that serve the light flat roofs (e.g. many French commercial and industrial customer) are few and are not tailored to French roofs. Consequently, they wanted to bring a new solution to the market by collaborating with a university R&D team. Similarly, the founder of Cloud Energy Optimizer has realised that the building energy management system has software that is working in isolation from environmental factors, such as weather, occupancy and energy prices. He thought there is a need to close this gap by improving the employed software. Forecasting occupant-related energy consumption in residential buildings, is associated with variability in consumption patterns due to diversity in occupants' socio-demographic and economic profiles (Zaraket, 2014).

c. **Business formation**

Opportunity type of “business formation” refers to the exploitation of well-known resources and capabilities to form businesses that can create and capture value. Initially, Enie.nl had defined its customer’s need as the need for “having Solar PV system”, their required capabilities were having a good PV manufacturer supplier in order to sell PV panels to their customers. However, the founders have found later that there is a great potential in attracting the customers who want solar PV panel but cannot or do not want to invest and pay the upfront cost. Therefore, a new need was noticed: “solar PV without upfront cost” which requires new capabilities of having high investment capacity and appropriate regulations.

d. **Dreams**

Opportunity type of “Dreams” can be applied to the case of Stimergy where both the problem and the solutions are unknown. In general, the datacentre managers do not consider the electricity consumption is a problem that needs to be solved, rather they consider it as an indispensable and a required resource, thus an expense. Furthermore, it is difficult to imagine that a datacentre could be transformed into an energy service company that provides heat. Given that, the founder of Stimergy created a BM structure that have revealed the exploitation of unprecedented capabilities which is the capability to use the wasted heat and the output of the datacentres as an input of another system (unspecific need) which could be any system that

consume heat as an input (e.g. residential water heater, swimming pool, etc.). Herein, the last point of the opportunity types has been discussed.

After presenting and discussing the first phase of the business model innovation process: opportunity exploration, the next paragraph introduces the second phase which is the business mode seizing.

3.5.2 Energy Business model seizing

In this phase the business model is constituted; each start-up has made its choice in terms of business model components. They are able to define the value proposition and the customer benefits, value creation and how they transfer their capabilities and resources into the desired product-service and value capture and how they generate revenue. Business model seizing is described through BM components which have been adopted from (Afuah, 2018) who has defined five main components: value proposition, market segment, growth model, cost-revenue model, and capabilities

In this subsection, the 15 companies have been categorised in three groups: Network-oriented, software-oriented and product-oriented. This categorisation is based on accumulated difference and similarities between the studied BMs and based on the theoretical framework introduced at the beginning of this chapter (Subsection 3.3.5).

3.5.2.1 Network-oriented business model

The analysis shows that the energy start-ups BMs of Enie.nl, Energy Pool, Eneida, Stimergy and EP Tender are a network-oriented business model. This categorisation is based on the analysis of value configuration (see subsection 3.3.3.2). In this subsection, the value network will be discussed followed by a business model component discussion. The main characteristics of the network-oriented business model are illustrated in (Table 17)

3.5.2.1.1 Value Network

The first characteristic of value network is that the value creation logic is being a mediator between interdependent customers. The cases show that Energy Pool mediates industrials and TSOs. The start-up selects industrials that have high electrical load consumption, and their production processes have the potential for load flexibility. They also provide the services for either TSO or energy utilities. Stimergy has datacentre's customers and heat customers. The start-up selects customers who need the datacentre service and the customers who need heat efficiency. The latter should be able to have the digital boilers installed on its premises. Anie.nl is mediating investors and PV manufacturers, and residential and commercial PV customers. Eneida mediates between DSOs and application developers with whom it provides an established platform.

The value derived from services is the second characteristic. It can be divided into service opportunity or linking opportunity, and service capacity or actual usage. Energy Pool gets its revenue from the TSOs, which are in the first customer group and which pay fixed fees to the Energy Pool in order to secure access to flexibility if necessary in some balancing services (e.g. ancillary services) (linking opportunity) and from variable fee based on kWh of the used capacity (actual use). Similarly, industrials, the second customer group, might choose "availability" offer, in which they get fixed fee for their commitment (linking opportunity), "call" in which they are paid based on kWh of curtailment (actual use), or they might choose both. In the case of Stimergy, datacentre's customers pay for the access for the service whether

they use all or part of the servers' capacity (linking opportunity) while heat customers might choose to pay for unit of heat supply (actual use) or for energy system guarantee which ensures of specific energy efficiency degree (linking opportunity). Enie.nl's customers pay for actually produced kWh of the PV panels, and there is no payment for linking opportunity. Eneida gets money from the DSOs and the applications' developers in order to have access to the platform (linking opportunity). However, DSOs pay an additional fee to use advanced applications (actual use). In the EP Tender case, the EVs drivers pay a subscription (linking opportunity) to get access to the renting points and a complementary application, and they also pay per hour of use (actual usage).

"Common pool" between the served customers is another characteristic. In the case of Energy Pool, TSOs and industrials are linked through a common pool of "flexibility availability pool". While the industrials are flexibility providers, the TSOs are flexibility purchasers. Stimergy customers, the datacentres customers and heat efficiency customer are linked by "heat pool". Practically, the datacentres' customers are the heat sources, thus the heat providers while customers, such as hotels, swimming pool, etc. are the purchasers and heat consumers. Enie.nl has "PV panel pool" in which PV manufacturers and investors are the PV providers, and customer, such as residential and commercials are purchasers. DSOs and application developers, in the case of Eneida, are linked by "platform application pool" in which developers are application providers, and DSOs are applications users. EP Tender established a "battery services pool" in which batteries investors/ providers provide the main assets, and the EVs drivers are the main users of the derived services from these assets.

Positive network externalities characteristic refers to the impacts that the increase of customer number on one side would influence the customer of the other side. Adding more industrials to the Energy Pool network affects the cost-revenue model. By increasing industrials participants numbers, Energy Pool is able to increase its capacity and shares in the market, thus increasing its profit. Stimergy would be limited to the number of the datacentres' customers; having more of them means more significant heat capacity to be sold. Enie.nl can minimize procurement cost through economies of scale regarding PV panel order size from the manufacturers and maximise governmental subsidies revenue (e.g. tax discount).

Furthermore, Enie.nl would be limited to its invested capital in terms of a number of customers; having more investors would lead to more customers. Eneida can increase its revenue by allowing more applications to be implemented on its network. In EP Tender there is a positive relationship between range extending service, grid balancing service and the invested capital or batteries number.

In the network value configuration, activities have simultaneous nature. Energy Pool performance depends on managing two major activities simultaneously including receiving, disaggregating TSO demand for balancing service and searching, activating and aggregating industrials latent flexibility. Herein, both activities should be done simultaneously due to the electrical network nature which depends on real-time balancing services. The TSO kWh required to specific curtailment must always be equal to the aggregated kWh of the industrials' curtailments. In the case of Stimergy, any failure to synchronise the amount of produced heat with the amount of commitment heat can lead to heat surplus or heat shortage, thus additional loss and cost. Enie.nl activities are done simultaneously but with much degrees of freedom. Eneida ensures that the applications services are available for the DSOs and both activities of

adding new applications and of selling these application services to the DSOs are performed simultaneously to avoid any failure to fulfil novel application need of the DSOs. The EP Tender makes a balance between EVs demand for range extender service and the trailer (batteries) availability; both activities are performed simultaneously to ensure adequate service.

What facilitates the matching and monitoring of two kinds of services, is the common standards of measures that are required to evaluate the services. Energy Pool's industrials have standards measures and indicators (e.g. capacity MW, maximum and minimum during, etc.). These standards enable effective matching between what TSO demand and what the industries offer.

Criteria	Energy Pool	Stimergy	Enie.nl	Eneida	EP Tender
Mediator	Between TSOs and industrials	Between datacentres and heat customers	Between investors/ PV manufacturers and PV panel customers.	Between DSOs and application providers	Mediating battery providers/ investors and EV drivers
Value is derived from service, service capacity and service opportunity	<p>Service opportunity: Value from load curtailment availability</p> <p>Service capacity: Value from load curtailment amount</p>	<p>Service opportunity: Value from access to datacentres. Value from access to energy efficiency</p> <p>Service capacity: Value from heat consumption</p>	<p>Service capacity: Value from produced kWh from the solar panel</p>	<p>Service opportunity: Value from access to the established platform.</p> <p>Service capacity: Value from advanced applications.</p>	<p>Service opportunity: Value from access to the trailers.</p> <p>Service capacity: Value from hours of trailer usage</p>
Common pool	Flexibility availability pool	Recovered heat pool	PV panel pool	Platform application pool	Battery service pool
Service value is a function of positive network demand side externalities	Adding more industrials to the network affects the value of the service to the TSOs and vice versa	Increase the number of datacentres customer in the network increases the available heat to be recovered and delivered to heat efficiency customers	More customer means economies of scale and more subsidies. More investors mean more customer	Adding more applications to the network by the developers will improve the electrical grid function	Increase the number of EV drivers who ask for the service will increase the number of tenders thus increase the available capacity for VPP providers
Mediation activities are performed simultaneously at multiple levels	Service is performed simultaneously with a High degree of synchronisation	Service is performed simultaneously with a degree of synchronisation	Service is performed simultaneously with a low degree of synchronisation	Service is performed simultaneously with a high degree of synchronisation	Service is performed simultaneously with a degree of synchronisation
Standardisation facilitate matching and monitoring	kWh, time of response, response duration, etc.	A number of servers, servers heat production, heat unit price, etc.	kWh, PV panel production capacity, etc.	Voltage, electricity quality, maintenance cost, etc.	Battery capacity, renting points, EV market share, etc.
Distinct life cycle phase of rollout and operation	Providing the required equipment and services (communication, meters, experts etc)	No rollout phase	Customer pays zero upfront cost as a rollout	Free basic application	No rollout phase

Table 17 Network-oriented business model and value creation logic analysis

In the datacentres industry, the servers often have standards measures in terms of heat production, thus through the calculation of the amount of recovered heat, Stimergy can accurately estimate and match heat efficiency customer needs. Enie.nl service standards can be described as PV panel annual production estimation kWh, electricity prices, PV panel lifetime etc. The capacity of the Low Voltage grid is one of the most important measures. DSOs have small margins to overcome the electrical and voltage capacity. EP Tender has total control of the implemented batteries, usage rate, availability of batteries etc. and therefore is able to package this service.

Finally, the value network configuration might include the rollout phase. In the Energy Pool, the firm installs the communication infrastructure (e.g. smart sensors) and provide industrial experts services for industrials (give away strategy) in order to accumulate enough capacity to perform the mediation service concurrently. Enie.nl attracts customers through a zero-upfront cost and Eneida gives DSOs free access to some basic applications while it charges them from advanced applications.

3.5.2.1.2 Business model elements analysis

In this subsection, the business model components of the network-oriented business model are analysed and examined. Five elements have been analysed: value proposition, market segments, growth model, capabilities and revenue-cost model. The Network-oriented BM elements are illustrated in (Table 18).

i. Value proposition

Regarding the value proposition, several value proposition types have been noticed that explain customer's benefits and drivers.

Firstly, network-oriented start-ups are promoting access to environmental and sustainable energy technologies, such as electric vehicles and a solar PV panel. By making these technologies available, the start-ups help customers in substituting the polluting and traditional technologies, with healthier and cleaner ones. Enie.nl co-founders have made an assumption that residential customers and businesses have the willingness to install solar panel systems on their roofs, but they are not able or do not want to pay the high upfront cost. Thus, their offer changed to "give for free" the PV panel systems. Herein the customer value proposition can be summarised by immediate electricity cost savings, predictable cost of electricity over 15-25 years, monthly bill payments and no upfront cost of installation and a simple switch to solar and no technological risk (Strupeit and Palm, 2016).

Secondly, energy start-ups are contributing to the integration of ecological and sustainable energy technology into the existing energy system. The current energy system has been designed initially to serve centralised, fossil fuel and large-scale power plants. On the contrary, renewable energies, such as wind and solar are decentralised and based on small-scale power generation. For this reason, integrating renewables in the existing energy system is an increasing action. Eneida provides a smart monitoring system to optimise the energy management the low voltage distribution networks. The customer, the DSO's value proposition is having benefits related to better service quality (e.g. automatic alerts for services breakdowns, fuses faults, etc.), energy efficiency (decrease technical and non-technical losses, such as maintenance cost reduction), an increase in assets productivity and lifetime (e.g. maximizing the grid capacity) and EVs and renewable technologies integration.

Thirdly, energy start-ups are contributing to energy efficiency and cost efficiency in the various sectors, such as datacentre industry as well as grid operation. Stimergy, through its business model innovation, has reduced the cost of datacentre's electricity by 45%, which led to having the lowest price of datacentres service in Europe. The customer value propositions are low datacentre service price for IT customers and low heat price for energy efficiency customers. Energy Pool, by using demand response service, has enabled the TSOs to reduce the cost of reserves (ancillary services) up to 40%. Similarly, Eneida has reduced the need for the DSO for maintenance and reduced the risk of network damage.

Fourthly, energy start-ups advance the clean-tech technology take-in by improving the productivity of usage. While affordable EVs are limited to small ranges, EP Tender has created a solution that enables a temporary extension of their range once drives need to travel. This solution enables full exploitation of EVs capability and usage. Eneida contributes to increasing in the productivity of low voltage network by optimising the usage of the electrical capacity and Energy Pool contributes to delay the grid reinforcement and infrastructure investment thus increase the productivity of the transmission grid.

Finally, energy start-ups are activating the customer role in energy transition. They enable and empower consumers to take part by providing the necessary technologies and the means of use. Energy Pool has enabled certain industrial plants to engage in their demand response service by providing apt communication technologies, flexibility identification experts and incentives.

ii. Market segment

The analysis of the market segments shows that customer can be divided according to their energy usage into small consumers, large consumers and energy system operators. In the small consumers' group, the network-oriented start-ups address needs related to ecological transportation and renewable electricity while large consumers' group needs are cost-efficient consumption and energy efficiency. Finally, in the grid operators' group, two distinct major needs are observed. First, the need to balance the grid on the system level or national grid, in which TSOs have this responsibility and the second the need to balance the grid on local level which is more the DSO responsibility.

iii. Revenue-cost model

Regarding the revenue-cost model and how the start-ups make money. In general, it has been noticed that some BMs requires large capital to be invested, such as the case of Enie.nl (cost of solar PV panel) and EP Tender (cost of batteries). Analysis of the revenue shows that the studied cases have a common model in which there is no one product transaction, as the traditional sell-buy model. The revenue model is based on recurring revenue that is generated from renewables or demand-side management services.

Enie.nl income is related to customer's solar electricity production, Stimergy income depends on the energy efficiency of the datacentres and their numbers, and part of Eneida income relies on the number of the applications in the platform. The customer's payment model is the "Pay per use" model, such as pay per kWh produced (Enie.nl), an hour of trailer use (EP Tender), kWh of shift load (Energy Pool), per application use (Enieda). Another income source is the income from subscription and access model. Customers have to subscribe to get access to the platforms or the basic service, such as the case of Eneida (platform access), EP tender

(application access), Energy Pool (access to availability) being available to shift or curtail consumption. These abovementioned two dimensions of revenue model have shaped the revenue model to be long-term, small and recurring model.

iv. Growth model

The growth model addresses two means of growth; one depends on expanding the sales in the current market by proposing an improved product-service and another which relies on the creation of a new market. However, two strategies of growth are addressed by the energy start-ups: "servicing the business model", "Creating platform" and "leveraging of partners" (Figure 19).

The first strategy is the servicing of the business model which means replacing the product offerings with a provision of product-service, taking responsibility for the equipment and providing installation, tailored maintenance, take back. This concept has been termed "Product-service system" (Baines et al., 2007). The way, firms servicing the BM and offer PSS, takes many forms. First firms may retain the product sale to add extra services to its product offerings. Second, firms may retain the ownership and lease the product, rent the product, or offer simultaneous use by product pooling. Finally, firms may offer the final result that a customer is looking for (Tukker, 2004). Enie.nl has increased its sales by changing its core BM and shifting from selling the PV panel to PSS. While the market of PV sales is limited and restricted to the customers who are able to pay five to six thousand euros, the solar PV PSS BM overcomes this barrier and enabling the construction of more attractive offer.

Developing a PSS offering is associated with the several elements. Some of these elements are considered in the business model design, such as partners and organisation of the enterprise, the benefits for both the PSS provider and customer, the user motivation to use the PSS (e.g. price, availability) and elements of solution (physical objects and service units) and others are not directly related to business models, such as environmental and social consideration and the interaction between the system and users (Maussang et al., 2009).

Notably, the value of a PSS model is not embedded in the physical product instead in the use of the product. This attribute encourages customer to be engaged as there is no need to learn how to use the product, maintain or dispose it (Tan et al., 2007).

PSS has been recognised as a promising approach to enhance the sustainability performance of the traditional product. PSS offerings embeds some strategies that support resources reduction, such as operational support (e.g. training, performance monitoring), product maintenance, product sharing, take-back and optimized results (Kjaer et al., 2019).

The second strategy of growth is the creation of a platform. Implementing a platform is addressed as a mechanism of business model scalability and a way that firms' competitors become partners or even customers (Nielsen and Lund, 2018). Energy Pool has added a new business model that is an information technology platform to operate flexibility. On one side of this platform there are the flexibility purchasers, in particular, the energy utilities and others, such as TSOs, DSOs, BRPs etc. and on the other side, there are the industrial plants. The interviewee has explained that the advantages of launching this new BM, simultaneously of being demand response aggregator, are that Energy Pool avoids the risk of monetising the flexibility on the market. In this case, the purchaser, mostly the energy utilities, take the risk. Another advantage is that the start-up does not have to pass through the energy market to

monetise flexibility. Energy utility being a balance responsible party can use the platform internally to optimise its portfolio and not necessarily to monetise explicitly on the market. The central value proposition is to put the possibilities at the disposal of the purchasers.

Furthermore, the start-up provides consulting service regarding flexibility identification. Similarly, Eneida has transformed the smart sensor installed on the distribution network, the employed software and several applications into an information technology platform. While currently the applications are developed by Eneida, the goal is to have applications developed by third-parties; thus, offering a platform that has on one side the DSOs and on the other side the application developers. This would ensure the BM growth as adding more applications will increase the number of services offered to the DSOs.

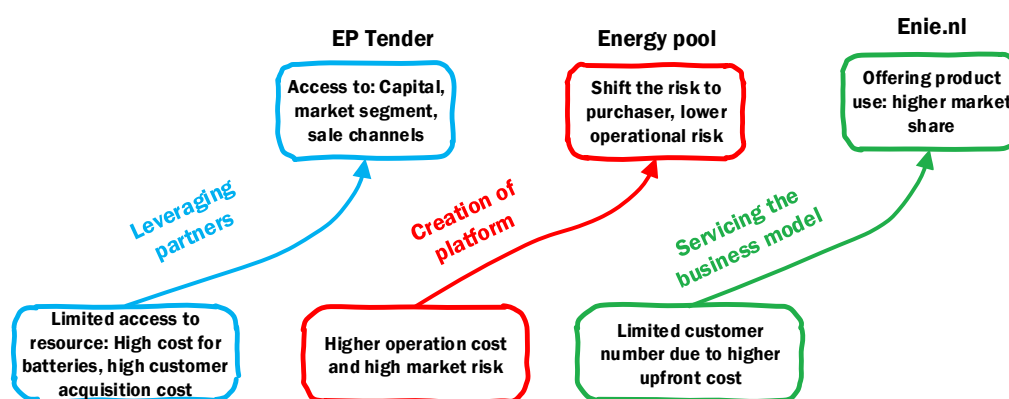


Figure 19 Network-oriented business model Growth Models

The third growth strategy is the leveraging of partners, which is about understanding the value perspective of the stakeholders and optimising the value proposition of the product-service offering them. Herein, strategic partners could be leveraged for distribution, creating customer loyalty, giving access to resources and other business model activities (Nielsen and Lund, 2018). EP Tender primer offer is extending the EVs range by trailers that function on the small combustion engine. Currently, the start-up is developing a trailer prototype that functions on an electric battery. However, launching the latter requires high capital. The founder has realised the value propositions of the potential stakeholders and included them in the growth model. The first key stakeholder is the energy utility which may be a strategic partner and can provide the required investment for the batteries. In return, the energy utility will profit from the available parking and unused trailers in order to use them as a virtual power plant that can provide capacity provision and ancillary services. The second stakeholder and a key strategic partner is an EV manufacturer who will have an increase in the sales and new market segment represented by customers who use EVs for long trips. In return, EVs manufacturer may provide the marketing service for the EP Tender service. These intersections of interests and potential synergies between the energy utility, EV manufacturer and the start-up provide spaces for further growth.

Another captured strategy is the expanding of sales in existing markets. Thanks to its BMI Stimergy expands its sales by offering a low-cost datacentre service. Its low cost operation is embedded in the BMI and the creation of the digital boiler which was a key enabler.

v. Capabilities

Capabilities refer to what firms need in terms of tangible and intangible resources, assets and activities to create a value. Two cases highlight that large capital is needed to launch the business. Enie.nl has created another firm in order to collect the required capital while EP Tender founder stresses on the need for investment from large corporations, such as energy utilities or car manufacturers. Convenience is an essential enabler and refers to fitness or suitability for fulfilling a requirement or need. When the founder of EP Tender thought about solution to the limitation of EVs ranges, the first thing he considered is the customer convenience. Remarkably, the introduced solution is very similar to what drivers do now to refuel their cars. They find the nearest trailer station, stop, spend a few minutes on changing the trailer, and drive again. There is no need to spend a long time in charging the battery, no need to worry about where you can charge it and no need for additional skills. Enie.nl BM is very similar to the traditional utility BM in terms of both customers pay per kWh, monthly bill and no upfront cost. Another case is found in the Energy Pool offer. While identification of load flexibility of industrials is a complex task for the customer to know about, the start-up provided this service in order to facilitate customer engagement. Besides, Energy Pool solutions for industrials have no significant adverse impact on the production lines of the plants which makes it suitable.

Contrary to expectations, the start-ups solutions are affordable in comparison with market alternatives. This can be explained by their innovation in energy saving or/and cost savings. The solar PV case is the most affordable as there is no initial cost and the solar electricity price is lower than the utility electricity price. The range extender solution is affordable in comparison with alternative (renting a conventional car). The monetisation of load flexibility has no initial cost, heat efficiency, as well as datacentres' service, have the lowest prices among rivals. Affordability can be explained either by the PSS model or by energy and cost savings from the novel and innovative alternative to the conventional means of consumption.

One unique capability is the capability to construct the "value network" where start-ups employ the technology as an intermediary between customers who are linked by interdependent relationships. For example, the datacentre' customers and heat efficiency customers have mutual and complementary benefits, similarly, are the TSOs and industrials.

It has been observed that in all the cases customers are engaged in the value creation process directly or indirectly. They contribute in one way or another, and their engagement is critical to implement the business successfully. This customer-orientation approach can be explained in the following: Solar PV Customers make their roof space available for Enie.nl, industrials put their operations under Energy Pool disposal for load flexibility, datacentres' customers are indirectly the source of free heat and finally DSOs' are co-developers of the low voltage applications as well as the software developers.

Following user-orientation approach can be extended to the degree that the customer is a co-developer. This is the case of Eneida where the co-founder explained that the DSO was the customer and the co-developer, and this was a key enabler factor in developing the BM and its applications.

"We described as a partnership in the sense that it is a continuous relationship with them (DSOs). They are customers, but it is a continuous relationship in terms of the services offered. And also sometimes in terms of development because some of these applications are developed with them. So they asked us for some kinds of applications sometimes, and so some of these applications are co-developed with them. They are co-developers in some cases" Eneida co-founder

Unlike the transactional model which ends once the transaction has been done, the cases show that the PSS model can generate customer lock-in strategy which ensures long-term revenue and low customer acquisition cost. An essential capability is the capability of the start-ups to work on international level tapping on similarity in customers need in terms of energy efficiency, cost efficiency, and operation efficiency. Making partnerships with system actors is a critical factor for some start-ups. The reason beyond these partnerships can be explained by the need for investment, such as the case of EP Tender or the need for those system actors' engagement as a co-creator and co-developer, such as the case of Eneida. However, those actors are described as slow movers.

The agility of the start-ups encounters by the slow decision-making processes embedded in these large corporations which defined as a barrier for those start-ups.

"Well, one challenge is because we are working with very large companies and so all the decision cycle. So we are dealing with the B2B sales process related to very large companies. And this is one of the challenges that we have" Eneida co-founder

"The car makers also are very slow moving. Because they have very large industrial base because they fear their clients. There is a lot of emotions around the car. And they fear the emotion and they fear to spoil their image by coming with the wrong product" EP Tender founder

Finally, working in a regulated market has created additional difficulties to the energy start-ups. Surprisingly, one start-up, Enie.nl which has encountered unfavourable legislation, was able to change these legislations to their favour after one year of court legal debate. Another start-up, Energy Pool, was the result of having new regulations in France that allow aggregators to participate in the energy market.

Business model sizing	Description
Value proposition	<p>Increase access to renewable</p> <ul style="list-style-type: none"> - Remove the upfront cost of the product <p>Accelerate the integration technologies in the existed energy system</p> <ul style="list-style-type: none"> - Active and real-time management of connected renewables and EVs charging station - Extending the limited range of EVs through innovative service <p>Energy Efficiency</p> <ul style="list-style-type: none"> - Increase the efficiency of the datacentre industry - Increase distribution network efficiency - Balancing and reserve market efficiency <p>Increase clean-tech productivity</p> <ul style="list-style-type: none"> - Efficient use of electric vehicle <p>Activate latent consumer capabilities</p> <ul style="list-style-type: none"> - Latent load flexibility capabilities (e.g. industrial flexibility) - Latent efficiency capabilities (e.g. datacentres)
Market segment	<p>Small consumers:</p> <ul style="list-style-type: none"> - Residential and businesses for PV panels and heat efficiency - Electric vehicle driver <p>Energy system operators</p> <ul style="list-style-type: none"> - Distribution system operator - Transmission system operator - Energy utility <p>Large consumers:</p> <ul style="list-style-type: none"> - Datacentre users - Industrials
Revenue-cost model	<p>Long-term, small recurring income</p> <ul style="list-style-type: none"> - From PV production - From range extender service - From industrial flexibilities - From heat energy efficiency - From smart sensor and platform usage <p>Pricing and payment model</p>

	<ul style="list-style-type: none"> - Subscription from access and equipment - Pay per use (kWh of PV, an hour of trailers usage)
Growth model	<p>Increase sale in the existing market</p> <ul style="list-style-type: none"> - by solar panel PSS - by proposing competitive prices of the datacentre service <p>Open new market segment:</p> <ul style="list-style-type: none"> - Range extender service for EVs - The monetisation of industrial flexibility - Distribution network optimisation
Capabilities (resources and activities)	<p>High invested capital</p> <ul style="list-style-type: none"> - Batteries, PV, sensors, etc. <p>Convenience and adaptation of customer behaviour</p> <ul style="list-style-type: none"> - Renewable energy supplier similar to traditional energy utility offer (pay per kWh) - Attaching trailer for EVs similar to refuelling gasoline in the gas station - Flexibility service for industrial without impact on the industrial production line <p>Affordability</p> <ul style="list-style-type: none"> - Competitive solar electricity price - Competitive datacentres and heat efficiency prices - Industries additional revenue from load shift <p>Value Network</p> <ul style="list-style-type: none"> - Datacentre customers and heat efficiency customers - PV panel manufacturers and residential and business customers - TSOs and industrials - DSOs and application developers - Batteries provider/investor and EVs customers <p>Customer-orientation</p> <ul style="list-style-type: none"> - Industries co-creator of load flexibility - DSO's and application developers are co-creator of low voltage platform <p>Customer lock-in strategy</p> <ul style="list-style-type: none"> - Long-term contract (Enie.nl, Energy Pool, Eneida, Stimergy) - Retaining the ownership of the asset and providing service <p>International market</p> <ul style="list-style-type: none"> - Service applicable in other countries (Energy Pool, Eneida, Stimergy, EP Tender) <p>Developing partnerships with key system actors</p> <ul style="list-style-type: none"> - TSOs and industrials - DSOs and EVs charging station, renewable generations <p>Active ecosystem intervention</p> <ul style="list-style-type: none"> - Changing the legislation of the PV panel (Enie.nl) - Influencing the market rules of demand response (Energy Pool)

Table 18 Network-oriented BM and Value creation essence

3.5.2.2 Software-based BM

In the software-based BM, the value creation is based on software solutions designed to tackle new emerging issues related either to renewable technologies or consumption patterns. In this subsection, five energy start-ups (Nnergix, Steadysun, Cloud Energy Optimize, Coturnix, Beeyon), whose solution is totally based on software development, are analysed and discussed. Business model seizing analysis is represented in (Table 19).

i. Value proposition

The software-based BM address three majors value propositions: Reducing renewables risk, Planning energy consumption, Demand response optimisation and the Consumption information visibility value. Though renewable technologies are a clean source of energy, their exploitation includes high risk because of their fluctuating nature and its influence on transactions between the involved stakeholders. This issue has been addressed by Nnergix and Steadysun whose main value proposition is to mitigate this risk by anticipating renewables future production.

This issue of renewable energy fluctuation has also been addressed by better planning and predicting the future consumption of human activities (e.g. human behaviour inside a building). This planning permits energy management systems to be proactive and responsive to renewable energy production. It also improves the efficiency of the buildings by better scheduling energy consumption and coupling building's behaviour with weather forecasts.

"That building probably tonight. We are on Friday afternoon; many people will leave at 4 o'clock. The sun will rise on the windows all afternoon. We are in winter. Probably you can cut you can stop the heating system around 11 o'clock in the morning, so you have the predictive needs of the building thanks to the weather prediction. You can set up different actions on the heating system" Coturnix co-founder

The demand response optimisation, as a value proposition, aims at reducing the energy consumption cost by shifting consumption to the periods where electricity is cheap or when there is abundant renewable energy.

Finally, the consumption visibility value provides new indicators and measures comparing to traditionally unknown or unmeasured consumption points. By that, managers have information and can take correcting actions and have a better understanding of consumption.

ii. Market segment

The addressed market segments of the software-based start-ups are five: renewable energy businesses, grid operators, buildings, energy service companies and datacentres. Software-based BMs address renewable energy businesses whose core business depends on renewables production, such as renewable energy traders, renewable energy retailers, and renewable energy suppliers and generations. As energy trading becomes a reality in Europe. Energy trading companies who deploy renewable energy technologies need to know the future production of their renewable portfolios in order to operate their assets and avoid penalties from production shortfall effectively. Those companies have an interest in two major markets, the day ahead and intraday. In France, companies commit to make a transaction before one day of the delivery in the day ahead market while they commit before just 30 minutes in the intraday market. Off-grid insular sites are not connected to the electrical grid; thus the electricity operators of those sites have a high risk of black-outs as there is no backup from the grid. Renewables' predictions also contribute to cost-efficient management of the renewables portfolios and better planning for the future mix of energy usage in each market transaction. Another party have interest in obtaining the renewables production are the grid operator, such as the energy utilities, TSOs and DSOs. These parties are responsible for most of the grid production and grid balancing, getting accurate forecast about the next day renewables' productions reduce their uncertainty and operational risk of having black-outs or congestion.

Buildings is another market segment and are responsible for the consumption of 40% of the produced energy, therefore reducing buildings' consumption is a challenge to reduce the overall consumption. The software-based BMs have integrated additional and unconventional factors to the buildings' energy management systems. These factors include a variation in energy prices during the day and the seasons, weather forecast and sun directions, inhabitant occupancy of rooms and physical, thermal storage (e.g. walls). Besides, the future behaviour of the building can also be added through the anticipation of overall human behaviour inside the building and the influence of future events on this behaviour. Energy Service Companies is

another market segment that has been identified, ESCOs that purchase the services of this new software.

Finally, the datacentre sector is a growing market and counts for a significant portion of the consumed energy. The internet will consume 25% of electricity worldwide by 2025. Datacentre's managers have an interest in reducing their operation cost as energy constitutes an essential part of the operational cost. One Datacentre might have hundreds or thousands of servers. However, some are idle and are not contributing to any productivity in the datacentres, even when they are non-productive. They are still consuming a lot of energy, and they must be cooled causing a large cooling overhead. Providing information and visibility over each server energy performance and consumption enables managers to determine the less productive servers, thus reducing the energy burden of those rarely used servers.

"We can give all the information about the users and the services and couple that with the carbon footprint we can bring in the energy information on a minute-by-minute basis that our information is updated every minute. So every server the information about what is happening in every server" Beeyon co-founder

iii. Revenue-cost model

Regarding the revenue-cost model, today storage technologies are not economically viable to handle renewable fluctuations. On the contrary, an efficient forecasting solution is the most economical solution to predict and manage these energy production variations. Software-based BMs' main cost is human resources. They count on the energy saving that customers (building, datacentre, trading companies, etc.) will have to promote their solution. Customers pay to have access to the software (subscription model).

iv. Growth model

The growth model of the software-based BMs relies on the growth of their market segments which is in continuous growth in some cases, such as renewable energy, datacentre and buildings. The primary strategy to guarantee continuous growth is to offering subscription. The software-based business model does not sell the software. Instead, they offer a monthly or yearly subscription. By that, they ensure a stable recurring income.

v. Capabilities

The major capabilities deployed in the software-based BM are the input data and data processes. The forecasting process, which designed to support production market transactions, is based on the integration of three distinct technologies. First, the meteorological method which is based on weather forecast information as solar production forecast essentially depends on sunlight and temperature and are influenced by different phenomena (clouds, fog, wind, etc.). Secondly, satellite imagery allows the evolution of the cloud cover and the production profile to be refined for the coming hours. Thirdly, camera usage, the start-up deploys camera pointing upwards that takes hemispherical photos. Used in conjunction with image processing algorithms, a cloud mass movement forecast and physical models, the state of the cloud cover is forecast for the very short term (up to 30 mins) along with the plant's production.

The optimisation process, which is designed to support consumption, is based on the integration of unconventional factors in the existing energy management systems. One of the most critical factors is the weather forecasting data, such as temperature, sun direction, humidity, etc. Variation of energy prices during the day is another factor and aims at maximising consumption during low prices and minimising consumption during high prices.

Inhabitants occupancy of the building contributes to the effective distribution of the temperature and reducing the cost of not occupied space.

The convenience of offers is associated with a few aspects of this BM type. First, concerning the acquired data from the customer, those start-ups are adapting the type of customer data. Second, regarding the energy efficiency actions in the building, the interviewees confirmed that their solutions have no significant impact on the inhabitants' behaviour. Thirdly, due to the intangible and non-physical requirement of the deployed solutions, these solutions are considered convenient for most of the customer. For example, Beyoon replaced the conventional solution which requires cables, meters and software installation with just software installation.

Software-based start-ups outsource some required capabilities to third-party enterprises in order to reduce the time and effort required to build these competencies. These outsourced capabilities are mostly some of the input data, e.g. weather forecast data, marketing, sales and product development.

Software-based start-ups that are intervening in the building management systems have built strategic partnerships with large corporations who are manufacturers and have access to buildings energy systems. For example, the building energy manufacturing systems have a monopoly over this sector, and they are key partners of Could Energy Optimizer. Another key market players are ESCOs who are the key partners and the main customers of Coturnix.

Finally, User-orientation refers to the capability of the start-ups to work closely to the potential customer (Keskin et al., 2013). Having a feedback from the customer is of great importance especially in the prototyping phase as the case of Coturnix where the founder has changed some of the prototype feature and function according to customer visit feedback.

"We had a prototype, and we tested the Prototype on Virtual data. Once we discover that the result was very good, we took that result to the visitor customer... we discover that the needs we have imagined previously was not exactly the needs of the customer and we do not need to adjust too much because the principle of predictive energy needs was the met needs of the customer, but for another application that we did not expect before" Coturnix co-founder

Start-ups emphasise the importance of the first customer, and often first customers are described as co-developers or co-creators. Choosing the right first customer can facilitate initiating product-service marketing.

"The first customer is the most important partner, and then you can spread the word and then you can say look at our reports, but that is the nice thing with our system that you looked at your kilowatt-hour meter in your gas meter, and you see the different thing. You said without our solution with our solution, that is an approve of the building" Could Energy Optimizer founder

business model Seizing	Description
Value proposition	<p>Reduce renewables risk</p> <ul style="list-style-type: none"> - Reduce renewables uncertainty - Reduce renewable fluctuation impact on the grid <p>Consumption information visibility value</p> <ul style="list-style-type: none"> - Providing detailed information over consumption <p>Planning energy consumption</p> <ul style="list-style-type: none"> - Real-time and future consumption planning <p>Demand response optimisation</p> <ul style="list-style-type: none"> - Shifting consumption to cheap price times - Shifting consumption to renewable, abundant times

Market segment	Renewables businesses <ul style="list-style-type: none"> - Actors whose core businesses are renewable energy technologies, such as producers, supplier, retailers, traders, off-grid sites. Grid operators <ul style="list-style-type: none"> - Actors who are greatly influenced by the impact of the increasing share of connected renewable energy on the grid, such as energy utilities, TSOs, DSOs, etc. Building <ul style="list-style-type: none"> - The buildings that are occupied with energy management systems Energy service Companies ESCO Datacentres
Revenue-cost model	Human resources are the major cost Subscription and pay per license Energy saving
Growth model	Growth based on expanding sales in the current markets <ul style="list-style-type: none"> - Renewable market - Datacentres markets
Capability (resources and activities)	The integration of unconventional data Production data <ul style="list-style-type: none"> - Weather data integration - Variation in energy prices integration - Satellite imagery and image process and analysis Consumption data <ul style="list-style-type: none"> - occupancy, energy prices, weather forecast Convenience: <ul style="list-style-type: none"> - adapting customer needs, habits, data types, etc. Outsourcing <ul style="list-style-type: none"> - Outsourcing processes to third-party (e.g. weather forecast, sales, etc. key partnerships with large market actors Customer-orientation <ul style="list-style-type: none"> - Customer engagement during product development

Table 19 Software-based business model analysis

3.5.2.3 Product-oriented BM

In product-oriented BMs, the core element of the business model is the technological advancement in the product-service offerings. Five cases are analysed and discussed in this subsection (Helioslite, Gulplug, Sylfen, Solable, EPC Solair). The analysis of product-oriented BM is summarised in (Table 26).

i. Value proposition

The value propositions analysis obtained from the product-oriented BMs cases shows that four distinct value propositions are offered: increase renewable productivity, improve people access to renewable, increase consumption efficiency and increase energy autonomy.

In “Increase renewable productivity”, the customer benefits from having more energy from the same renewable resources, which decreases the kWh cost and makes renewable more appealing. Helioslite offers a tracking system device that can replace the fixed PV panel base and increase solar PV yields. The second value proposition is “Improve access to renewable”, the provider contributes to open new access channel to those who used to have no apt renewable solution that can fit into their conditions or requirements. EPC Solair offers novel and light mounting system for commercial and industrial buildings whose roofs are without ballast, flat and should not have a perforation. This technological-based innovation facilitates the acceleration of PV panel take-in in this market segment. “Increase consumption efficiency” is the value proposition that is driven by many value creations. Solable founders invented new

water heater for the shower usage that recovers the heat of wasted water and reinjects it in the cold water, by that customer can save upon to 90% of the cost of the traditional water heater device. Gulplug founders invented an energy efficiency system for industrial electrical machines which is based on sensor and monitoring platform which can reduce electricity consumption upon to 30%. Sylfen proposes a system based on hydrogen batteries that can be used to store the excess renewable energy which can be consumed later. Sylfen provides its customers with energy autonomy by securing the energy supply, thus contribute to “increase energy autonomy” value proposition.

ii. Market segment

Regarding the marker segments, it has been noticed that start-ups with innovative product prefer B2B businesses as they lack capabilities to commercialise their product on the end-user level. For example, Solable prefers to sell their innovation to other companies that are able to invest in marketing, sales and customer services. The founder stress on that they have no time and no human resources for this kind of activities. In the same vein, Helioslite prefers to deal with small PV panel installers that have contact with the end-user. EPC solair uses its network partners as a customer channel; they depend on the already established trust relationship between huge supermarkets and their large corporation partners in the building sector. Besides that, the other start-ups, such as Gulplug and Sylfen commercialised their product to the customer whose energy bill is high enough to make the start-ups energy saving solution economically viable (e.g. building and industrial plant).

iii. Revenue-cost model

The revenue-cost model of the studied start-ups shows their dependence on product sales rather than service provision. Governmental subsidies represented in a tax discount format, have been addressed by one start-up that works with a PV panel as a revenue source. Moreover, the cost model can be different depending on their development phase: Start-ups with no significant cost as they are in the prototype development and pilot project (e.g. Sylfen). Alternatively, starts ups like Solable, that they encounter main costs in the manufacturing of the first order. The studied start-ups tend to deal with smaller manufacturing facilities because of they have small demand for their products. Furthermore, in the early phase development, they do not have the required capital to deal with large orders (e.g. Helioslite).

iv. Growth model

The product-oriented BMs contribute to bring in disruptive technologies and to create new markets, thus effective growth strategy. However, the technology applications, in some cases, are not yet all explored and exploited. At least one main application has been found in the development phase. For example, the hydrogen batteries main and the first application is in the building sector. Another defined application is on the district level where different renewable technologies are connected to the storage system. While the magnetic plug has many applications in industries, the first two identified applications are related to the electric vehicle charging plug and robotics plugs. EVs can easily and automatically be plugged to the charging point without the human intervention as soon as the VE is parked (Figure 20).



Figure 20 Selfplug - source: (Gulplug, 2018)

Another growth strategy is adding improvement to existing products. For example, “Save-it-yourself” product of Gulplug is a simple, easy to implement a metering system for electrical, industrial machines. The PV panel tracking system and the water heater device are already existing markets. However, the added value is embedded in the improvements in energy performance and in the cost.

In the beginning, the Heloslite has developed the PV panel tracking system for specific market niche represented by High Concentrated PV module. However, this market did not develop at that time. This challenge did not prevent the start-ups from being developed. Notably, the co-founders were able to upgrade the tracking system main characteristics to fit into new market niche represented by the residential customer and isolated sites. Furthermore, they offered this product for utility-scale and smart grid projects (Figure 21). There were able to offer a product with better performance and effective cost.

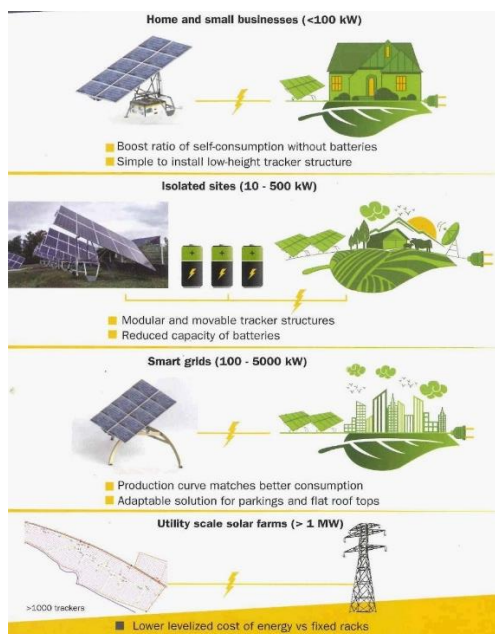


Figure 21 Heloslite new market segments

v. Capabilities

Though the product-oriented BMs core value is in the product innovation, it has been found that they provide complementary services. By providing these services, they aim at differentiating their product’s offerings. The identified complementary services are pre-audit (Sylfen), monitoring energy performance platform (Helioslite, Gulplug, Sylfen) and after sales maintenance.

One of key capabilities that is crucial to develop technological innovation is the collaboration with research and development labs. This is the case of Sylfen and EPC Solair.

Another capability that can compensate the R&D is the previous experience which was the case of both Helioslite, EPC Solair and Solable.

Offering an affordable product is an essential part of the product-oriented BMs in the sense that they make significant savings either from the low cost of the product (e.g. Solable) or from the product performance during its usage phase (Solable, Gulplug, Helioslite). This feature allows customers to have a reasonable payback period. Designing a convenient product is a common and crucial capability, remarkable result to notice is that there is no product from the product-oriented BMs requiring consumers to change some or part of their behaviour. One of the interviewees stresses on that his crucial success factor is designing conventional products. He explained that even he had developed a breakthrough technology, he introduced it to the customers in the form of a very well-known product (the case of Solable). Gulplug designed “save-it-yourself” technology in a very simple way that allows end-users to install the metering systems by themselves easily.

Because start-ups are often introducing innovations, gaining credibility is essential. One of the interviewees explained that credibility is the confirmation of usefulness and the viability of the product provided by third-persons. Credibility can be gained from one of the large market actors or from consultants who would evaluate the product far away from the entrepreneur’s point of view. Our findings emphasise those energy start-ups who do invent a technological-based product tends to outsource some business activities or to avoid the commercialisation phase. For example, Solable with its efficient and cost-efficient appliance has favoured to sell the innovation to another company.

Participating in communication activities and interacting with the surrounding environment is a key success factor for both Solable and Helioslite. The former introduced its invention in an international competition and gained the first prize which permits the start-up promote its product, gain credibility and interact with potential customers. Helioslite participation in an international exposition was a channel to one of its key customers.

Networking and Finding the right partners would facilitate the start-up market penetration in a significant way. EPC Solair Co-founder points out that one of the firm’s partner, which is one of the largest corporations in France, put them in contact with potential customers. In this partner’s network, many customers trust him. Solable’s -co-founder said that they have more than twenty partners, this seems reasonable as the two co-founders work alone in the start-up and they outsourced many tasks to their partners. These two start-ups have a mono-disciplinary team; monodisciplinary teams are considered to consist either of one person or of partners that have worked together in the same industry for a long time (Keskin et al., 2013).

Porting capabilities from other industries or domain is identified as a BM capability. The co-founder of EPC Solair affirms they had a unique capability to link and simultaneously work on two different market sides: on one side the electronic and solar PV panel market and on the other side the buildings market. This capability permits the start-up to differentiate itself in the market and create a unique value proposition.

Flexibility was a survival capability for Helioslite. This start-up has originally developed its tracking system to the HCPV market; however, this market has never materialised. Because its agility, the start-up adapted its tracking system to small projects, such as solar farms and residential customers. For Helioslite flexibility is more about adapting

customer need rather than the start-up needs. Another valorisation of start-up flexibility its ability to work in an unstable regulated market, such as the case of EPC Solair and the regulation of the solar PV panel market. Its co-founder stresses that the fast changes in the regulations are similar to playing a game which its rule has not been set yet.

"It is a new market. So, I used to say we are playing a football game and the rules are not really existing. We are waiting for the rules while we are playing the game." EPC Solair co-founder

For Gulplug simplicity is what has distinguished its BM. They designed a system that can be installed and managed by the customer without any need for any external workshop. Furthermore, the start-up is working on the creation of a community for the users in which they can exchange information and experiences.

Finally, the ambiguity surrounding novel innovations makes customers reluctant to purchase the product. It has been noticed that product-based start-ups overcome this issue by proposing a trial project in which customer can valorise the product's benefits in terms of economic saving and product performance. This was, for Helioslite, a good strategy to convince its customers about its product's advantages.

business model Seizing	Description
Value proposition	<p>A product that increase renewable productivity</p> <ul style="list-style-type: none"> - Tracking device for PV panel that increases its effectiveness <p>A product that improve people access to renewable</p> <ul style="list-style-type: none"> - Light mounting system for PV panel <p>A product that increases consumption efficiency</p> <ul style="list-style-type: none"> - Efficient water heating device - A system of sensor and platform for machine efficiency - A system based on Hydrogen battery <p>Increase energy autonomy</p> <ul style="list-style-type: none"> - Promoting local energy
Market segment	<p>Prefer Business-to-business</p> <ul style="list-style-type: none"> - e.g. Regional PV installers <p>A customer with modern to the high consumption level</p> <ul style="list-style-type: none"> - Industrials plant - Building
Revenue-cost model	<p>Cost</p> <ul style="list-style-type: none"> - Product development, manufacturing marketing and sales <p>Revenue</p> <ul style="list-style-type: none"> - From innovation selling license - From product sales - From tax discounts
Growth model	<p>Opening a new market</p> <ul style="list-style-type: none"> - Hydrogen battery, magnetic plug <p>Expanding sales in the existing markets</p> <ul style="list-style-type: none"> - Machine meters, tracking system, Water heater
Capability (resources and activities)	<p>Product sales and complementary service</p> <ul style="list-style-type: none"> - Product: e.g. Home appliance, building battery, PV panel Tracking device, PV panel fastening system, Machine sensors - Services: monitoring platform, maintenance, guarantee, etc <p>Based Research and development collaboration</p> <ul style="list-style-type: none"> - Sylfen: 10 year of research, 22 patent and 40 million investment - EPC solair: several years of research <p>Deep experience</p> <ul style="list-style-type: none"> - Solable, Helioslite co-founders <p>Affordability</p>

<ul style="list-style-type: none"> - Cost saving from energy bill (Solable, Sylfen, Gulplug) - Cost saving from renewable productivity (e.g. Helioslite) <p>Convenience</p> <ul style="list-style-type: none"> - No changes in the behaviour requirements <p>Third-person Credibility</p> <ul style="list-style-type: none"> - Consultant, key market actor, etc <p>Outsourcing</p> <ul style="list-style-type: none"> - Manufacturing processes, customer channels, complimentary services <p>Participation in competition</p> <ul style="list-style-type: none"> - Exhibition, expositions, competitions participation - Articles publishing <p>Networking capability</p> <ul style="list-style-type: none"> - High independence on a network of partners (Solable) - High independence on large key actors in the market (EPS Solair). <p>Porting capabilities from other industries</p> <ul style="list-style-type: none"> - Constructing a link between two industries (PV panel and buildings) <p>Flexibility</p> <ul style="list-style-type: none"> - Working in an unstable regulatory environment (EPC Solair) - Adapting customer needs (Helioslite) <p>Simplicity</p> <ul style="list-style-type: none"> - Easy to implement and to remove <p>Community creation</p> <ul style="list-style-type: none"> - Autonomy in the product installation <p>Free trial projects</p> <ul style="list-style-type: none"> - E.g. Helioslite
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Table 20 Product-oriented business model analysis

3.5.2.4 Synthesis of business model seizing

After examining the Network-oriented BMs, Software oriented BMs and Product-oriented BMs, the author made a synthesis of the fifteen cases (Table 21).

i. Value proposition

The value proposition element includes six unique value propositions that are identified from the start-ups BMs analysis. Defining new value propositions is a need for the transformation of today electric power system (Richter, 2012). “**Renewable accessibility**” means that the entrepreneurs provide access to people who used to be unable to obtain renewable energy resources. Customer-site BM solar PV systems have employed in distinctly different BMs in different countries. This variation is highly associated with contextual conditions, such as electricity market, policy schemes, transaction cost and PV legislation (Strupeit and Palm, 2016). On the contrary, the Enie.nl was able to shape some contextual conditions, such as enabling legislation and transaction cost. Solar accessibility is driven by removing the upfront cost, no technological risk, access to high capital, net metering scheme, and tax discount on renewable investment. The second identified value proposition is “**clean technology productivity**” in which renewables and EVs become more appealing and practical solutions. For example, residential customers can get more electricity from solar panels by using a tracking system of Helioslite; EVs drivers are able to drive for long distances using the EP Tender services.

While energy utilities are struggling to develop new energy saving business solution and become energy service providers due to their conflicting institutional demands including structural and regulatory, customer relationship challenges (Apajalahti et al., 2015), energy start-ups explore and exploit various ways to **energy efficiency** solutions. Start-ups major contributions can be explained in four values. First is the maximization of building energy

efficiency by new data integration (e.g. energy prices, weather prediction, building behaviour, thermal storage, etc.). Second is giving visibility over consumption and real-time information (e.g. datacentre servers). Third is taking behavioural aspects in consideration into predicting the energy need. Fourth is extending efficiency to the electrical grid by reducing its cost operation and maximising its electrical capacity.

Another value proposition is the **integration of clean technologies**, as renewables and EVs, into the current energy system. One of the barriers to renewables exploitation is their generation's fluctuations in which production is highly associated with weather conditions. Start-ups provide accurate predictions about renewable technologies future production that mitigates the risk of renewable energy trading and being penalised for over or under supply. Another service that has been identified regarding renewable integration is the optimisation of the capacity of a low voltage network. In most cases, renewable energies are connected to the distribution grid which is a low voltage network. Eneida has improved and increased this network capacity to connect with renewable technologies and EVs charging stations by providing real-time information regarding electrical capacity and load management.

The need for **flexibility** in energy system is increased by the increase of renewables and its variability which makes challenging to balance the generation and load. Recently flexibility has been identified as a product that can be traded in a specific energy market (Villar et al., 2018). Because of their extensive consumption, industrial plants, are economically viable resources for flexibility (Shoreh et al., 2016). Monetising flexibility of the industrial plants is the main value proposition of Energy Pool. Furthermore, TSO in France has reduced its reserve cost by 40% according to the start-up. It is evident that flexibility is also a low-cost alternative for storage systems and backup plants. Identifying and activating consumers' flexibility was a key competence for Energy Pool success.

The last identified value proposition is the **energy autonomy**. Sylfen, through their energy storage system, increase energy supply and optimize local and renewable energy consumption.

ii. Market segments

Nine market segments are observed in the sample. They are divided in three main groups of customers. The first group contains customers who are mainly working with renewables. This group contains the customer of the residential solar PV system (Enie.nl), commercial and industrial solar PV (EPC Solair), regional PV installers (Helioslite), energy trading companies (Nnergix and Steadysun). The second group is the customers who look for improving their energy efficiency. Datacentres energy efficiency has been enhanced through two different services. While Beeyon increases visibility over datacentres' energy consumption, thus its efficient management, Stimergy has reduced the operation cost directly by illuminating the need for the coolant. Buildings energy efficiency has been increased by an upgraded version of the energy management system (Coturnix and Cloud Energy Optimizer), low-cost boiler (Stimergy) and energy storage system (Sylfen). Finally, the third group contains customers who need energy flexibility. This is the case of TSOs or system operators (customer of Energy Pool), the DSOs (customer of Eneida) and energy utilities.

iii. Cost-revenue model

The main cost part, which energy start-ups encounter, is product development and product manufacturing cost. Regarding the software-based BMs, product development cost is

associated with human resources that are mainly specialised in data science and big data. In the case of Energy Pool and Eneida, the main cost part is related to smart meters and communication infrastructure.

Five major revenue sources have been detected: revenue from the product, from license, subscription, service provision and tax discount. Customers are paying for an innovative product, such as the new solar PV mounting system designed for flat and thin roofs. A customer is paying for innovation license, such as the case of Solable co-founder who sold his innovation to another business company. Subscription is mainly associated with soft-based BMs. Finally, customers are paying for service provisions, such as flexibility services or range extending for EVs.

iv. Growth model

On the one hand, it has been noticed that some start-ups have been innovative to the degree of creating new market segment, such as the case of low voltage network optimisation service. On the other hand, energy start-ups BMI have been contributing to the extension of already existing markets, such as the residential PV solar market. It has been noticed that the growth is a continuous process characterised by having high flexibility in the business model. For example, Enie.nl shifted its BM from solar PV sales to rent and give-away, Energy Pool simultaneously created IT platform in which the energy utility and industrial plant meet for flexibility identification and activation purpose. Helioslite adapted its tracking system to small project PV, and residential customer after its initial market segment HCPV has failed to be developed.

Element	Description	
Value proposition	Renewable accessibility	- Access to renewables
	Clean technology productivity	- Increase renewables and EVs productivity
	Energy efficiency	- Maximise consumption efficiency - Visibility over consumption - Consumption behaviours prediction - Grid efficiency: Optimizing electricity distribution
	Clean technology integration	- Facilitate the connection of DREs and EVs to the grid - Reduce renewable fluctuations effects
	Consumption flexibility	- Activate flexibility of consumption - Cost efficient grid balancing
	Energy autonomy	- Local consumption
Market segment	Renewable technologies customers	- Residential and small solar PV - Commercial and industrial solar PV - Regional PV installers - Energy trading companies
	Energy Efficiency customers	- Datacentre - Building
	Load Flexibility customers	- DSOs - TSOs - Energy utility

		- Industrial plant
Revenue-cost model	Cost sources	- Product development, manufacturing marketing and sales - Smart meters and communication infrastructure - Human resource
	Revenue sources	- Innovation license sale - Product sale: smart meter system, hydrogen-based batteries, solar PV tracking system, solar PV fixing system, water heater - Tax discounts - Software subscription: energy management systems, renewable energy prediction - Service provision: flexibility service, monitoring service, EVs range extending, heat efficiency, solar PV service.
Growth model	Creating a new market	- Hydrogen battery - magnetic plug - EVs range extending service - The monetisation of industrial flexibility in the energy market - Low voltage network optimisation
	Expanding sales in the existing markets	- Machine meters, - Tracking system for small PV project - Douche water heater appliances - Building energy management system - Datacentre energy management system
	Creating a platform	- Mainly between power system operators and energy consumers
	Leveraging of partner	- Mainly with power system actors to get access to market niches
	Servicing the business model	- Mainly for illuminating the upfront cost of the new technology
Capability (resources and activities)	Customer need capabilities	- Convenience - Cost-saving - Affordability - Free-trial propositions
	Market capabilities	- Flexibility - Gaining credibility - Complementary services - Thinking globally - Having an influence on market regulation - Customer Lock-in strategy
	Network capabilities	- Outsourcing unfamiliar competence - Synergies with system actors - Participating in competitions - Constituting a link between system actors and consumer
	Technological capabilities	- Engineering know-how - Collaboration with R&D labs
	entrepreneurial capabilities	- Considerable experience - Access to capital
	Sustainability capabilities	- Developing ecological products and services

Table 21 Business model elements synthesis of the fifteen BMs

v. *Capabilities*

BMI innovation requires the firm to have capabilities relating to the technology, markets and customers. Capabilities refer to the firm's resources, assets, skills and competence. (Danneels, 2002) have divided the firm's capabilities to develop new product into customer competencies and technological competences. Customer competences are market-related and are the ability of the firm to serve specific customers. This is constituted by acquiring knowledge of customer need, channels, firm reputation, communication channels, etc. On the contrary, technological competencies allow the firms to design and make products with certain features and are constituted by resources, such as design and engineering know-how, process and product design, manufacturing know-how and quality control.

Six distinct capabilities have been identified: customer capability, Network capability, technological capability, entrepreneurial capability and sustainability capability.

The first capability is customer capability, which is the ability of the start-ups to have a deep understanding of the customer's need and how they can satisfy this need. The result shows that customer capability is associated with designing a convenient and affordable product-service that can generate cost-saving and can be tested in free trial-projects. Disruptive innovations often encounter difficulties of customer acceptance due to its novelty. Solable's founder has stressed on designing and introducing a product that is known to the customer. Once Solable has invented a technology that can recover the heat output of water, they introduced its technology as a shower water heater appliance. For the co-founder, it was important the familiarity of the product to the customer. Another example is the EP Tender service. This service has been introduced to the customer in a very similar way to refuel the car with gasoline, implying there is no need for the customer to acquire new knowledge or practices.

Energy BMI products and services contribute to improving energy performance in terms of the amount of consumption, cost of energy or renewable energy. For example, Stimergy, Solable, Beeyon enhance energy efficiency. Energy Pool, Sylfen and Cloud Energy Optimizer reduce the energy cost while Enie.nl and Heloslite encourage renewable energy substitution which embeds a lower electricity monthly bill.

Affordability means proposing attractive products in terms of cost. Enie.nl is a pioneer in this capability as its offer has zero upfront cost, Solable technology has very competitive price regarding similar products in the market, the Cloud Energy Optimizer payback period is two years with 15% energy saving rate. One of the start-up's challenges is to convince customers to purchase their products; the results show energy start-ups might use free trial period in which customers are able to test their products (e.g. Nnergix and Helioslite).

Market capabilities are related to knowledge about competitors, market regulations, market segments and marketing and competitive strategies and sales. Flexibility is an essential capability that supported the development of Enie.nl, Helioslite, Energy Pool and EPC Solair. Enie.nl was able to change its BM from being a product provider to service provider, Helioslite has adapted its product to a new market segment, Energy Pool was able to deal with different industrial plants and to design customised solutions, and EPC Solair was able to adapt the changeable regulation of solar PV markets. Credibility is essential to commercialised innovations, and energy start-ups show different ways to gain this credibility. Heloslite

emphasised consultants as third persons to evaluate its BM, EPC Solair was able to be in partnerships with key actors in the building and roof industry, Solable has got its credibility from participating in international competition. Cloud Energy Optimizer's first customer, which was a municipality, was a good reference for the following customers.

Complementary services could be the source of competitive advantages for start-ups, such as Steadysun, or the source of performance optimisation in the case of Helioslite and its monitoring service of the performance of the tracking system. The capability to work on an international level, diversify the revenue resources and brings plenty of opportunities (e.g. Energy Pool, Nnergix, Solable, EP Tender, Steadysun). Two cases have shown the capabilities to influence the market regulations. While Energy Pool explicitly emphasised the importance of having experts that can influence the market regulations in France, Enie.nl has practically applied this competence and has changed the local legislation of solar PV.

Some energy start-ups have developed customer lock-in strategies that increase customer loyalty and guarantee long term revenue. Creating a platform that supports physical product operations has been used as one of these strategies. For example, Eneida created an IT platform to enable customers to manage their smart meter over the low voltage network. In the same way, Gulplug's platform enables to manage industrial machine's energy management and smart meters measurements. Servitization is another strategy that maintains customer loyalty, such as the case of Enie.nl and EP Tender. Herein, the start-up pays the initial investment in the place of the customers. For example, Enie.nl makes long term contracts with its customers for up to 15 years. The subscription revenue model is another strategy that is employed by Beyoon, Cloud Energy Optimizer, Coturnix, Nnergix, Steadysun.

Network building is a way to incorporate missed competences and knowledge by constructing platforms of contacts. Thus it compensates the lack of knowledge within specific areas of the firm (Keskin et al., 2013). Energy Start-ups use networking to build their supply chain where there is no manufacturing background and knowledge (e.g. Helioslite). They also employ networking as a reference for "proof of concept" clients (e.g. Cloud Energy Optimizer). Furthermore, Energy Start-ups take advantage of networking to gain new customers through tapping on key partners' customer list (EPC Solair). On the contrary, the network enables the start-ups to outsource some of the competencies that are not familiar with. The analysis shows that start-ups are often outsourcing the manufacturing process due to its complexity and huge capital requirement. Sales are also outsourced in some start-ups due to the prevalence of technical competences rather than business and management.

Marking synergies with energy system actors were the key to enter the market for some start-ups: Cloud Energy Optimizer's solution depends totally on the integration with building energy management systems which are manufactured by few corporations. The engagement one of these actors has been a prerequisite to initiating the BM. Eneida's co-developer and the main customer is one of the DSOs in Portugal. EPC Solair key partners, which are from the building and roof industries, constitute a market channel to the customers. One of the factors that can support the rise of a start-up is its capability to participate in competitions and exhibitions (Keskin et al., 2013). Start-ups, in their participation, seek to obtain validation from external actors and to get feedback from a professional audience. Once they get this credibility, start-ups are more eligible to get funds and are more trustworthy by the customers. By presenting their products in well-known exhibitions, they also seek to be known by the potential

customers which are useful for young firms as they have not yet built their marketing strategy and market competences. Solable founder has stressed his participation in an international competition which has compensated the need for marketing and reputation building. Helioslite's participation in an international exhibition allows the co-founder to make important contacts with key market players.

Finally, networking embeds the start-up capability to make a link between energy consumers or new actors and traditional energy system actors. For decades, traditional energy actors have had weak relationships with consumers. It has been noticed that energy start-ups are constituting and rebuilding those links. Energy Pool has made a linkage between industrial plants and the main TSO in France. Eneida, through its two sides platform, has put DSOs and energy optimisation application developers in contact.

Having storage engineering knowledge and experience is a critical capability for some start-ups, such as Beeyon, Solable, Cloud Energy Optimizer, Gulplug Helioslite. Nevertheless, Energy start-ups might collaborate with R&D labs in order to find a solution to complex problems; This was the case Steadysun and Sylfen.

The analysis of energy start-up entrepreneur's characters shows that some entrepreneurs have relied on their experience in order to innovate. These experiences include raising other start-ups, working in international corporations, working in research and development labs or universities. For example, the founders of Solable, Cloud Energy Optimizer and EPC Solair have emphasised their experiences in developing other start-ups. Another essential entrepreneurial competence is raising the required capital. Energy start-ups have shown various ways to collect money: private investment, loans, public funds, shares and crowdfunding.

Finally, developing product and services that consider the ecological and social issues are in the core of the most start-ups missions. Most of the interviewees have clearly shown and explained their start-up's positive impacts on the environment and the energy system.

3.5.3 Energy business model impact

This subsection shows the results and discusses of the business model innovation impacts on the start-ups and the energy system. The analysis is limited to three impacts: innovativeness degree, the competitive advantage and the sustainability impact.

The innovativeness degree is associated with being radical or incremental, thus with the changes that are brought and its effects on either the industry or the market, or on both. Competitive advantages are the benefits in the market in comparison with other existing products/ services that the BMI addresses. The sustainability impact points out the major improvements that the environment and the society capture from the BMI of the start-ups.

3.5.3.1 Innovativeness degree

Due to the variations in the BMI of each start-up, it is interesting to evaluate the innovativeness degree of each BM. Based on the work of (Bucherer et al., 2012) on innovativeness degree, the studied BMs are examined and analysed according to four types of BMI (See subsection 3.3.4.2). The summary of innovativeness degree is showed in (Table 22).

In the group of "incremental BMI", which refers to a novel business model that embeds incremental innovation for both the market and the industry, three BMs are identified: Nnergix, Gulplug and Steadysun. The "Do-it-your-self" solution of Gulplug is an example of this kind

of innovation because its offer consists of improvements and advancements to already existing markets. However, the start-up proposes a system that can be installed directly by the customers and a monitoring platform which gives some competitive advantages as complexity is mitigated. Similarly, the solutions of both Nnergix and Seadysun BM has no discontinuous innovation, and their services of renewable energy forecasting already exist in the market where the demand for this service is already identified. However, they add value by improving the accuracy in the former start-up and by customising the services in the latter (Figure 22).

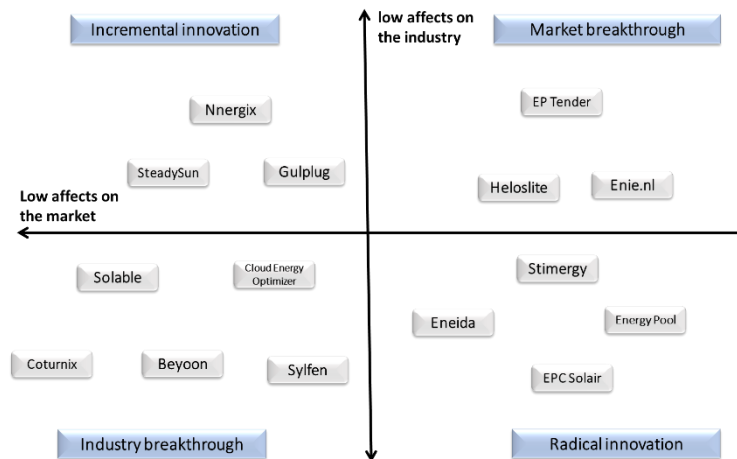


Figure 22 Innovativeness degree of the Energy Start-ups, source (Bucherer et al., 2012)

The second group, “Market breakthrough”, refers to firms that have a low impact on the industry, but that their BMs bring changes to market or customer’s behaviour. Three BMs are outlined in this group. First, Heloslite did not invent the PV panel tracking system, but they have applied it to new users. Remarkably, the start-up has found a new market segment for its PV panel tracking system. While its tracker is initially designed for high concentrated PV project, they adapted their solution to fit into the residential scale. In a similar vein, Enie.nl started with a very traditional BM based on selling PV panel. However, they realised the limitation of this BM which is limited to a very small market segment. The co-founders have opened a new market segment with an interesting offering of zero upfront payment. Finally, EP Tender has created a new market segment for EV drivers who need to drive a long distance from time to time. Notably, no significant changes are associated with EVs industries as the proposed solution is an external trailer which can be attached and dispatched. Furthermore, customer behaviour is very similar to the conventional car driver's behaviour. The customer should find the closest trailer station, stop and spend a few minutes changing the trailer.

Regarding the third group, “Industry breakthrough” describes firms that propose new solutions to the industry without significant influence on the market structure or customer behaviour changes. Cloud Energy Optimizer has changed the way that the building energy management function. The software-based solution employs real-time information from the surrounding and the outside environment and integrates the future weather prediction to optimise buildings' consumption. Coturnix has also integrated future building behaviours in these systems. However, both start-ups technical solutions have neither behavioural modification requirements nor new market segments.

Solable solution brings novelty to shower water heater system industry as it is based on heat recovery from the wasted water. Beeyon has replaced the physical and the material-based

energy management system of the datacentres with software one. This radical change to the industry brings accuracy and efficiency to the offering. The novelty of Sylfen hydrogen-based energy storage system brings many changes to the energy sector, such as the possibility to store the excess of renewable energy and re-used it is needed. This solution which is directed to be implemented into the buildings sector does not require any changes on both market and customer behaviour levels.

Finally, the fourth group “Radical innovation” refers to BMIs that capture value from changes that reach both the market and the industry. Energy Pool, which is the first independent aggregator in France, has brought a radical BM. It is novel to the industry, creates a new market segment and is associated with some customer behavioural changes. The grid balancing industry is often based on the construction of new production units often based on fossil fuel to increase grid capacity once there is grid stress or higher temporary electricity demand. Energy Pool employs a totally different mechanism that is based on the shift of consumer’s load consumption to reduce load during these peak times or grid stress periods. This BM has created a new market segment for industrials who profit from the compensation for their participation in the demand response programs. Furthermore, because customers have to shift or to reduce their consumption during peak hours, some customer’s behavioural changes are required such rescheduling manufacturing planning, activating demand response, etc.

Another interesting radical BMI is the BM of Eneida which integrates the real-time metering with the low voltage network’s operation. This innovation changes radically the way this network is managed. Besides, the created platform permits new actors to participate and contribute to the network optimization. Finally, EPC Solair BM is based on novel technology which is designed to support a specific market segment that lacks an apt solution. EPC Solair’s BM creation was based on the observation that commercial and industrial building roofs lack a suitable solution to fix the PV solar panel. The co-founders have noticed that most of the existing solution are not appropriate to the French market. While at that time the co-founder had no ready solution, their R&D collaboration with a French university has led to a novel solution based on a mounting system customised for the commercial and industrial building requirements. Stimergy proposes a unique business model that differs totally from the extant BMs in the industry, and it combines two BMs in one BM to optimise its cost. Therefore, Stimergy’s BM has created a new market segment for the datacentres provider which is the heat customer.

Start-up	Degree on BMI innovativeness	Description
Gulplug	Incremental innovation	Improving industrial machines energy metering system by offerings “Do-it-your-self” using the plug-and-play concept and contributing to simplicity in installation.
Steadysun		Proposing a customised solution for renewable forecasting energy production service
Nnergix		Add accuracy as value for renewable forecasting energy production service
Helioslite	Market breakthrough	Creating a new market segment for a tracking system for solar PV panel which is the small-scale project at a residential scale.
EP Tender		Creating a new market segment: range extending service for EVs drivers without changing the EVs industries main practices.
Enie.nl		By shifting to a service business model, the start-up created a new market segment including the customers who have the willingness to install a PV system but cannot afford it or do not want to invest money

Cloud Energy Optimizer	Industry breakthrough	Changing the way building energy management system works by integrating new variables, such as weather forecasts, energy prices, building occupancy, etc. without changing the market structure of customer's behaviour
Solable		Introducing radical changes in the way the shower heater system work and proposing a highly efficient device. No real changes regarding the market or customer's behaviour.
Beeyon		Introducing changes to the energy management systems of datacentre' industry and replaces the meter-based conventional system with software. However, no critical changes regarding the market
Sylfen		Contributing to the advancement of the energy storage industry and introducing a hydrogen storage system, on changes to the markets or customer's behaviour.
Coturnix		Introducing a new approach in the buildings energy management systems industry that integrates future building's behaviour patterns and demand response. without changing the market structure or consumer's behaviour.
Energy Pool	Radical Innovation	Creating a new market for an industrial plant to sell their load flexibility and introducing new practices in grid balancing industry based on demand-side rather than supply-side.
EPC Solair		creating a market for commercial and industrial flat roof building and introducing new technology in the mounting solar PV panel systems industry.
Eneida		Creating new market DSOs smart network and changing the operating practices of the distribution network operation
Stimergy		New technology (the digital boiler) which affects the whole Datacentre industry and creates a new market segment for datacentres which is heat efficiency.

Table 22 Innovativeness degree of the energy start-ups

3.5.3.2 Competitive advantages

One of the essential consequences of innovating in the business model is having a higher value proposition than competitors. Creating competitive advantage is associated with what the customer really needs, the product feature and customer's awareness of the product-service novelty. Competitive advantages are also determined by customer segment and competition. In this subsection, each start-up's competitive advantages are illustrated in the (Table 23).

Two start-ups are outlined as cost leadership. First, Enie.nl's competitive strategy created a cost leadership strategy. This start-up has removed the upfront payment from the PV panel offering, and this made the offering attractive from an economic point of view. Second, Stimergy organisational and technical innovation enables the start-up to gain significant operational efficiency (e.g. lowest datacentres price in Europe).

The majority of the cases (eight cases) have created a differentiation strategy as a result of their BMI. Nnergix has created competitive advantages by differentiating itself from other rivals. The start-up provides more accurate renewable energy forecast than the competitors and is able to create a forecast for renewables portfolio rather than single renewable technology (e.g. just solar), its offering includes multiple technologies forecast (e.g. wind, solar, hydropower). Gulplug through its technology has differentiated itself from the competitors by a plug-and-play concept, and its solution is easy to be installed and operated. Solable's water heater system has the feature of heat recovery which makes the product very different from other alternatives. Besides, the price of the heater is very competitive. Beeyon's solution has different technological base than the existing market offerings. While datacentre's energy management systems rely on physical equipment to measures energy performance, Beeyon has created a software-based system that is less expensive, easy to install and more accurate. Cloud Energy Optimizer focus was on a specific market segment which is the energy management system of buildings. The start-up solution is superior to the conventional solution in that it integrates more factors and variables, such as occupancy, energy prices, etc. Coturnix has the feature of integrating future data, and its solution is based on weather forecast, future events effects and building's behaviour. Thanks to its R&D investment, Sylfen has brought novel

storage technology to the energy industry that can be implemented on both building and district level. This new solution is unique in its nature. Steadysun relies on customised and complementary service in order to differentiate itself from other market competitors.

Finally, five start-ups address that market focus strategy is a competitive advantage of their BMs. Helioslite followed focus strategy; the start-up has chosen the unserved market niche which is the small project PV panel and the residential sector. The start-up adapts its tracking system to this segment and customers' requirements. Also, its tracking system has superior performance than other similar products. EPC Solair has determined a market segment that lacks an appropriate product. Its competitive strategy was to design a customised solution that serves thin, flat roofs of commercial and industrial buildings. Energy Pool offering is for a specific market segment which is the industrial plants which have high electrical load consumption and have the potential for load flexibility. Energy Pool is a pioneer in serving this market segment. The competitive advantage of Eneida is its specialisation in providing very customised service for the DSOs.

Furthermore, transferring its BM into an open platform supports its market growth as new applications will be developed, installed and sold. EP Tender is a pioneer in providing range extending service for EVs. The system nature of the start-up's solution requires infrastructure and large capital investment. The founder emphasises the collaboration with a large corporation in order to launch the commercialisation phase of the start-up development.

Start-up	Competitive advantage strategy	Competitive strategy
Enie.nl	Cost leadership strategy	In the Netherlands, it is the first mover employing PV service BM. The firm managed to change the existing regulation and got special permission to conduct its business and at the same time profit from the subsidies
Stimergy		Competitive heat price over competitors (recovered heat) Competitive datacentre price over competitors, 30% less (no cooling system operation cost)
Gulplug	Differentiation strategy	Advanced technological solution based on the magnetic connection
Solable		Product design: smaller, efficient and less noisy product Rational and competitive price
Nnergix		The ability to give a forecast for multiple technologies: PV, wind, hydro, which makes it easy for the customer The accuracy and reliability
Cloud Energy Optimizer		The first mover in the Netherlands, with a software-based solution
Beeyon		While the competitors use physical metering, the firm uses software-based which enables rapid installation, no physical impact on the infrastructure and greater visibility over the energy consumption
Coturnix		Software-based solution with a feature of integrating future events data
Steadysun		Complementary and customised service

Sylfen		Bringing novel storage technology to the market
Helioslite	Focus strategy	Opening a new market niche: a small project tracking system High performance: the customer gets more energy from the sun
EPC solair		Customised and apt product for the French market A stronger partnership with two big companies in the ceiling and metal roof which <u>privilege access to market segment</u> :
Energy Pool		Provide a comprehensive solution for industries to exploit their electrical flexibility Lower operational cost and lower prices
Eneida		Transferring the technological competences of real-time voltage and electrical load capacity monitoring to an open platform Many applications: quality of LV distribution service, energy efficiency, capacity optimisation, and EV integration
EP Tender		Employing the range extending service into a collaborative BM between EVs' manufacturers, energy utility and grid operator.

Table 23 Competitive advantages of the energy start-ups

3.5.3.3 Sustainability impact

In this subsection, the sustainability impact of each case is discussed and analysed. Regardless of the innovation degree and its economic value, herein the focus is on the way each start-up creates social and ecological values in the energy system, besides the economic value. These added values are of great interest as they are considered novel values that replace some or part of the conventional energy system and contribute to the energy transition (Table 24). For this purpose, a well-known framework of (Bocken et al., 2014) for business model for sustainability has been chosen as a unit of analysis. Herein, each case study has been examined in the light of this framework (Table 25).

The Enie.nl BM contributes to mitigate carbon emission by reducing customer dependence on conventional carbon-based grid electricity. Enie.nl is promoting renewable energy resources by facilitating customer take-in of solar PV panel systems. Besides the ecological impact, this BM addresses social value. The co-founders have realised that the capability of having a PV panel is limited to 4% to 5% of the citizen in the Netherlands which raises an issue of social equality and the renewable energy subsidies distribution. Therefore, they decided to repurpose their mission for society and took responsibility for this issue. Nowadays, their mission is to give access to renewables to most of the residential customers by removing the upfront cost of the solar PV systems. Finally, customers of Enie.nl benefit from energy bill savings. Enie.nl puts ecological and social issues as a priority rather than economic profit. Removing upfront payment for the customer implicate high capital cost for Enie.nl. Accordingly, Enie.nl contributes to changing the fundamental purpose of its business to deliver environmental and social benefits.

A complementary trailer which can be attached to the EVs is the solution EP Tender. The founder stresses on the start-up's vision of "batteries as a service". By servicing the batteries, the start-up can diversify its offers and contributes to grid balancing services. Furthermore, because long-trips are made rarely for most the drivers, possessing a trailer with a battery would be worthless. Also, the provided solution increases EVs efficiency and turns on

the EVs into an attractive, economical and practical solution. The potential benefits from the alignment of the customer's needs with the manufacturer can be summarised in the following issues: Breaks the link between profit and production, reduce resource consumption and motivation to handle the end-of-life issues as the provider retains ownership of assets.

Eneida sustainability impact can be summarised in its mission which is to allow low-carbon technologies to spread much faster. They increase the capacity available in the LV network and facilitate those connections. Eneida BM goes beyond the LV voltage network optimisation. Its collaborative model allows rapid scale-up through a platform and peer-to-peer model. This platform allows applications developers to benefit from the installed smart meters to provide services for the DSOs or other stakeholders, such as aggregators or energy utilities. This seek to bring like-minded individuals, firms and DSOs together to drive adoption of low carbon technologies can change LV network management systems radically.

Energy Pool has a business model that substitutes the traditional mechanism for balancing the grid. The current prevalent mechanism is the supply-side solution and is based on construction and activation of new production units during the demand peaks or grid stress. Energy Pool has identified two sustainability impacts. First, it replaces the production units which are fossil fuel based and non-efficiently used (just during grid stress) with load consumption shifts. By that, the emissions from those units are mitigated or avoided. Second, the increase in electricity demand requires continuous enhancement for the grid infrastructure and reinforcement. By voluntary limiting or reducing the load, thus the demand during peak's times, the start-up delays investments in the grid infrastructure. Energy Pool core competencies is its capability to influencing consumers' behaviour, promoting conservative energy behaviours during the peak's times or grid stress, therefore the start-up is contributing and encouraging industrials plants to be sufficient, as sufficiency is defined as solution that actively seeks to reduce consumption and production and argues that current initiatives solely focus on the product (supply-side) are insufficient overcome unsustainable way of living. (Bocken et al., 2014) (Figure 23).

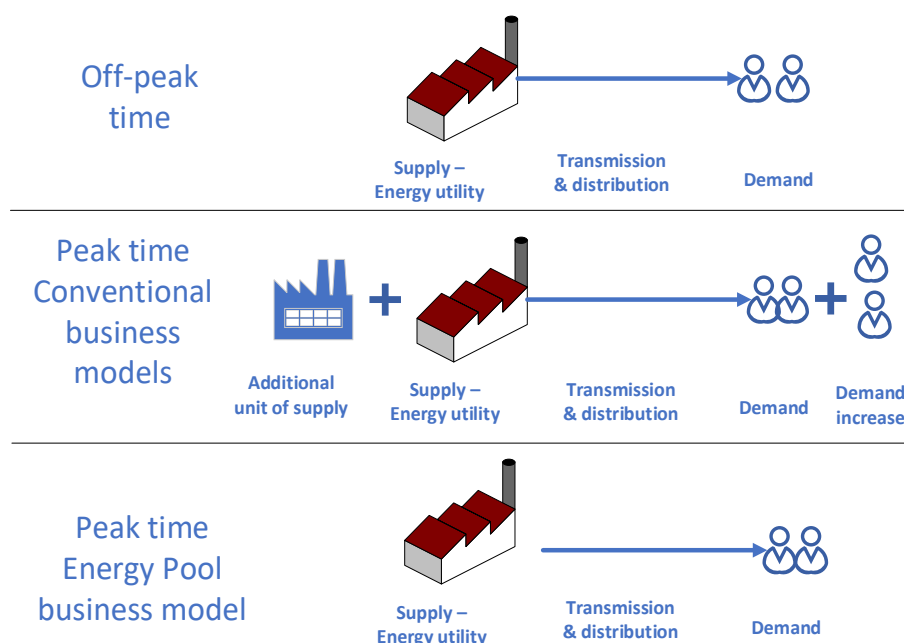


Figure 23 Energy Pool business model sustainability impact

Stimergy eliminates datacentre heat waste and turns the cooling burden into income and resource. Rather than reducing waste to its minimum, Stimergy identifies and creates new value from what is considered and perceived as waste and cost.

The sustainability impact of Steadysun and Nnergix is the optimisation of the operation of renewable energy portfolio, increase renewables efficiency and reduce the uncertainty associated with the intermittency nature of those resources. Cloud Energy Optimizer and Coturnix have employed software-based solution and real-time data collection and processing to increase buildings energy efficiency. Beeyon is also a software-based solution, and it employs its technology in the datacentre energy management system in order to achieve efficient operation and energy reductions.

Solable's technology, which is an efficient water heater system, contributes to waste reduction by recovering the heat of the warm waste water that goes out of the shower and re-conjecting it in the cold water. EPC Solair has invented a solution to fix the PV solar Panel that fits into light and thin roofs, such as the commercial and industrial buildings roofs. Heloslite solution permits the installation of PV panels on destabilised or invalid land, and it increases PV solar panel productivity. Gulplug provides an automated solution and real-time information that contributes to decrease the industrial machines energy consumption. Finally, Syfen provides an energy storage system that can exploit locally produced renewable energy in order to reduce buildings and districts energy consumption cost. The start-up shows a sense of stewardship as it emphasises its responsibility for energy transition and the willingness to manage and plan the consumer's energy consumption in a way that guarantees secure energy supply from local and renewable resources with low cost.

Case	Theme	Description
Enie.nl	Increase renewable access	Give people access to solar energy Promoting clean and renewable energy
EP Tender	Push-on Green transportation Contribute to sustainable grid balancing	Augmenting EVs efficiency Contributing to grid balancing service, reducing the need for grid upgrades Expanding clean technology markets
Eneida	Accelerate renewable integration Increase grid efficiency Contribute to sustainable grid balancing	Speed-up renewables integration within the electrical grid Optimising the LV network electricity capacity Reduce the need of additional infrastructure to for the increase future capacity
Energy Pool	Contribute to sustainable grid balancing Increase grid efficiency	Replace fossil fuel production units during peak hours with load shift Reduce the need for future grid upgrades Encourage energy sufficiency
Stimergy	Energy efficiency Heat recovery	Reducing datacentres' energy consumption Recover datacentres' heat waste
Nnergix	Push-on green energy	Reducing renewable uncertainty
Steadysun	Push-on green energy	Reducing renewable uncertainty
Cloud Energy Optimizer	Energy efficiency	Reducing buildings energy consumption
Coturnix	Energy efficiency Contribute to sustainable grid balancing	Reducing buildings energy consumption Reducing consumption during peak hours
Beeyon	Energy Efficiency	Reducing datacentres' heat consumption
Solable	Energy Efficiency	Decrease the heat consumption of residential consumer

EPC Solair	Increase renewable access	Expand the renewables market into the commercial and industrial flat roof
Helioslite	Increase renewable access Energy Efficiency	Turning unviable and destabilised sites into a viable site for PV installation Increase PV solar panels productivity
Gulplug	Energy Efficiency	Decrease electrical, industrial machines energy consumption
Sylfen	Push-on green energy	Reducing the intermittency effects of renewables by a storage system Managing energy consumption Optimising local renewable energy consumption

Table 24 Sustainability impact of the energy start-ups

Case	Maximise energy efficiency	Create value from waste	Substitute with renewable	Deliver functionality	Adopt a stewardship	Encourage sufficiency	Repurpose for society	Develop scale up a solution
Enie.nl			X	X			X	
EP Tender				X				
Eneida								X
Energy Pool						X		
Stimergy		X						
Energix	X							
Steadysun	X							
Cloud Energy Optimizer	X							
Coturnix	X							
Beeyon	X							
Solable		X						
EPC Solair			X					
Helioslite			X					
Gulplug	X							
Sylfen					X			

Table 25 Energy start-ups contribution to the sustainable business model (Bocken et al., 2014)

3.5.4 Energy Start-up business models process

This subsection synthesises the findings related to the following research question: how energy start-ups pursue Business Model Innovation? The author defines an Energy Start-up Business Model process as changes beyond the current traditional energy actors' business practices, as a result of recognizing a market imperfection as an opportunity, followed by changes in one or more of the business model elements and ending in significant improvements in the business model impacts in terms of the ecological, social and economic values. To deepen our understanding of this process, pieces of evidence have been accumulated from new value creation logics brought by entrepreneurs who explored new value propositions. Based on that, the defined framework is divided into three main phases: opportunity exploration, business model seizing and business model impact. The defined framework is expected to lead to more focused research on BMI in the energy transition field while also generating prescriptive implications for entrepreneurs who seek to push energy transition through (Figure 24).

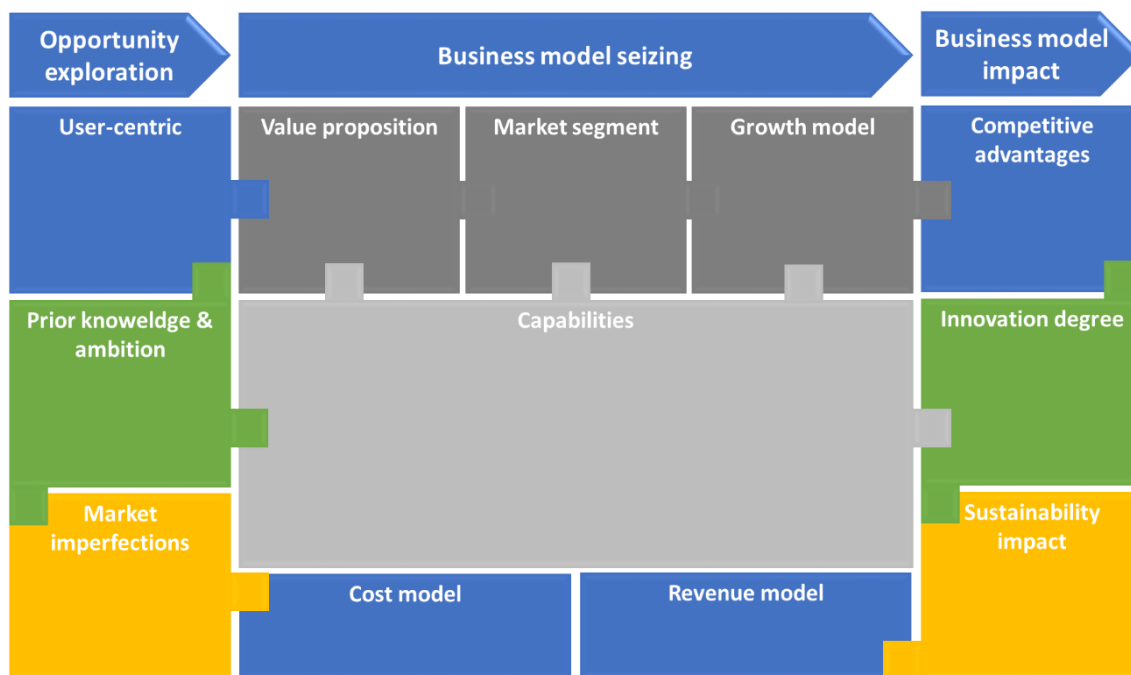


Figure 24 Energy Start-up Business Model Innovation Process

Phase 1: Search for opportunity

Regarding the first phase, opportunity exploration has been explained in a triangle of three elements: user centric approach, market imperfection and motivation. The interaction between the three elements explains the opportunity discovery. (Figure 26) shows each start-up motivation, the energy market imperfection the start-up deals with and the way it addresses the user centric approach. For example, EP Tender founder was motivated by the desire to get rid of the air and noise pollution of cars by using EVs. Driven by this motivation, the founder solution is adapting EVs behaviour and does not oblige drivers to learn or take additional actions. He has assumed that customers would not buy a small engine combustion/ second battery because it would be expensive, second, customers drive for long distance from time to time and not often, so owning a small engine combustion/ second battery would be inefficient. Third, fixing a small engine combustion/ second battery inside the car seems impractical. Thus, the only solution is a modular external trailer that can be attached and dispatched once needed. Additionally, this process should be similar to the car refuel process in which drivers search nearby station, stop, spend few minutes and then restart driving. Finally, the founder has realized that this idea could be a market opportunity, as the car are using unsustainable fuel with a price that does not reflect the degradation of the its natural resources. Thus, prices would be raised as these resources becomes less and less allowing alternative business model such EVs to replace the traditional business model of fuel-based cars (Figure 25).

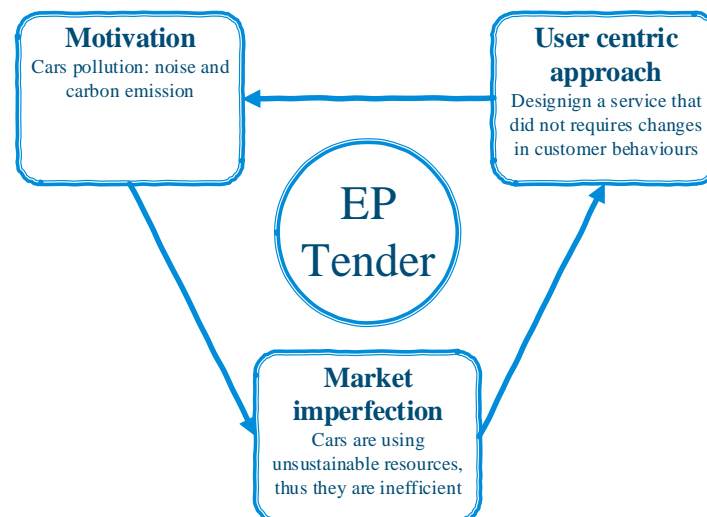


Figure 25 EP Tender opportunity exploration

The motivations of energy entrepreneurs have been grouped in four groups: Economic opportunity, Technological opportunity, Regulation changes and Environmental concern.

The **economic opportunities** have been found in:

- Demand response monetisation of (e.g. Energy Pool)
- Lack accurate service for renewable predictions (e.g. Nnergix)
- Lack customized service for renewable predictions (e.g. Steadysun)
- Lack PV solar panel tracking system on residential scale
- Potential energy savings from the integration of new variables in the energy management systems (e.g. Cloud Energy Optimizer)
- Potential energy efficiency from linking consumption with future events (e.g. Coturnix)

Opportunities from **regulation changes** have been found in:

- Regulation allows aggregators to participate in the energy market (e.g. Energy Pool)
- Regulation oblige energy savings (e.g. Coturnix)

Opportunities from the **technological changes** have been found in:

- Decrease cost of the smart meters & increase the renewable technologies shares in the LV network (e.g. Eneida)
- Energy software solutions (e.g. Sylfen)
- Development of new technology (e.g. Gulplug)

Opportunities from **environmental concern** have been found

- Car noise and pollution (e.g. EP Tender)
- Limited access to PV solar panel due to the upfront cost (e.g. Enie.nl)
- Fluctuation of renewable energy resources (e.g. Sylfen)
- Shower water heater consumption (e.g. Solable)

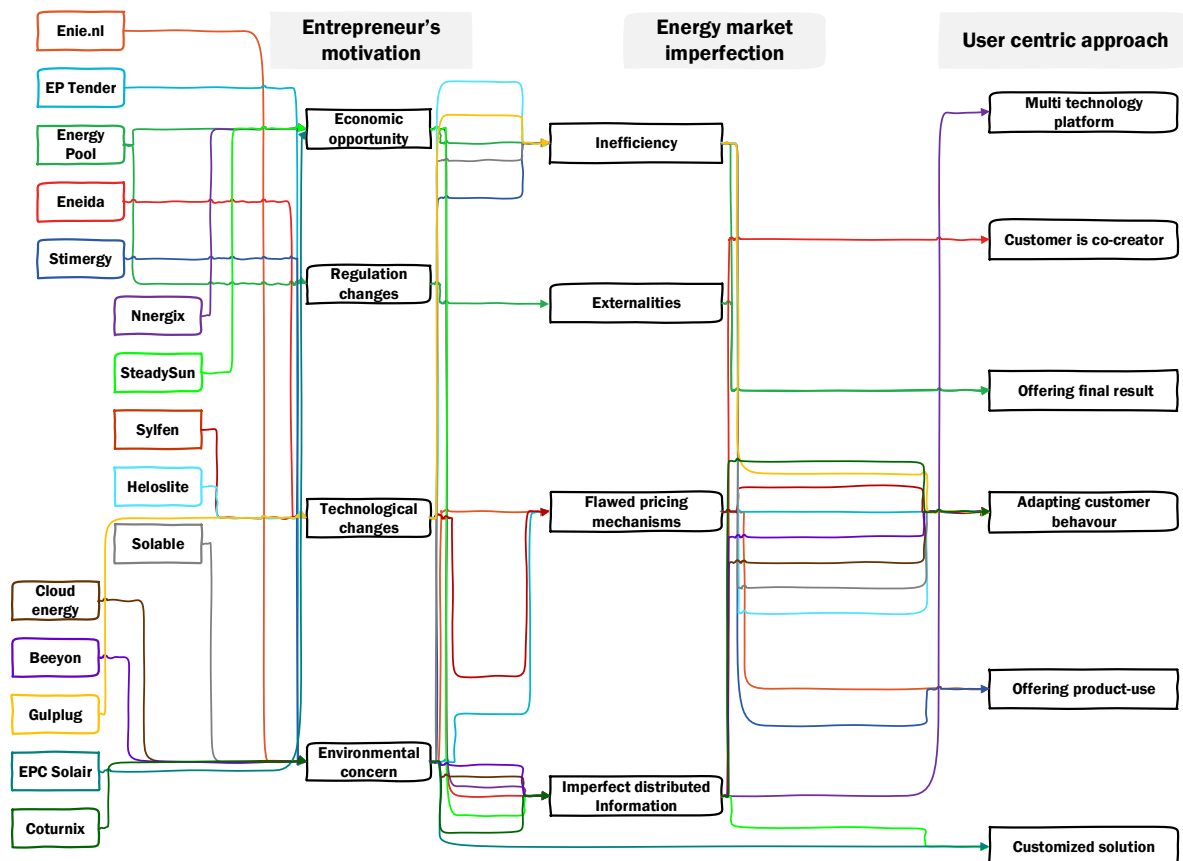


Figure 26 Opportunity exploration elements relationships

Entrepreneurs motivation is not enough nevertheless there is a market demand for an ecological product-service. Herein, energy entrepreneurs exploit one market imperfection in order to resolve an environmental or social issue related to his/her motivation. The energy entrepreneurs have exploited the market imperfections as followings:

Inefficiency:

- Overconsumption of the datacentres and having outputs as heat waste (e.g. Stimergy)
- Overconsumption of shower water heaters and have heat as a waste (e.g. Solable)
- The fixed axe of PV solar panel restricts the system energy production (e.g. Helioslite)

Imperfect distribution of information

- Absence of granular measures for datacentres' servers energy consumption (e.g. Beeyon)
- Absence of measures regarding the real-time capacity of different parties in distribution network (e.g. Eneida)
- Absence of measures and information representation about industrial machine real-time consumption (e.g. Gulplug)
- -Current building energy management systems lack information regarding weather forecast, energy prices, occupancy and future events impact (e.g. Cloud Energy Optimize & Coturnix)
- Absence of accurate prediction about renewable energy technologies production (e.g. Nnergix & SteadySun)

Externalities:

- The current business model for grid balancing and grid security requires grid reinforcement investments and release carbon emissions (e.g. Energy Pool)

Flawed pricing mechanisms:

- The current prices of cars fuel do reflect the true cost of natural resource degradation (e.g. EP Tender)
- The current energy utility electricity prices do reflect the true cost of natural resource degradation (e.g. Enie.nl & Sylfen)

Finally, user behaviour innovations are associated with user behaviour and product design (Cor and Zwolinski, 2015). It has been observed that energy entrepreneurs adapting customer behaviours and proposing a product-service that is convenient and dose not require new learning behaviour. The author refers to some aspects of this behaviour centric approach in four points:

- **Multi-technology platform:** proposing a platform that can be used by many customers and with a customised solution (e.g. Nnergix, Energy Pool, Eneida).
- **Customer is co-creator:** developing a product-service in cooperation with the customer who might also come a key partner (e.g. Eneida).
- **Offering final result:** some services are complex and requires experts, thus shifting from offering a service to offer the final results would facilitate customer acquisition (e.g. Energy Pool)
- **Offering product-use:** new technologies require high upfront cost, this barrier could be overcome by offering product use instead of product sell (e.g. EP Tender, Enie.nl)
- **Customised solution:** proposing customized solution for niche market (e.g. Steadysun, EPC Solair)

Phase 2: organising the business model

In this phase, the structure of the business model is drawn by determining its core elements and their relationships. The analysis of the start-up business models elements is described in (Figure 27). The new value propositions have been observed, such as the integration of renewable energy technologies and consumption flexibility. The power system operators such the TSO and DSO are two new customers that are served by the energy start-ups. The growth model shows that there is a trend among the energy start-ups to be an intermediate between energy consumers and power system main operators and key actors. A set of capabilities that are employed to create value these capabilities are grouped in six groups: customer need capabilities, market capabilities, network capabilities, technological capabilities, entrepreneurial capabilities and sustainability capability. Finally, the cost-revenue model shows a variation in the payment models, the financial resources and the income streams.

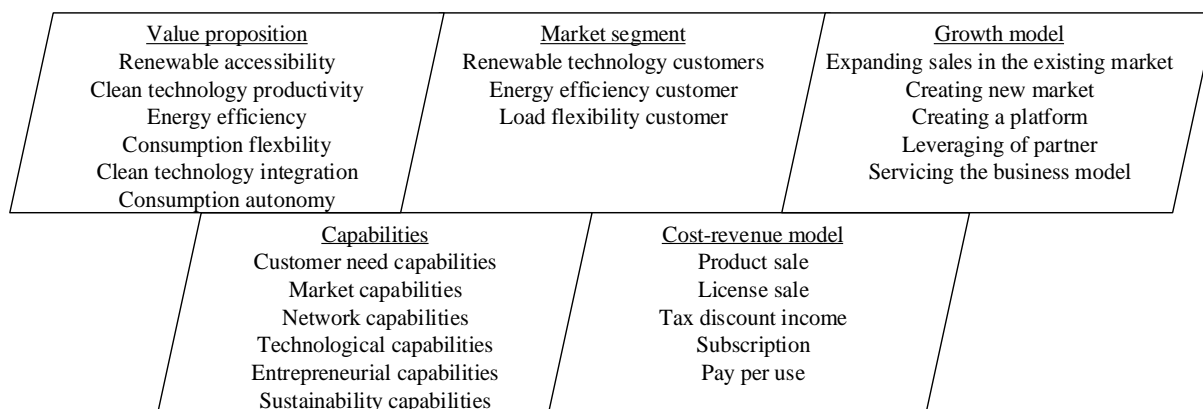


Figure 27 Energy Start-up business models elements description

Phase 3: evaluating the business model impact

In the third phase, the business model impacts, three elements can describe impact of business model innovation: competitive advantages, innovativeness degree and sustainability impact.

The innovativeness degree, which is related to the degree of change that the BM brings to the market and the industry. The competitive advantages can be improved by differentiating the offerings, cost leadership or by focusing on the unserved market niche. Finally, sustainability impact can be evaluated by the ability of the offer to having product-service that addresses one of ecological and social issues and could handle one of the market imprecations which have been already identified in opportunity exploration phase.

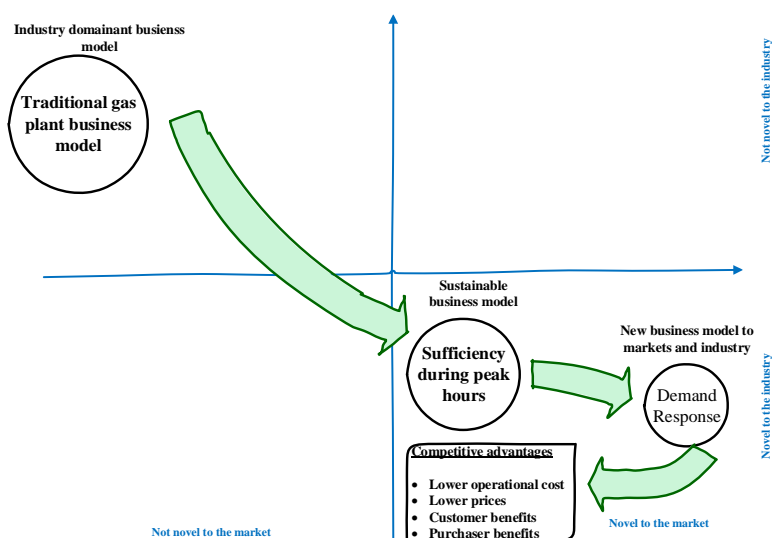


Figure 28 Business model impact elements links, example of Energy Pool case

Despite of the separation of these three elements, they are interrelated. For example, in the case of Energy Pool, the dominant business model that deal with peak hours and provide ancillary services is the construction of gas plants that provide energy once there are peak of consumption or when they power system is jeopardized. However, this business model is not efficient as these gas plants are disposed to on/off several times per day, they do not work all the time, just several hours, and they use fossil fuel resources, thus they are pollution as an outcome.

Energy pool business model sustainable impact is more sustainable than the traditional gas plant. The main purpose of this business model is to achieve sufficiency during the peak hours or system jeopardize (Figure 28). That is, reducing energy consumption or demand, instead of increase supply, during the peaks. This sustainable business model has generated competitive advantages, such as lower operational cost in comparison with a gas plant and lower flexibility products prices. In addition, this BM enables customer (industrial plants) to benefits from their load flexibility and maximize their income. Purchaser benefits are related to competitive market price offered by the Energy Pool.

3.5.5 Energy Business model types

Business model has been defined as “models” and has the feature of being a concise description of the business logic. Tapping on this character, the author has defined 12 types of business models from the empirical data (Figure 29). These types are not separated but rather interrelated to each other and can be found in one or more energy start-ups (Table 26). In this subsection, each type is discussed and defined.



Figure 29 Energy Start-up Business Models types

Providing range extending services by a trailer has many other applications. The EP Tender founder emphasises that the fleet of mobile batteries can be used as virtual power plant during stationary times. Thus, many services can be provided to the energy system actors, such as frequency regulation services, ancillary services, capacity provision, etc. when the trailers will be rented, they are range extenders, and they can also be used as a mobile charger for EVs. Moreover, they can be used as a rescue recovery service for a car, and lastly, it can be used as a zero-emission genset in cities, in places where there is no power, in big events or concert etc.

Herein the batteries concept would have multiple value propositions if they are exploited in a service model. This can maximise their usage by being alternatively used by many stakeholders. Therefore, the first pattern is “**Battery as a service**” and is defined as a business model that employs storage systems for multi-service purposes, including the primary service that is designed for and other services for energy system actors (e.g. TSO, Energy Utility, etc.).

The Co-founder of Enie.nl has approved that selling solar PV panels contains many constraints limiting their ambitions to reach the mass customers. Therefore, their main strategy was to switch their BM to a service model. This shift from product to a solution can be described by the “**Servicing renewables**” pattern which is defined as a business model that is replacing the traditional product-oriented offers with a service model, shifting ownership and responsibility to the provider.

Stimergy valorises multiple sites of energy efficiency gain in one business model. Accordingly, “**Distributed efficiency**” pattern is a business model that aggregates distributed energy efficiency values from its dispersed operational units to create competitive advantages.

Linking energy system actors and consumers through a platform is also identified as a pattern. For example, Eneida BM and Energy Pool BM. In the former, the DSOs and distribution network applications developers are linked and the latter the TSO, energy utilities, DSOs and BRPs and industrial plants have been put in connection. Thus “**Energy platform**” pattern is a business model that creates a platform where energy system actors and entrepreneurs or consumers can meet and exchange values.

EPC Solair has brought building sector competencies to the solar PV panel sector. This unique combination has resulted in a distinct value proposition. Like this, the “**Industrial combination**” pattern is a business model where competences from the energy industry and another industry are combined and aligned to create novel value.

In the traditional BMs of energy utilities, consumers have a passive role; they cannot contribute to the energy transition. However, Energy Pool BM has proved that industrial consumers can be active and can contribute to the grid balancing services. Herein, the value, which traditionally flows from the supply-side to provide balancing services for grid operation, has been inverted. Nowadays, it is possible that the value stems from the demand-side and provides grid balancing services. Consequently, the “**Reversal value**” pattern is a business model that identifies and valorises values that consumers can deliver to the energy system tapping upon the latent consumer capabilities to contribute to energy services, such as grid balancing, efficiency, renewable, etc.

Sylfen BM is based on maximising energy consumption from local renewable energy. Where the main challenge is renewables fluctuation, this start-up is trying to employ hydrogen storage technology in order to get this goal. Therefore, the “**Empower autonomy**” pattern is a business model that maximises renewables and local energy consumption.

The next three patterns are dealing with information and insufficient information issues. Having the right information about consumption will increase consumer’s awareness (e.g. Beeyon). By that, consumers can define actions to improve energy usage. Accordingly, “**Information visibility**” is a business model that provides useful indicators about energy consumption for previously unexplored consumption measures to minimise energy operational cost.

Anticipating the future patterns of energy production and consumption can reduce the operation cost and maximise energy efficiency (e.g. Cuternix). In this regard, the “**Energy behaviour**” pattern is a business model that determines the future energy consumption or/and production behaviour patterns in order to optimise energy planning cost.

Increase the dependence on renewable energy technologies requires having real-time information regarding weather forecast and other important variables, such as occupancy, thermal storage and energy prices. ICT can enable the realisation of the value creation of these business models. Therefore “**Internet of energy**” is a business model that provides real-time information regarding energy consumption, production, external and internal related environment factors (occupancy, weather forecast, thermal storage, energy prices, etc.).

The increasing cost of energy pushes entrepreneurs to reduce energy consumption by reusing and recovering heat from the consumption resources e.g. Solable and Stimergy. Thus, “**Valorising wasted energy**” is a business model that captures the wasted energy and transforms it into value.

The changeable weather conditions can have a harsh impact on renewable technology production. Therefore, decreasing this uncertainty, can improve renewable operation and increase its take-in (Nnergix, Steadysun). The “**Renewables in control**” is a business model that reduce renewable energy fluctuation cost by providing predictions, thus reducing uncertainty and risk.

Energy Start-ups Business Models types	Nnergix	Enie.nl	EPC solaire	Stimergy	Cloud Energy	Solable	Beyon	Energy Pool	Coturnix	Sylfen	Eneida	EP Tender
Battery as a service												
Servicing renewables												
Distributed efficiency												
Energy Platform												
Industrial combination												
Reversal value												
Empower autonomy												
Information visibility												
Energy behaviour												
Internet of energy												
Valorising wasted energy												
Renewables in control												

Table 26 Energy Start-up business model patterns applied to the case studies

3.6 Conclusion and implications

The history of innovation suggests that start-ups have an advantage in innovation and have a greater potential for offering radical solutions to the issues and challenges of sustainability and the system's transition. However, few studies address how the innovation process takes place within new start-ups in the context of the energy transition. Although there is an array of factors that influence the BMI process, this chapter discusses and describes a select number of characteristics that emerged from the data based on fifteen start-ups.

Developing a start-up's BM is a difficult task, especially in the energy sector where BMs and BMI have not been widely used, and sustainability can be considered a prerequisite (Wainstein and Bumpus, 2016). On the practical level, this process can assist entrepreneurs in reviewing current start-up business practices in detail. These insights are relevant for sustainability-oriented and energy entrepreneurs. The empirical-based conceptual model of the BMI process can support managers and decision-makers in the context of the energy transition.

First, at the beginning of the process, the BMI process shows that entrepreneurs are highly motivated to change the current power systems' polluting practices. They draw on the market's imperfections in terms of their capability to deal with social and ecological problems. They think out of the traditional frame which considers only the financial benefits. They use

various a whole range of different knowledge from personal experience to collaboration with university research centres to large R&D laboratories. They adopt customer behaviour and transform their innovation into familiar products that do not require significant customer learning efforts.

Then, later in the seizing phase, energy entrepreneurs have built special capabilities, such as developing a convenient product-service, constructing linkages between energy consumers and energy system actors, and proposing services with regard to the energy system. They offer new value propositions for new market segments and introduce distinct growth models. Finally, impact evaluation phase describes variation in the innovativeness degree, competitive advantages and different sustainability values incorporated in the start-up's BM.

The author recommended firms' managers and entrepreneurs who seek to develop a sustainable business model in the energy sector to use the BMI process for the initiation or analysis of their current BM, as such processes have an influence on the cognitive processes and mental model. The manager's cognition and sense-making provide the most important input in terms of initial business model design (Aversa et al., 2015; Martins et al., 2015). The author also suggests that such entrepreneurs and managers identify the capabilities needed to develop their activities and investigate how these capabilities can be obtained and used in improving the future or current BMs design. This identification of the BMI process helps outline the barriers faced by energy entrepreneurs, such as unfavourable regulations. This can be of practical use for policy-makers and entrepreneurs.

Additionally, entrepreneurs who are engaged in the BMI process may benefit from the idea of how to explore new market opportunities. The process explains the power system market imperfections which can be transformed into valuable ecological and market opportunities. This research illustrates the variation in energy innovation that is found among the studied cases. This may also be useful for evaluating the firm's current position in the energy markets in terms of the degree of innovativeness. Thus, managers can evaluate a strategic decision in terms of moving from the current position to a position where novelty in industrial practices or/and novelty in market practices can be achieved therefore, providing greater competitive advantages.

The selected number of cases enabled an analysis of BMI process of sustainability-driven start-ups. The results show the environmental and social values introduced by the energy start-ups.

Nevertheless, this approach also has several limitations. Firstly, research relies on a limited sample of fifteen start-ups making it difficult to generalise the findings. A second factor that complicated the analysis further is that all the start-ups were chosen for the purpose of this study. This bias should be addressed in further studies. Finally, few start-ups are in the very early development process which question the viability of their BMs in the future.

3.7 Summary of the major contribution of Chapter 3

- The literature review conducted in chapter 2 indicates that the business model concept has been used to explain and describe some new business practices with primary focus on the energy utility and minor attention for entrepreneurial business models.
- The literature review also reveals that an insignificant and slight research has been done examining the energy start-up business model innovations. This chapter seeks to close this gap by focusing on new energy entrepreneurial business models and, in particular, the energy start-ups in Europe. Accordingly, the research question of this chapter investigates how the energy start-ups pursue business model innovation.
- To achieve this goal, the author draws on a constructed theoretical framework based on the business model innovation literature. The framework has been employed to analyse the empirical data of fifteen case studies and consists of three main phases: opportunity exploration, business model seizing and business model impact.
- Two main theories are investigated: the dynamic capabilities and the strategic entrepreneurship.
- The first phase of this framework explains the opportunity recognition and describes the opportunities types and their correlation with the sustainability aspects. The second phase details the business model aspects by dismantling the business model into elements. It also explains the different value configurations. Finally, the last phase shows the impact of each business models in terms of the innovativeness degree, sustainability impact and the competitive advantages.
- The author follows an explorative approach and attempts to describe the new innovations brought to the energy sectors by entrepreneurs. The selected cases belong to five areas that explicitly support energy transition: renewable energy resources, demand response, energy efficiency, ecological transport and energy storage.
- The result of this chapter is a business model innovation process that describes the business model of the European energy start-ups in the context of energy transition. The process has three phases of opportunity exploration, business model seizing and business model impact.
- The first phase explains that energy entrepreneurs have higher motivation to change the status quo of the unsustainable business practices. Given this motivation, they rely on their experiences and prior knowledge to exploit some market imperfections and to introduce sustainable innovations for the customers.
- The second phase indicates that three groups of business models have been observed: network-oriented, software-oriented and product-oriented. The network-oriented are mainly start-ups that do not rely on advanced technological inventions, instead they re-organise the existing businesses in a novel way. The software-oriented are start-ups that introduce innovative software that reconsider the type and nature of information and its flow along the energy value chain. Finally, the product-oriented are start-ups that mainly introduce technological inventions in form of new products.

- The business model seizing analyses each start-up business model by investigating five elements: value proposition, market segment, growth model, cost-revenue model, capabilities. The results indicate novel values that have been introduced, the capabilities that have been employed to create them, the growth models for further development and the economic model.
- The last phase of the business model innovation process shows the generated impacts made by those business models. The analysis determines to which extent each start-up was innovative. The impacts also include the start-ups superiority over the competitors in terms of the competitive advantages and environmental sustainability added value.
- This chapter ends by highlighting 12 types of business models that have been identified in the analysed cases.

Chapter 4

4. Towards Demand Response Business Model Canvas

4.1 Introduction

In this chapter, the author limits the scope of the thesis to a particular energy business model: the “Demand response”. This convergence has emerged due to the innovative aspects of this field and the research gaps identified as a result of the accumulated experience of the author about the demand response and business model field. This knowledge has been obtained from both practical cases and from scrutinised academic studies. It can be also explained by the availability of the data and the intersection between one case study (Energy Pool) and the sum of academic articles examined in the literature review (Behrangrad, 2015; Boscán and Luis, 2016; Boscán and Poudineh, 2016; Gordijn and Akkermans, 2007; Hall and Roelich, 2016; Helms et al., 2016; Matusiak et al., 2015). The author realised that the demand response is a promising approach for an ecological balancing of the grid, integrating renewable energy resources, reducing infrastructure costs, thus reducing consumer taxes and generating economic benefits for the participating consumers and finally reducing carbon emissions from the energy sector. The demand response has been found in several energy start-up business models and it presented explicitly in Energy Pool, EP Tender, Cloud Energy Optimizer and Coturnix. Furthermore, it has the potential to be used by Enie.nl and Sylfen.

As it has been mentioned earlier, the energy system is now in transition’s phase toward a cleaner and more sustainable decarbonised resources with the objective to reach also efficient consumption. In this respect, renewable energy technologies are becoming an essential part of the energy system and therefore have a role in new business models (Strupeit and Palm, 2016; Wainstein and Bumpus, 2016). Despite the significant environmental benefits of renewable energy technologies, their stochastic nature makes their integration in the current established energy system a complex process that requires advanced balancing mechanisms to maintain the energy system’s security. Historically, the energy system is designed around what generators could conveniently deliver. However, this narrow vision can be considered a central issue and a barrier that prevents low costs, diverse and distributed demand-side resources from being part of the energy system. This barrier would increase the energy procurement costs (O’Connell et al., 2014; SEDC, 2017).

Demand response (DR) is described as a mechanism that empowers consumers by providing control signals or/and financial incentives to adjust their demand-side resources, which include consumption, generation or/and storage capabilities (SEDC, 2017). DR is a proper and justifiable service as electricity is difficult to store economically and must be balanced in real time. Additionally, grid conditions cannot be fully controlled and are exposed to rapid and unexpected events. What distinguishes DR from the traditional power plant is that the resources used can perform in a more efficient way than generators and are much faster than ramping a power plant. While DR actors provide load curtailment, generators can be free to supply energy. Moreover, the power plant, in a standby state, would have a fuel consumption penalty due to lower efficiency (Shoreh et al., 2016). DR has two approaches regarding its applications (Albadi and El-Saadany, 2008): one explicit, and the other implicit. The former is incentive-based in which consumers receive direct payment from the TSO or an aggregator upon their adjustments of their demand-side resources (generations or/and loads). The aggregator’s role is to accumulate consumers’ flexibilities and trades them in the energy market. The latter is price-based, and participants react to dynamic market or network pricing signals. However, customers may also respond voluntarily driven by ecological issues in the power system.

Typically, demand response has been used to serve large industries because of its profitability at a large-scale load level (Shoreh et al., 2016). However, DR services can be used to serve other customer segments by aggregating small loads (Yao et al., 2016). Many factors contribute to the increasing need for flexible energy systems. Such factors are the increasing share of renewable energies and Electric Vehicles (EVs), the decrease of energy storage system costs, and the development of reliable and fast communication infrastructures. DR business models are crucial for increasing the electricity system's efficiency, reliability and sustainability at a reasonable cost (Shariatzadeh et al., 2015). These BMs usually mediate different actors who are located on both sides of the energy value chain: consumption and production and their implications can foster renewable energy integration, can ensure the security of the supply, and improve market competition as well as consumer empowerment.

Despite the considerable benefits of using DR services in the energy system, there is a lack of experience and familiarity with this concept (O'Connell et al., 2014) and there is a gap regarding the business model's aspects (Behrangrad, 2015). Significant academic work has been carried out on the implications of renewable energy technologies, sustainable and innovative business models (Kanda et al., 2016; Okkonen and Suhonen, 2010; Överholm, 2017; Richter, 2013; Strupeit and Palm, 2016; Wainstein and Bumpus, 2016). This primary focus of the academic literature on renewable energy BMs neglects an essential and integral part of energy transition BMs that deals with energy system balancing and reliability. In this chapter, the author tries to further advance in this research area by combining demand response and the business model concepts. Therefore, the research question has been formulated as follows: *How can the business model concept contribute to the development of innovative demand response activities?* and an ontology perspective is used to research an answer following Business Model Canvas of (Osterwalder, 2004). By answering this question, the author tends to further advance the research on the business model and specifically the sustainable energy business models as well as to help new market actors to create ecological flexibility products through the implementation of demand response business models. The objective is to attempt to build a Demand Response Business Model (DRBM) tool. The main aim to assist entrepreneurs in the value creation process and provide them with a pre-determined and well-established framework that can be used to guide their steps in business model building processes.

The remainder of this chapter is organised as follows. Section 4.2 explains the main theories and concepts that will be used in this chapter, therefore, subsection 4.2.1 discusses the various approaches of the demand response concept that are mentioned in the literature. In subsection 4.2.2 the author discusses the business model literature, then the ontology perspective is introduced in subsection 4.2.3. In section 4.3 the author outlines an approach for implementing the demand response business model and the chapter's methodology, including the literature review, empirical data from a case study and the tool test workshops. Section 4.4 shows the results obtained from a single case study and from the ontology on the demand response. Subsection 4.4.1 presents one case study of how a demand response business model has been implemented in the French market, emphasising the business model elements, then the author introduces, in subsection 4.4.2, the DRBM ontology drawing on the business model conceptualisation of the activity system perspective and demand response. Section 4.5 advances the results and suggests the DRBM canvas. Section 4.6 presents the results of three tests used to evaluate the usability of the DRBM canvas with three start-ups. Section 4.7 summarises the results of this work and draws some conclusions. The summary of the main chapter's points has been shown in section 4.8. Additionally, the author provides some enrichments by

mentioning and referring to some highlighted examples of five different demand response business cases (examples in grey boxes). The objective with these further examples is to show how demand response has been used in real-life, what problems have been solved and the results of its implementation.

4.2 Theoretical Background

In this section, the main concepts used in this chapter are introduced and discussed. Three main concepts are presented: the demand response and its approaches, the business model perspective and the ontology perspective.

4.2.1 Variation of the Demand response approaches

In this subsection, the author highlights and refers to a set of academic approaches. The aim is not to present all the employed approaches in the literature review, but to show the approaches range and demonstrate their variations. To do so, firstly, the approaches are listed and explained, and secondly, these fragmented approaches are synthesised using the CIMO-logic (Content, Intervention, Mechanism, Outcome) which is adopted from design science methodology. This logic is based on the identification of a problematic context and the proposition of a required intervention to trigger a specific mechanism that can deliver the desired outcome (Denyer et al., 2008). This method has been tested and used in the energy transition business model context (Hellström et al., 2015). The synthesis of the selected approaches has been illustrated and presented in (Table 27).

Before presenting the explored demand response approaches, the author introduces the main terms that will be used in this chapter and their definitions:

- **Demand response provider (DRP)** transforms the demand response activity into a business by offering value to another actor.
- **Generation actor** is the actor who generates energy (e.g. energy utility, local renewable generation).
- **System Operator (SO)** is the actor who is responsible for achieving and maintaining reliable operation of the system in cost-efficient way.
- **Transmission System Operator (TSO)** is responsible for achieving reliable operations of the transmission grid. In some European countries, such as France, the TSO is also the SO. So that, the author uses TSO to refer to the SO.
- **Distribution System Operator (DSO)** is responsible for achieving reliable operations in the distribution network, which transfers the electricity to the end users.
- **Retailer** is responsible for purchasing the electricity from the energy generation and selling it to the energy consumers.
- **Customer** is the energy consuming entity.
- **Demand response purchaser** is who has an interest in the demand response service and who pays for this service which could be TSO, DSO, energy generation, energy retailer or even the customer.

4.2.1.1 Electric vehicles providing ancillary services

In this approach, an intermediate Demand Response Provider (DRP) employs a Virtual Power Plant (VPP) of a fleet of EVs to provide ancillary service and energy in the market. The DRP participates in the wholesale energy market selling and purchasing electricity. The batteries of the participating EVs are storage resources that require heavy bi-directional communication. The participating EVs need to have a minimum state-of-charge by the time it

is involved in the VPP, and the participating EVs submit their cost function to the market operator. The system operator sends signal prices like real-time electricity price and reserve price, and DRP decides the control action and chooses the less costly combinations of EVs from the available set of EVs. The intervention cost is associated with an avoided cost of not participating which is associated with the battery deterioration, the availability of EVs participants and the type of pricing mechanism (fixed or dynamic). The result of examining this approach shows that The VPP would be profitable and the system operator would get energy and ancillary services, yet there is an insufficient reward for EVs to cover their battery deterioration cost (Bhandari et al., 2018).

4.2.1.2 Electric Vehicles providing frequency regulation service

The DRP acts as an aggregator using an EVs fleet to deliver frequency regulation services. Herein the same DR resources are employed. However, the main difference is in the market segment. The frequency regulation service is a continuous service aiming at minimising deviation from nominal and unscheduled electricity interchanges with neighbouring balancing authorities. It should be delivered within a short period (5 minutes) and maintained for one hour. The frequency regulation is symmetrical which means the provider should be able to offer decrease and increase of the power output in a fast response. EVs with a bi-directional capability, are considered a good DR resource for the frequency regulation service as it requires low commitment capacity with a reasonable payment. The service is often provided in the day-ahead frequency reserve market. For example, in the U.S, the offer must be bid at least one day before delivering the service. Therefore, in the horizon of 48 hours, the first 24 is used to generate actionable bidding plan while the next 24 hours are used to ensure the terminal conditions are put in place (e.g. state of charge) (DeForest et al., 2018).

The demand charge can have impact on the facility that EVs are charging from. EVs may cause an increase in the demand charge of the facility when total facility load is near the monthly peak. Thus, any increase in demand charge should be avoided due to their extreme cost. On average, the fleet state-of-charge should always be 50%, this can be explained by the nature of the frequency regulation service of having the capacity reserve to participate in both up and down regulations simultaneously. In contrast, EVs participants tend to maximise their charging to have the total benefits of the battery. Herein, the availability of the participants and their commitment to the service conditions is an essential factor. Another factor is the enforcing regulation bidding symmetry which obliges the DRP to provide up and down regulation. This factor profoundly affects the service as there is considerable disparity between the regulation up prices and regulation down prices. The service also depends on the utilisation factor which refers to how much a resource will be exercised in each direction (DeForest et al., 2018).

4.2.1.3 Refrigeration and Chiller providing Powermax service

Other resources for DR are the thermal storage. A DRP can employ and coordinate the supermarket refrigeration systems and chillers (part of the air conditioning system) in conjunction with an ice storage for delivering a PowerMax service. PowerMax service is a service to maintain the capacity within its limits in the distribution network. The objective is to limit the active power consumption and maintain DSO network security by ensuring the capacity will not jump off the PowerMax limit. In the PowerMax service, the aggregator pools the thermal storage resources to stay below a predetermined value during the service activation. By receiving this service, DSOs will ensure that the feeders of interest will never be higher loaded than a specific value, especially during winter months of the year when those feeders

are exposed to higher risk to be overloaded. The value creation is based on thermal energy storage in which electrical energy can be stored in the form of thermal energy to be consumed later in other time windows. Therefore, two storage resources are used: the supermarket refrigerators and chillers combined with ice storage. The state-of-charge of chillers should be measured to estimate the activation and duration time. The avoided cost is the cost of the deterioration of food from the supermarkets and discomfort for the air conditioning systems. The main value creation logic is to use two thermal storage resources with different characteristics in which the aggregator keeps the total consumption below the PowerMax level during the service activation (Figure 30). The sequences of actions can be described as following: before the service activation, the chiller can make and save some ice during the off-peak hours in an isolated tank, this ice will be used later for providing cooling while the chiller is off during the service activation of on-peak hours. The refrigerators do not have the capabilities to store energy for a long period, therefore the process of reducing consumption is run by switching between two consumption resources. While the chiller is off, refrigerators can increase consumption and stock energy in thermal form in the refrigerated food. Afterwards, the chiller will be turned on, and the refrigerators will decrease their consumption to the minimum taking advantage of the saved energy. In the case presented by Rahnama et al (2017), the aggregator was able to provide the aforementioned DSO service to a satisfactory level. Results indicate that the total power consumption exceeded the maximum limit in just a few short periods, which is not consequential from a DSO point of view. (Rahnama et al., 2017).

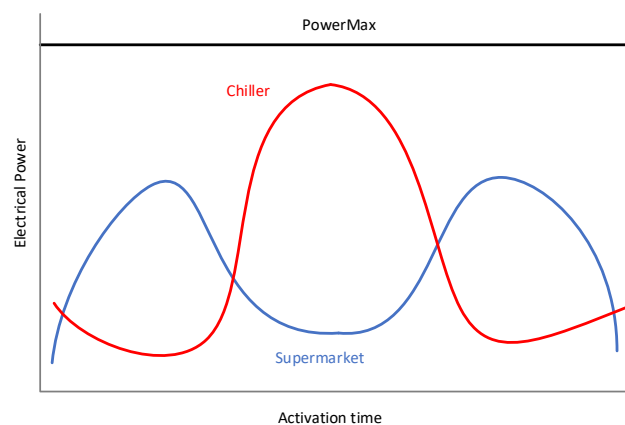


Figure 30 Aggregator potential power distribution for the PowerMax service, source (Rahnama et al., 2017)

AusNet: Demand Response service for DSO

Ausnet has engaged large commercial and industrial consumers in a demand response program that aimed at reducing electricity demand during times of network constraints in selected parts of the distribution network. Ausnet added and linked the consumption patterns to the particular network feeder peak demand. Customer would be able to reduce consumption during network stress (evening and afternoon of hot days) by using temporary generation or reducing load of plant, air condition, pumps etc.

The firm estimated that customers were able to remove of up to 800kW from the network up to 4 hours at a time. The idea was to make the customer response to ad-hoc Demand Reduction Days notification in response to signals sent by the Ausnet within short notification interval and an appropriate financial incentive. The project resulted in a successful implementation of the local network support service and improvements in the Critical Peak Demand response performance. (Figure 31) illustrates the demand response results in reduction of peak demand on the feeder in the afternoon. In addition, at the end of the year, the demand response program was evaluated for the contribution to defer network investments referred to as “firmness”. Finally, Ausnet expanded its commercial and industrial customer portfolio throughout its distribution network to total of 22.5 MW of 25 customers (Ausnet, 2015).



Figure 31 Ausnet customers performance on Demand Reduction Day, source: (Ausnet, 2015)

4.2.1.4 Residential refrigeration providing ancillary services

Residential consumers can also be precious resources of the DR services. A DRP can make use of the thermostatically controlled loads and aggregates multiple residential refrigerators to provide power reduction and ancillary service. As the refrigerator has the ability to store the temperature effect in a thermal form, they can be used to provide power reduction services. This service is quantified in terms of temperature; therefore, the deviation in the quality of the service along the different power reduction levels can be analysed. Moreover, the

temperature represents the amount of thermal energy stored within the system, in other words, its flexibility. The value creation logic is to control the refrigerators' states (ON/OFF) to maintain a given set-point value of the aggregated power consumption without affecting the temperature limits of the individual refrigerators. (Figure 32) shows the natural thermostatic cycles of a refrigerator without control of an external aggregator in which fridges are out of control and when they are off, they reach the lowest temperature. However, this approach changes this status quo and propose an external control intervention that aims at aggregating the mass fridges in order to limit the aggregated power of the participating fridges.

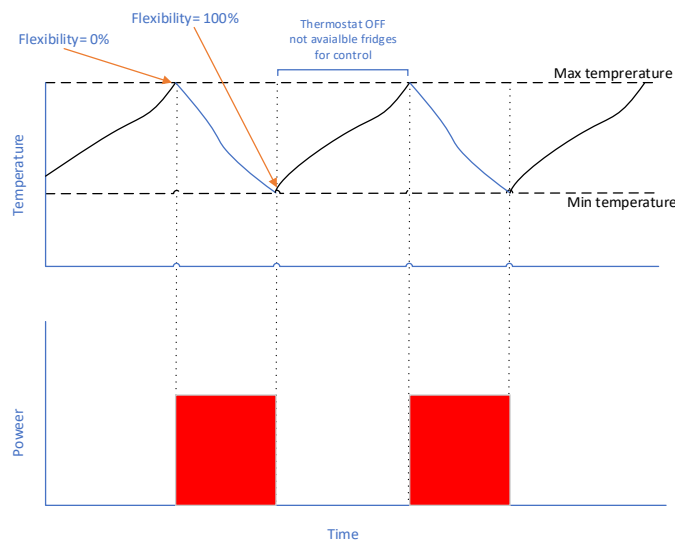


Figure 32 Natural thermostatic cycle of a refrigerator without the intervention of external controller and aggregator, source: (Lakshmanan et al., 2017).

If the power is higher than the set-point, the coolest fridge is switched-off, the procedure continues till reaching the control set-point. On the contrary, if the power is less than the set value, then the hottest fridge is switched on, and the procedure continues until the aggregated power reaches its set point. The fridge flexibility is the duration of being OFF that can be maintained without affecting the individual refrigerator's temperature limit. It has been found that the available flexibility under normal operation is 28% while it is 54% under the aggregator control (Lakshmanan et al., 2017).

4.2.1.5 HVAC providing ancillary service

The DRP can utilise the Heating Ventilation and Air Conditioning (HVAC) system to provide Frequency Regulation (FR) services by adjusting the power consumption following the frequency signals without sacrificing the occupant thermal comfort. The HVAC systems are not considered ramp-limited resources because they can get a response faster than the traditional online generators (available and connected to the grid), this can be explained by the smaller moment of inertia of the motor (Zhao et al., 2013). In the PJM energy market (Pennsylvania-New Jersey-Maryland), in the U.S, the resource must be able to provide at least 100 KW of frequency capacity in both directions up and down. The resources must be able to receive FR signals and make the response data available for the regional transmission organisation. An initial test is required to participate (Zhao et al., 2013). The FR transactions are established through the following procedures: the SO sends the FR signals every 10 s, the resource owner determine the maximum FR capacity for each resource every 2 s. Then the SO sends back FR signals every 2 s. The result shows that the commercial building HVAC systems are capable of

providing ancillary services to electric grids by accessing building thermal energy storage while maintaining building occupant comfort (Zhao et al., 2013).

Honeywell: *Demand response in commercial company*

Guthy Renker Fulfillment Service (GRFS) is a logistics and warehousing service provider, has 235,000 square-foot distribution centre in California and operates from 4 a.m. until 8 p.m. The energy demand during peak period is on average 500 kilowatts and its monthly energy bill is more than \$30,000. The energy utility of GRFS, Southern California Edison (SCE) changed its pricing scheme to dynamic pricing that tying electricity rates to supply cost. As a result, the prices during peak hours increased from \$0.13/kWh to 1.36/kWh. SCE can call up to 12 peak demand events each summer, which means a significant increase in GRFS electricity bill. GRFS made attempts for manual changes of 45 HVAC units, 29 battery charges and hundreds of lighting fixture during peak events however they had limited saving and were time consuming.

GRFS enrolled in SCE Auto DR program managed by Honeywell which enables automated demand response to energy price signals sent by SCE. This energy management system includes secure path for SCE to communicate with building systems during peak events, automatically triggering load-shedding measures. In addition to modules to oversee forklift battery charges and commercial thermostat for the HVAC system. The DR mechanism includes precooling the distribution centre before an event, then adjusting the thermostat set points by four degrees higher during the peak events to maximize saving and maintain comfort. Complement the forklift battery charges with a locked mode during peak hours to prevent charging during peak hours. Finally, turning off most lighting and exhaust fans during peak events (Honeywell, 2012).

4.2.1.6 Wind farm and storage providing ancillary service

Wind farm and energy storage system can optimise the bidding strategy in energy and spinning reserve markets by coordinating their operations and offerings to the market. Because of the stochastic nature of wind generations, the deviations between the bids and the real-time supply are expected. Therefore, they are exposed to imbalance penalties. This coordination can reduce imbalance risk and generate extra revenue from the spinning reserve markets. The avoided cost for the storage system is the cost of earnings from participating in the market instead of reserving the capacity for the potential imbalances of the wind farm. The maximum duration of the service is 2 hours, and it must be in both directions up and down spinning reserve. The results show that conducting a coordination bidding strategy can reduce the imbalance cost by 51% and increase the total profit up to 26% in comparison with uncoordinated bidding strategy in which energy storage systems submit bids independently from the wind farm (Rodrigues et al., 2016).

EnerNOC: *Demand response in a hospital*

Kell West Regional Hospital has 41 beds located in Texas with a 445,000 square-foot facility. The hospital energy monthly cost is \$70,000. The hospital has an on-site generation system that has been used to reduce the energy cost during peak hours. The hospital used EnerNOC's energy intelligence software to reduce its energy cost. In 2008, the hospital engaged a demand response program with EnerNOC "Emergency response service" in which it earned annual \$10,000 for its willingness to switch to hospital's on-site generation during demand response dispatches. For the first two years, the hospital passed successfully occasional test dispatches without any real emergency event. However, in February 2011, a severe snowstorm led to a loss of 7,000 megawatts of generation about 15 per cent of Texas's total electricity supply. In response, the Electric Reliability Council of Texas ERCOT dispatched EnerNOC's demand response network including Kell West Regional Hospital. The EnerNOC notified the customers of the dispatch, and they reduced demand via curtailment and activation of on-site generation. The EnerNOC activated the on-site hospital generation directly without requiring intervention from the hospital. Nevertheless, the dispatch continued, exceeding to 25 hours the maximum length defined by the ERCOT's Emergency Response Service, nevertheless the hospital continued to work normally. Besides, the installed monitoring system, the hospital took a closer look at the hospital ongoing energy use (e.g. non-essential lighting, unused equipment, etc.) which led to a 30 per cent energy reduction (EnerNOC, 2012).

4.2.1.7 Scheduling appliances for electricity bill reduction

Appliances scheduling refers to providing optimised energy consumption patterns that reduce cost and mitigate peak-loads. This optimisation requires a load shift from high price periods to low price periods and from high load time to low load time during a typical day (Shaheen et al., 2016). The value creation is based on sending price signals through a smart meter, assuming a Time of Use pricing mechanism in which the prices change hourly during the day. The appliances can be classified as elastic (e.g. washing machine, dishwasher, etc.) and inelastic loads (lighting, refrigerators, networking devices, etc.). Users' ability to delay consumption depends on the week days. It is less flexible during the weekdays while it increases in the weekend. Studies show that users make a trade-off between comfort and cost. Scheduling of appliances with Energy Management Systems (EMS) produces more efficient results by reducing the cost and peaks when the user is willing to offer more delay in shifting the appliances (Shaheen et al., 2016).

Itron: Demand response of residential sector

Gulf Power is an energy utility that is located in Florida and serves more than 455,000 residential customers. In 2000 the utility and Itron (technology company) initiated the Energy Select program which is a price-based demand response program based on time-of-use / critical peak pricing in which critical-peak component is added to time of use rate. The challenge was to obtain the amount of load control and verification while sufficiently incentivizing customer to participate. The solution was a smart thermostat complemented with software platform. The program entails four variable prices based on the time of day, the day of week and the season that reflect the actual cost of the produced electricity. The customers can automate their energy usage through the platform either at home or their smartphone and can pre-program their central cooling pumps and heating systems, electric water heaters and pool pumps to respond automatically to specific pricing signals from the utility.

As a result, customers benefit from up to 15 percent annual saving on electricity bill. The program delivers high amount of load per household and cumulative megawatt that makes the program a meaningful load source for the utility. In winter, each household contributed to 2.4 kilowatts to the peak load, proving approximately 46 MW. While in summer, each contributes to 1.7 kilowatt and a total aggregated capacity of 32 MW. This substantial reduction enabled the utility to defer building additional generation units (Itron, 2018).

4.2.1.8 Residential scheduling for voltage rising problem service

As it has been addressed in the previous approach, the residential energy consumption scheduling has the potential to shift consumption from peak hours to off-peak hours, but what if this approach has been coupled with a residential PV solar panel system. Herein, the focus is on shifting consumption to hours when the solar power generation production is in its maximum. This approach can reduce the consumer energy expenses and at the same time mitigate the voltage rise problem. The traditional distribution network has been designed to be unidirectional, performing electricity flow from the substation to the household. The high share of PV systems installed on the household rooftop can produce substantial power flows from the households to the substation and can cause the voltage magnitude of the households exceeds the upper limit of the allowed voltage, what is termed “voltage rise problem”. Thus, there is a need for maintaining the voltage within determined buses in the distribution network in a specific limit. There are few strategies for tackling the voltage rise problem. For example, the DSO can upgrade the transformers and the feeders to host higher share of PV systems in some areas. Another strategy is based on active and reactive power of PV inverters in which the generation curtails the PV production, following a control signal received from the DSO or limiting the active power of the PV system to 70% permanently. Residential energy consumption scheduling is a strategy that aims at shifting consumption from peak hours to hours with high solar power generation. By that, it reduces the consumer’s energy expenses and mitigates the voltage rise problem. The DR resources are divided into three categories: *Deferrable, Must-run and Energy storage system load*. This approach requires an energy consumption scheduler who determines the operational schedule of the deferrable load to

minimise the electricity bill and reduce the power flow of the PV systems. The scheduling process is based on the historical data provided by the DSO (Yao et al., 2016).

4.2.1.9 Industrial plant providing demand response services

Industrial plants are high electricity consumers, and their peaks load can reach hundreds of MW; thus, network connection is made directly from the transmission lines. The large industries, such as chemical, cement and paper plants are under-utilised and have great potential to make revenue from the DR service (Xenos et al., 2016). The consumption of industrial plants can be divided into production and support services. The former is linked to the production lines and processes, such as furnaces, motors and pumps etc. and without production would be reduced to zero. The latter is more flexible and is part of all the services around the production, such as lighting, heating, ventilation etc. Technologies that can be used to support industrial plants in performing demand-side activities can be divided in Energy efficiency, direct control, Storage, on-site generation and Microgrid. *Energy efficiency* improvement can be achieved through real-time data and granularity of control on operations. This can provide managers with the needed support to respond to stress signals from the electricity grid. *Direct control* indicates that energy utility controls the facility load directly without the engagement of the facility owner. *Storage* entails three technologies: electrical storage, thermal storage and inventory storage. In addition to the distributed *generation on-site*, as these large industrial facilities often have on-site generations. Finally, *Microgrids* refer to multiple uses of energy resources, storage systems and network in a way that the facilities can function off the grid. The demand response events depend on some factors: notification time, duration, frequency and quantity of electricity and granularity of control. Open automated demand response OpenADR, which is a specific tool, enables industrial participants to receive the market signals which are converted into price, reliability or load instructions. Then, they are communicated with supervisory control and data acquisition systems or with programmable logic controllers (Samad and Kiliccote, 2012).

Centrica: Demand Response in a paper plant

Sappi is a global paper company with 12,800 employees and a production of 5.7 million tonnes of paper. Because the paper industry is a very energy intensive sector, the firm had to find ways to reduce its energy cost and one of them was to integrate demand response programmes. The Sappi Lanaken mill facility consists of a pulp plant and two paper making and coating lines. After the wood chips are produced, the pulp can be buffered before entering the paper making process, which makes pulp plant curtailments possible without an impact on the production downstream. Sappi employs this flexibility into the reserve market via the TSO. However, the return was low, and the company wanted to participate into more profitable DR programmes.

With the help of Centrica, Sappi flexible pulp plant could be leveraged within a fast response reserve (primary reserve) which requires a response time of 30s and a short duration up to 300s. Centrica provided automation systems that react in seconds with no human intervention required and Sappi was inserted in the portfolio of Centrica. The result increased Sappi payment with no impact on production. Additionally, the risk has been shared between Centrica and a large group of consumers (Centrica, 2018).

As a result, the GRFS, in the first summer, with the new pricing scheme Time Of Use was able to reduce energy cost by more than 30 percent over the previous year. In addition, GRFS benefited from a \$8,000 rebate from the SCE for their participation (Honeywell, 2012).

4.2.1.10 Microgrid voltage congestion service

By using the aggregated flexibilities of microgrids, a DRP can run local optimisation and aggregate small to medium size distributed generation, energy storage systems and consumptions and sell them to the DSO to solve congestion problems of low and medium voltage network. A microgrid can provide a coherent structure to manage and coordinate a set of distributed generations, flexible and inflexible loads and energy storage systems. Due to the small size of low and medium voltage signals, in most cases, they are kept out of electricity and service market. However, (Amicarelli et al., 2017) proposes a market mechanism similar to the electricity market where participants can submit their bids for each traded block with a minimum price at which they are willing to sell. This market is identified as “*a Flexibility Service Market for active management of distribution grids is a parallel market to the electricity market, which could be managed by DSOs or by new authorities, such as a local services market manager*”.

Approach / reference	Context			Intervention type		Mechanism	Outcome		
	Problematic	Type of resource	Resource size	Involved partier	Main activity		Economic model	Constraints	Evaluation
EVs providing ancillary service (Bhandari et al., 2018)	Trading energy in the market using EVs	Storage (electric storage)	Granular and small distributed capacities	EVs, DRP and TSO (market)	DRPs create virtual power plant	Exploiting the availability of the parking EVs	Bidding in the energy market and selling ancillary service	Battery deteriorations, Minimum state of charge	Service successfully implemented but insufficient reward for EVs to cover their battery deterioration cost
EVs providing frequency regulation (DeForest et al., 2018)	Solving the problem of grid frequency variation using EVs	Storage (Electric storage)	Granular and small distributed capacities	EVs, DRP and TSO (market)	DRP coordinates by charging and discharging fleet of EVs	Exploiting the availability of the parking EVs	Bidding in frequency regulation market	Symmetry of energy, Maintaining 50% average fleet capacity, utilization factor	The result depends on utilization factor and regulation direction
Refrigeration and Chiller providing PowerMax service (Rahnama et al., 2017)	avoiding overload in the distribution network during winter using refrigeration	Storage (thermal storage)	Medium distributed capacities	DSO, Aggregator and commercial supermarkets	Limiting the active power consumption	Exploiting alternatively two thermal capacities	Selling congestion management service (reducing overload) to the DSO	Food deterioration	The aggregated power consumption stays below a certain level during an activation time
Residential refrigeration providing ancillary services (Lakshmanan et al., 2017)	Providing ancillary services using refrigeration	Storage (thermal storage)	Granular and small distributed capacities	Residential fridges users, TSO, and aggregator	Reducing consumption during peak hour	Exploiting the thermal effect and coordinating a mass of residential fridges to keep their aggregated power consumption at a given set-point	Participating in the ancillary service market	Food deterioration	Aggregating and controlling the residential fridges increase their flexibility
HVAC providing frequency regulation (Zhao et al., 2013)	Responding to the grid frequency variation by adjusting HVAC consumption	Storage (thermal storage)	Medium distributed capacities	Commercial HVAC users, and TSO	Automatic control of the HVAC based on frequency signal from the SO	Exploiting the quick response and the thermal storage capacity of a commercial HVAC	Participating in the frequency regulation market	Associated with how many pieces of HVAC equipment are operating in response to the weather	Commercial HVAC system are capable of frequency regulation service
Wind farm and storage providing ancillary service (Rodrigues et al., 2016)	Providing spinning reserve by combining wind farm and storage system	Storage (electric storage) Supply (wind farm)	Medium to large distributed capacities	Storage facility, wind farm and energy market	Coordinating the bidding in energy market of the wind farm and storage system	Store the surplus production otherwise curtailing and generating electricity once the production is low	Participating in the spinning reserves market Reducing imbalance cost of wind farms	Inefficient usage of the storage system by limiting its usage to the potential imbalance of the wind farm	Avoiding penalties and generated additional income from the spinning reserve services
Scheduling appliances for electricity bill and peak reduction (Shaheen et al., 2016)	Reducing consumer's energy bill by consumption scheduling	Load (residential consumption)	Granular and small distributed capacities	Consumer	Scheduling consumption according to the variation in the electricity prices	Shifting consumption to low cost electricity price times	Generating savings on the electricity bill	Residential consumer behaviours changes by Real Time Pricing	Users can have a cost reduction by using EMS however, there is trade-off between comfort and cost and it depends on

									willingness of the user
Residential scheduling for voltage rise problem service (Yao et al., 2016)	Maintaining the voltage in distribution network under upper limit using households scheduling in local intensive PV area energy	Load (residential consumption) Supply (Residential Solar PV)	granular and small distributed capacities	DSOs, Energy consumption scheduler	Scheduling consumption based on PV generation conditions	shifting consumption to hours with high level of PV production	Selling congestion management service (voltage rising) to the DSO	Residential consumer behaviours changes, Time Of Use	The result shows a reduction in the electricity bill consumer besides reduction in the average voltage peak
Industrial plant providing demand response services (Samad and Kiliccote, 2012; Xenos et al., 2016)	Large energy consumption are currently under-utilised in terms of load flexibility	Load (industrial plant)	Large capacity	TSOs, large industrial plant	Creating flexible consumption to response to the TSO signals	Shifting or reducing consumption	Selling various demand response services to the TSO	Loss from reducing or censing some production line in the plant	Industrial plants can profit from demand-side activities to save the electricity cost and contribute to efficient grid operation
Microgrid voltage congestion service	Employing Microgrid to mitigate voltage congestion	Load, storage and supply	medium capacity	Microgrid energy manager, DSO	Creating a microgrid	Manging various resources based on DSO signals	Selling congestion management services (voltage rise) to the DSOs	Loss from reducing or censing some production line in the plant	Flexibility service market may be a high value solution and could generate additional income for microgrid. It is an alternative solution for network reinforcement

Table 27 CIMO synthesis of the different demand response approaches

4.2.2 Business model concept

As the author has indicated in the introduction, the usage of the business model concept since its emergence in the 1990s has been continuously growing, yet there is no consensus on what business model actually represents (Zott et al., 2011). It is a multifaceted concept and its use depends mostly on the purpose and the theoretical perspective of the researchers and the practitioners.

One of the common understanding of the BM is a useful tool with a main purpose of the creation, delivery and capture of the value creation (Amit and Zott, 2001; Baden-Fuller and Morgan, 2010; Teece, 2010). On the one hand, managers can use BMs to define their required resources and the associated activities. On the other hand, to address the customer's needs and the market offers in terms of products and services. The BM is widely recognised as a heuristic logic that translates the technical aspects into economic value (Chesbrough and Rosenbloom, 2002) and is studied as a unit of analysis (Zott and Amit, 2007). The BM usually contains components that shape the architecture of the business model, in this regard, BM can be explained in a series of connected elements (Amit and Zott, 2001; Mason and Spring, 2011; Osterwalder, 2004; Teece, 2010). More specifically, (Osterwalder, 2004) has proposed nine elements: value proposition, resources, activities, partnership, customer segments, distribution channels, customer relationship and cost and revenue. Demil and Lecocq (2010) highlight three core components: resources and competencies, internal and organisational structure and value proposition and point out to the dynamic changes between and within the business model components. BMs are not only regarded as tools or tangible frameworks but also as stories, ideal types and templates that can be used by entrepreneurs to design and replicate a successful business model (Baden-Fuller and Morgan, 2010).

In this chapter, the business model concept is conceived as a tool, which consists of a set of objects, concepts and their relationships, aims at expressing the firm's logic in a simplified description and representation (Osterwalder, 2004). The activity system business model perspective of (Zott and Amit, 2010) is adopted as a main framework to build upon the research. This framework can be described by design elements and design themes. The design elements are the main focus of this work and have three constituent parts: content, structure, and governance. The content refers to the selection of activities to be performed. Herein, the firm, for example, can innovate by performing activities that are not typical to its sector. The structure describes how the activities are linked and in what sequence. Innovation can be triggered by initiating new links between parties, thus novel exchange mechanisms. The governance refers to who performs the activity and where (e.g. Franchise BM). In addition to these three design elements, the economic aspects have been integrated by adding the value capture as a fourth element, following the analytical framework of (Hellström et al., 2015) which have investigated business model collaboration mechanism and ecosystem changes in the energy sector. In this chapter, The Content, Structure, Governance and Value capture are termed BM dimensions in order to distinguish them from the DRBM elements (Figure 33).

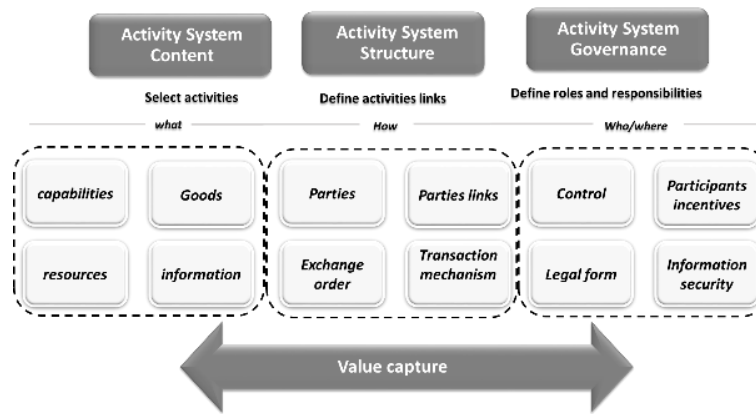


Figure 33 The four Business model dimension, source (Zott and Amit, 2010)

4.2.3 Ontology construction

Ontology, in philosophy, focuses on the nature and structure of things per se, trying to give a description in terms of general categories and relations. However, ontologies in Computer Science focus on existent observation, trying to formally model the structure of a system. Ontology is defined as an “explicit specification of a conceptualisation” (Gruber, 1995) in which conceptualisation is an abstract, a simplified view of the world that we wish to represent for some purpose. This view consists of concepts (e.g. entities, attributes, process), their definitions and their inter-relationships (Uschold and Gruninger, 1996). Ontologies give a common understanding of the structure of the information that can function as a unifying framework for variant viewpoints, enable domain analysis and make domain assumptions explicit (Guarino et al., 2009). Ontology can be explained as a group of definitions aiming at better understanding the world’s view. The representation of a specific domain in an ontology is not just compact but also comprehensive. The ontology includes the domain terms and expressions describing the meaning and the relationships of these terms. The relationship between concepts in ontologies can be of different types (e.g. is, set of, part of, etc.). In this chapter, “Set of” explains that an element can be dismantled into granular sub-elements. “Part of” refers to from where an element descends.

In this chapter, the process of ontology building follows (Uschold and Gruninger, 1996) methodological procedures based on three steps. The first step is to identifying purpose and scope by identifying the intended uses and clarifying the reasons. The second step is the “ontology building” which refers to ontology capture and coding. Ontology capture refers to (i) the key concepts and relationship identification, (ii) unambiguous text definitions production and (iii) identification of terms to refer to such concepts and relationships. Coding includes committing to the basic terms (e.g. classes, entities, relationships) that will be used to specify the ontology. The third step is the evaluation of the ontology, testing its consistency and generating an adequate document.

4.3 Research methodology

This section discusses the methodology that has been used to obtain the results and to construct the demand response business model canvas. Firstly, the author draws on one of the case studies introduced in Chapter 3 (Energy Pool case) and secondly, an academic literature review has been done. Finally, three tests have been taken up to examine the tool’s usefulness and obtain practical feedback from the users.

4.3.1 Literature review

Demand response concept is rather a new concept, and it is a research area in the energy transition literature. The objective of the literature analysis is to explore, classify, evaluate, and compare the different approaches of the demand response and its relationship with the business model concept. The literature review has been followed by concepts and relationships identification and has been finalized with the expansion and adoption of the activity system perspective to demand response concept. The method that has been employed consists of the following phases: searching, data extraction and finally thematic synthesis (Thomas and Harden, 2008) (Figure 34).

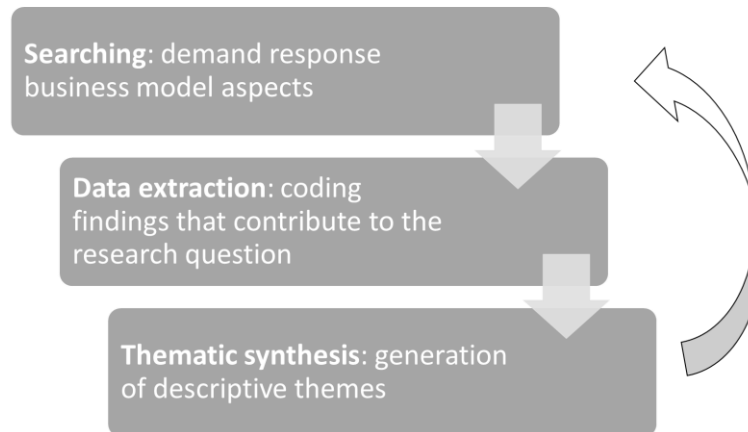


Figure 34 Literature review method

The author has used the Scopus search database. The search includes articles between 2007 and 2018 that examine the demand response, the DR: business models, products, services and markets. It included the following terms in the Title “Demand-side management” OR “Demand response” OR “electricity market” OR “ancillary service” OR “Frequency regulation” OR “flexible electricity” OR “energy storage” OR “aggregator” OR “Congestion management” AND the “Demand response” in the Key works. The search yields in 1076 documents, 236 papers were selected after titles reading, from which 77 papers have been included after abstract reading. Finally, 35 papers are selected that include nine papers selected from the first-round paper’s references.

The sample is purposive rather than exhaustive because the objective is not to locate every available study but rather to have a range of concepts found in the studies. In the next phase, the author extracted the key concepts and key relationships from the selected studies. The question about which should, and which should not be chosen, has been clearly answered by the theoretical framework (Activity System perspective and value capture) which has been considered as a reference. So that, the selected concepts and relationships have been evaluated in terms of the definition of activity system *Content, Structure and Governance*, and the value capture. The synthesis took the form of three states: the coding of the findings of the primary studies according to its contribution to the activity system perspective business model conceptualisation; the organisation of these codes into related area to construct themes and the development of analytical themes. The author has extracted and synthesised the findings according to the chapter objective which is to define the demand response business model areas. Therefore, the coding process includes first coding the business model elements of activity system conceptualisation (*content, structure and governance*) and value capture (*cost-revenue*

model). After that, the author has looked for similarities and differences between codes in order to start grouping them into a hierarchical tree structure. The findings of all the studies have been gathered and put in one list that describes the different business model aspects of the demand response. Until this phase, the author did not go beyond the original study's findings and did not generate additional concepts. In the next phase, the author used descriptive themes that emerged from the inductive analysis of the study findings, as shown in the example in (Figure 35). This process was an iterative process which has been repeated until the new themes were sufficiently abstract to describe what could be the demand response business model.

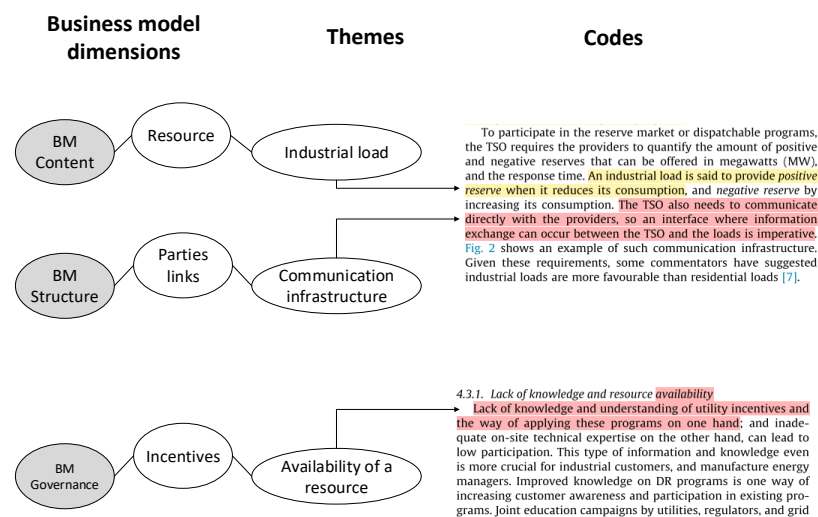


Figure 35 Example of the coding and themes creation

4.3.2 Case study

Research on the business model concept has been a subject of interest during the past decade. Nevertheless, the BM role in changing the industry mainstream remains an unexplored phenomenon. Therefore using the case study approach could bring significant value to the literature (Eisenhardt and Graebner, 2007). The case study research method is defined as an approach that employs empirical inquiry to investigate a phenomenon within its real-life context in which multiple sources of evidence are used (Yin, 1989). Given that there is a limited theoretical background about BM concept and demand response, the inductive research through a case study offers a useful and reasonable methodological approach. One crucial aspect of BM is that it can be used as a unit of analysis (Zott et al., 2011). Scrutinising a practical case on the demand response, which is a disruptive business model in the energy sector, might contribute to bring radical changes to the energy system. A case study design methodology has been chosen to be a source of evidence that contributes to this research study (Yin, 1989). It should be noticed that taking one case study, might not be sufficient (Eisenhardt, 1989). However, the demand response is a somewhat new business and finding suitable and reachable cases is difficult.

The case was selected based on its revelatory and its recognition as a significant phenomenon that makes available unusual research access (Eisenhardt and Graebner, 2007). Energy Pool is a unique case because it is the first independent aggregator in France that provides demand response services. The used research approach is an explorative approach. Overall, the data of the interview was the primary source, including questions related to business model elements; resources, capabilities, partners, operational activities, incentives, economic model, etc. In addition to this primary data, extensive secondary data from the firm's internal sources was examined to get a comprehensive picture of the respective firms' business

model dimensions. This includes the firm's website, social media pages, blogs etc. Additionally, the gaps have been closed by including the firm's external resources, such as published articles, presentations and news clips.

4.3.3 Usability test

The usability and applicability of the DRBMC have been examined by doing three tests to receive primary feedback about the capability of the users to exercise the tool. Applicability is defined as *“The extent to which the effects observed in published studies are likely to reflect the expected results when a specific intervention is applied to the population of interest under real-world conditions”* (Atkins et al., 2010). The author has conducted three tests with the developed tool. The population consists of three start-ups, two of them working in the energy domain and one in the big data processing (Table 28). The objective of including this third start-up is to examine if the tool could also be useful for entrepreneurs who are not familiar with the energy sector. The interventions include two phases. First the introduction of the tool and the description of the different elements. And second manipulation of the tool by the participants. Finally, the outcomes have been evaluated based on the reactions of the participants during the workshops. These outcomes have been completed by the results of a survey that has been sent to the participants after the test.

Phase	Description
Population	3 start-ups: eGreen: is a French start-up that looks for energy savings in buildings through a behaviour change approach Enargia: is a French energy retailer in form of an energy cooperative Hupi: is a French data analysis start-up that allows firms to have analytical information to improve their competitive advantages.
Intervention	Three workshops to test the usability of the tool
Evaluation	Evaluation questionnaire

Table 28 Usability test procedures

4.4 Results

This section shows the obtained results that describe the demand response business model. Firstly, the result of single case study analysis is introduced in subsection 4.4.1 and secondly, the achieved results, from following the ontology perspective on demand response business model, is revealed in subsection 4.4.2.

4.4.1 Energy Pool case

Energy Pool is the first independent electricity aggregator in France. It was found in 2009 and one year later settled a strategic partnership with Schneider Electric. Energy Pool, among others, is an energy aggregator that bundles industries' megawatts and electricity consumption flexibility, based on real-time metering in exchange of payment. These megawatts are sold to the TSO of France: Réseau de Transport d'Électricité (RTE). On the one hand, the firm aims to optimise the industries' consumptions and reduce electricity bills up to 40%. On the other hand, it offers a demand response mechanism to reduce RTE's load peaks. Most of its commercial development today is based on offers for energy utilities provision of services and consulting services to operate demand response and flexibilities.

As illustrated in the theoretical background, the activity system framework will be used to illustrate the BM logic (Table 29). Regarding the BM content, the main feature of this BM

is the capability of identifying the flexibility of each individual industrial plant among other plants despite their different activities. Thus, the firm performs an audit analyses in order to check out the potential of load curtailment or shift. The second main activity is the aggregation of the identified flexibilities in order to have a sufficient and worthy load curtailment. Herein the firm offers its value proposition to a potential flexibility purchaser (Figure 36).

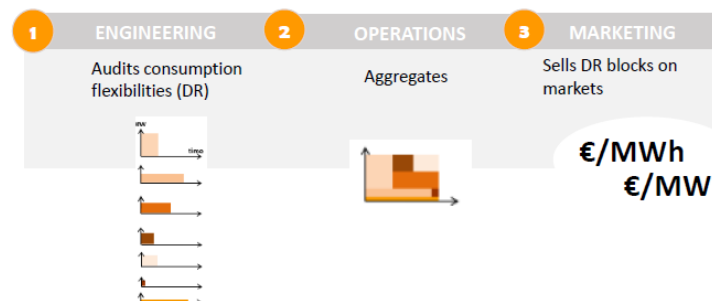


Figure 36 Energy Pool business model main activities, source : (Chamoy, 2017)

Flexibility evaluation, aggregation and marketing.

Concerning the structure of the Energy Pool activity system, Energy pool is an intermediate that lies between industrial consumers and RTE. It makes a link between RTE's need for load curtailment at specific periods and the latent capacity of industrial consumers to shift their consumptions. The process works as follows. First, Energy Pool receives a "Call" from the transmission system operator, in this case RTE. Energy Pool asks the industrial consumers to shift their consumption each according to its capacity. The aggregated consumer's megawatts should be equal to the RTE capacity demand. For example, (Figure 37) shows that Energy Pool made a curtailment of 561 MW during two hours long and with an advanced notice of two hours. This curtailment is the result of aggregating four industrial plants curtailments (494 MW by the first industrial plant, 28 MW by the second, 10 MW by the third and 29 MW by the fourth).

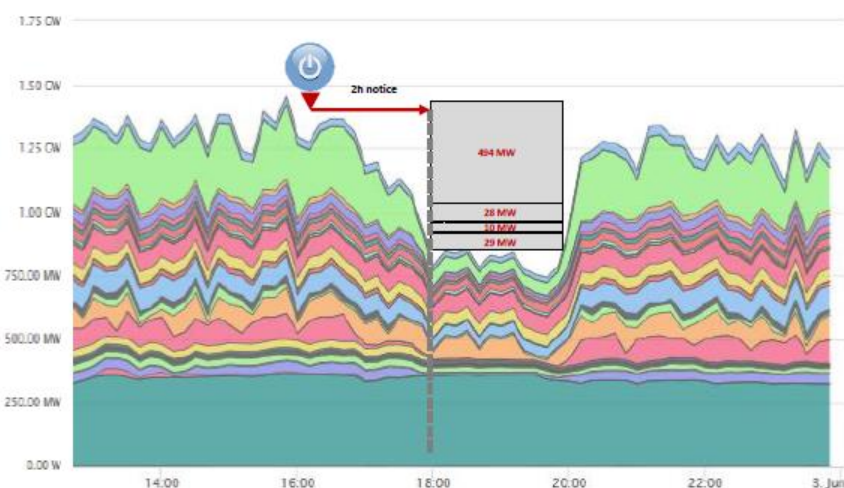


Figure 37 Example of Energy Pool aggregation of a curtailment. Source: (Chamoy, 2017)

The firm employs a dispatchable and controllable demand response approach (explicit demand response), which is an approach relies on paying the energy consumers for their curtailments, to avoid the behavioural risk and using their own smart meter to measure the real-time consumer's consumption. Energy Pool is working in the ancillary service market segment mainly in the frequency regulation, and frequency restoration reserves (Figure 38). The firm

constructs links between industrial plants and flexibility purchasers by translating market signals into value propositions, for both the DR purchaser (RTE) and customers (industrials), using reliable and effective communication infrastructure. Due to the variation in the curtailment's sources and curtailment market segment or purpose, each curtailment has specific characteristics in terms of capacity size, response time, advanced notice, curtailment duration, and times of practising. (Figure 36) illustrates the evaluation of potential curtailments, the aggregation and the sale in the market.



Figure 38 Energy Pool main market segments. Source: (Chamoy, 2017)

The activity system's governance defines who performs the defined activities. Energy Pool controls and manages the demand response services by gathering real-time consumption measures from their DR boxes installations, and by evaluating the industrial plants' performance. On the operational level, shifting consumer's consumption may be automatically performed by Energy Pool or might be performed by the consumer. Calculating consumer's remuneration is also the responsibility of Energy Pool. Each curtailment has its own portfolio of industrial plants, which depends on the plant's characteristics (e.g. availability, load size, etc.).

Finally, regarding the value capture, the firm captures the economic value from providing ancillary services and frequency regulation to the TSO (RTE). Then part of this income is distributed among the industrial participants according to the provided capacity. The industrial plants have two complementary offers: "Availability" and "Call". In the former, the consumers put their availabilities at Energy Pool's disposal and stand-by for consumption shift. Often, they have a pre-determined capacity and price. However, the fee may be reduced by a penalty if the consumer finally is not available. In the latter, Energy pool calls the consumers and asks for load shift by making an offer. In this case, the consumer is paid according to its performance. If the consumer is engaged into a program entailing « availability payments » and « calls », it cannot refuse (otherwise must face penalties).

Additionally, the firm BM contributes to mitigating the environmental impact of the energy sector through two outcomes. First, it reduces the need for additional energy supply plants, which are usually a source of CO₂ emissions. Second, it delays or avoids the need for distribution and transmission network reinforcement, thus reducing material usage on the system level (Figure 39).

Business model elements	Energy Pool
Content	Identify flexibilities of each industrial plant, aggregating industrial plant curtailments, creating a value proposition for the TSO or for an energy market actor.
Structure	Identifying the customer needs (Frequency regulation, ancillary services, energy, capacity, etc.), translating the customer signals (e.g. TSO) into curtailments and actions through communication channels, matching industrial sum curtailments with customer kWh demand (curtailment size, duration and response timing, etc).
Governance	Choosing the available and the right industrial plants among others according to its available capacity and to its location if necessary (in some cases), coordinating, managing and controlling the curtailments.
Value capture	Customer's offers: availability (fixed price based) and call (performance based)

Table 29 Energy Pool business model description

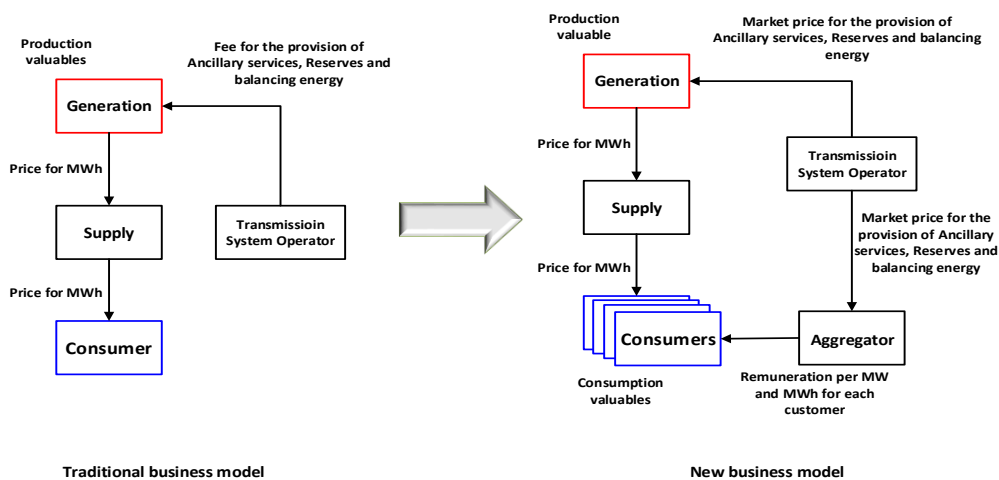


Figure 39 Energy Pool business model in comparison with the tradition business models

4.4.2 Demand Response business model ontology

The main goal of this subsection is to provide an ontology that describes the demand response business model. In order to achieve this, firstly, four business model dimensions are identified (See subsection 4.2.2), which cover and constitute the core business model functions of a company. In the second step, the four dimensions are split into twelve interconnected elements that illustrate in detail and give a deep understanding of the demand response business model. (Figure 40) clarifies the dimensions, the elements, their relationships and their sub-elements.

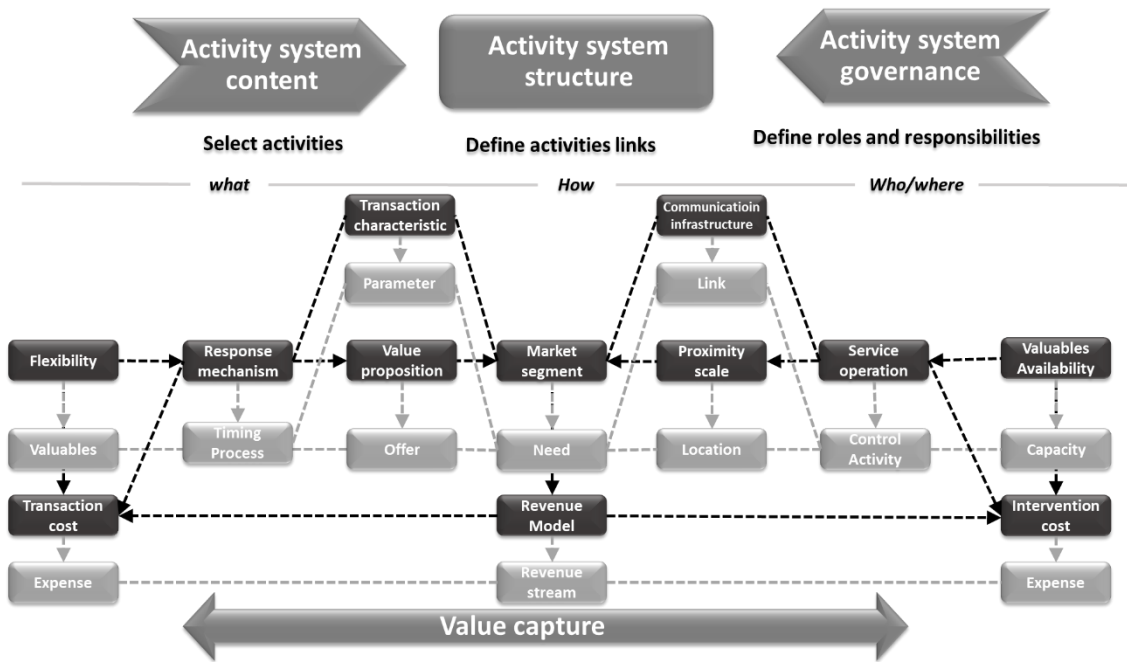


Figure 40 Demand Response Business Model Ontology

The demand response business model ontology consists of twelve elements and twelve sub-elements that aiming at describing the money earning logic of the demand response. Each element’s characteristics are explained in the form of the Table 30. Each element in the ontology is described with another sub-element which gives more granular level of description.

Element name	Name
Definition	Description of the demand response business model element
Related to	Shows to which part of the activity system conceptualisation on business model the element belongs.
Set of	Describes to which other elements an element is related to
Attributes	Indicates the properties of an element
Reference	Indicates the main references related to the element

Table 30 Description of a business model element

The graphic representation, the black boxes, describes the elements while the grey boxes indicates the sub-elements. The relationships between the elements and sub-elements are related to each other through a “Set of” relationship which indicates that the element can be dismantled into further finer level of granularity and “part of” which explains from which BM’s dimension an element descends (Figure 41).

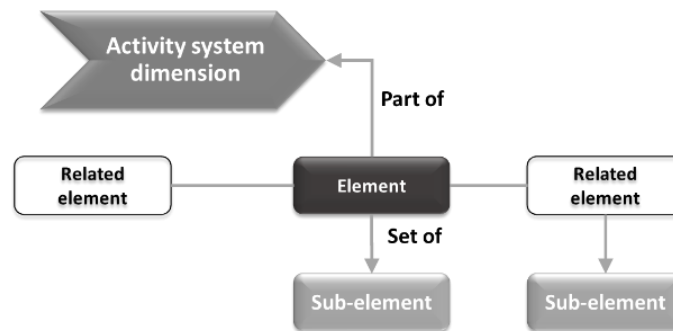


Figure 41 Graphical illustration of an element of ontology

4.4.2.1 Demand response BM content

According to the activity system, the BM content includes the exchanged goods and information between the involved actors and the required resources and capabilities (Amit and Zott, 2001). The DRBM content contains three elements (Figure 42). The first element is “flexibility” which is the main resource for any DRBM. The second element is the “response mechanism” which refers to the required capabilities to transfer flexibility into a product. Third, the “value proposition” which is the final product-service provided to the DR purchaser, and it is where the available capabilities and resources are combined with the need of the customers to form an attractive and competitive market offer.

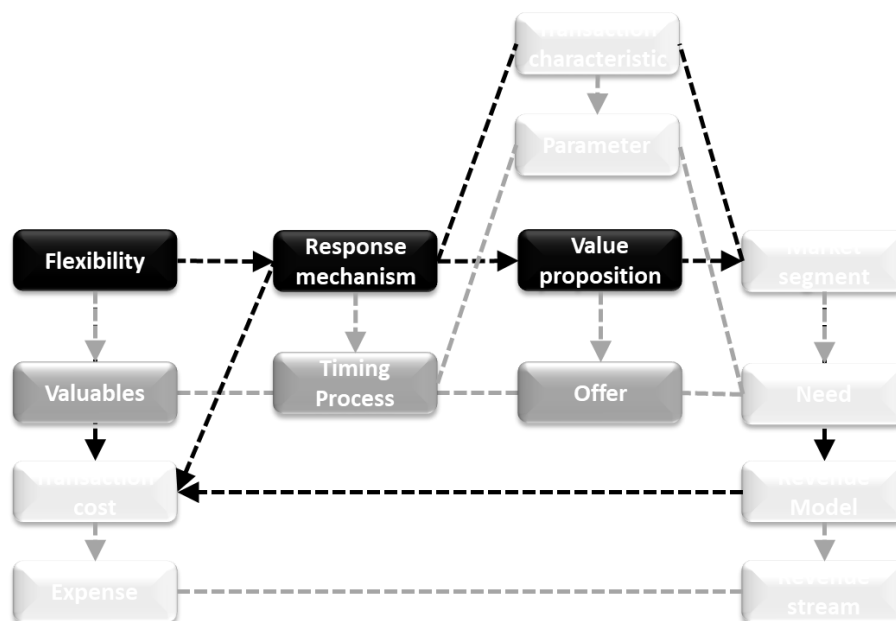


Figure 42 The Demand Response Business Model Content Elements and sub-elements

4.4.2.1.1 Flexibility

Flexibility is the potential of modifying the patterns of generation or/and consumption in response to an external electrical grid signal to contribute to the power system stability, reliability and security in a cost-efficient way (Villar et al., 2018). In more details, flexibility is the power adjustment maintained at a specific moment for a given duration from a specific location along the electric network (Eid et al., 2016). Flexibility is the base on which the DRBM is built on and is the main resource of value creation. Thus, a firm has to set out its flexibility

in a way that fits into a value proposition (Figure 43). Flexibility identification is not always obvious and straightforward; thus, it is often not valorised.

The increased share of renewable energy resources has been bringing uncertainty and instability to the energy system. This change is increasing the demand for a more flexible system. The element's details are explained in (Table 31).

BM element name	Flexibility
Definition	Flexibility is the possibility of power adjustments from a specific consumption pattern or generation that contribute to grid balancing.
Part of	Activity system content
Inherits from	Valuables
Related to	A Flexibility allows firm to create a value proposition
Set of	Valuables
Attributes	Ramping capacity Energy modulation Capacity size
References	(Boscán and Luis, 2016), (Villar et al., 2018), (Eid et al., 2016)

Table 31 Flexibility element characteristics

The flexibility products have three characteristics (Villar et al., 2018). First, the ramping capacity (power) are flexibilities demanded by the TSO and traded in the market closer to real-time for covering the increasing uncertainty of the net electricity demand. The main difference from the traditional reserves is their fast ramping responses without blocking a generation capacity as a reserve. Second, energy flexibilities are flexibility products supplied for energy modulation for peak shaving and grid usage optimisation. They aim at handling the increasing demand and reverse power flows from the distributed generation and defer investments. Third, capacity flexibilities are flexibility products designed to match demand and supply in the long-term through the efficient use of distributed generation.

Flexibility may be generated by the customers or outsourced to DRP. Customers who own supply-valuable, such as renewable energy resources or operate demand-resources, such as large industrial plant can enter in a direct agreement with a DSO/TSO or sell their flexibilities in the energy market without going through a DRP. However, small capacity flexibilities (small companies and the residential consumers) are often pooled and provided by an aggregator.

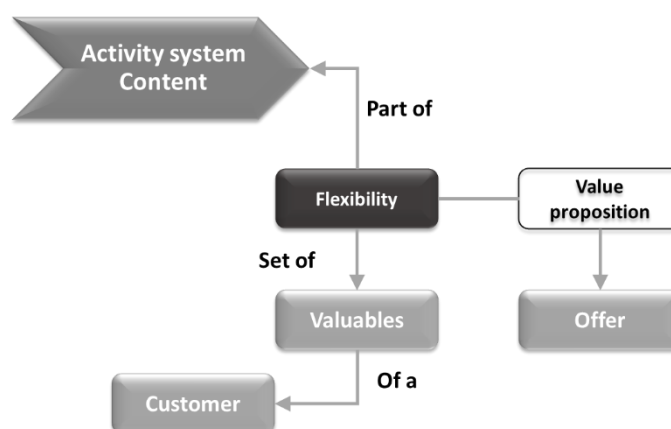


Figure 43 Flexibility element in the demand response ontology

Flexibility is a hidden and latent capacity inside a consumption pattern, an under-utilised distributed generation or inefficient use of a storage system. Thereupon, flexibility can be found in resources; these resources are termed valuables.

4.4.2.1.2 Valuables

In the traditional energy system, flexibility was created by power plants (e.g. coal and gas). Currently, flexibility can be also created from load adjustments, distributed generation, renewables and storage systems. These emerging resources are termed demand response valuables. Defining a DR value proposition requires one or more DR valuables (Figure 43). In this regard (Helms et al., 2016) distinguish between two kinds of valuables: the asset-based and the consumer-based. The former refers to the exploitation of flexibilities on the generation-side e.g. power plant or virtual power plant; while the latter is about achieving flexibilities on the consumption-side e.g. large-scale industrial plants or small-scale householders. Besides, the energy storage is considered an important and distinct DR valuables (Shoreh et al., 2016). In this chapter, the energy storage is added as a third type of valuables. Thus, the addressed valuables are: supply-based, demand-based and storage-based (Table 32).

Some examples for each kind of the valuables are given. Supply-based valuables includes distributed generation systems (e.g. Combined Heat and Power), renewable energy resources (e.g. wind farm and solar PV), in addition to the traditional model of power plant (e.g. gas fire plant). The demand-based valuables are divided into three categories. First, residential (e.g. home appliances), commercial and buildings, (e.g. HVAC systems) and large industrial plants loads. In storage-based valuables, three types are addressed: electrical (e.g. Energy Battery Systems); thermal (e.g. refrigerators and chiller with ice storage, heating system, etc.); and inventory storage (the reconfiguration of the industrial plant productions schedules to optimise load flexibility). These examples show that first, valuables are not owned by the DRP or by the TSO rather they are owned and used by the customers. Second, these valuables have potential for power adjustments.

BM element name	Valuables
Definition	Valuables are the resources of flexibility and they are either tangible assets or intangible load adjustments.
Part of	Activity system content
Related to	A Valuables can be offered by a customer
Attributes	Having three types (demand, supply and storage) Owned and used by the customers Usability Accessibility Convenience
References	(Helms et al., 2016), (Eid et al., 2016)

Table 32 Valuables element characteristics

The suggested valuables have attributes that can improve or constrain the capability of the DR activities. State-of-Charge (SoC) is an attribute of storage valuables. For example, a minimum SoC is required from the participating EVs in a Virtual Power Plant designed to trade energy in the market (Bhandari et al., 2018). In more complex services, such as frequency regulation, the EVs fleet should maintain, on average, a SoC near 50% due to the symmetric nature of this service (DeForest et al., 2018; Haakana et al., 2017). Elasticity degree is an attribute that is associated with consumption valuables and refers to the ability of customers to

switch off the device, appliance or the machine in use. In the household, for example, three categories are addressed. The *base loads* are loads that must be turned on without delays, such as lighting and networking, hence cannot participate in the DR service, the *elastic load* are the loads that can be shifted and interrupted, such as washing machines. *Inelastic loads* are the loads that can be shifted but cannot be interrupted (cut) during operation, such as the HVAC and water pump (Shaheen et al., 2016). Intermittency is an attribute of the renewable energy technologies and refers to the fluctuations in the production of the renewable energy resources, thus the uncertainty of supply (Rodrigues et al., 2016). For example, wind farms are exposed to undesirable curtailments when there is wind but there is no demand.

DR Valuables have three features. They are usable, in the sense that it is capable of generating flexibility if it couples with timing. DR valuables are accessible when the DRP or the customer is able to increase, decrease or adjust the operation of the valuables at a given time. When DR valuables are convenient, it means that they are suitable for a specified DR service. For example, the EVs are usable as they have a margin of time and not are driven all the daytime. They are accessible as they can be controlled and connected to the grid during parking time. They are convenient for frequency regulation DR service due to the symmetric nature of the service.

DR valuables are often owned and operated by the customers. When a DRP exploits a set of valuables, the valuables' ownership does not change; however, the operation partially or completely might be outsourced to the DRP. Recently the increase capacity of ICTs and the decrease of its cost makes possible for DRP to bundle the operation of the valuables with timing's indicators that are given by the system operator (Helms et al., 2016). Additionally, the opening of the energy markets to trade DR services has given value for the latent flexible capacity inside the valuables.

In the DRBMs, the valuables are bundled with timing activities and connected on the system level to ensure the effective use and to allow flexibilities to flow from customers to the purchasers through an aggregator (if necessary).

4.4.2.1.3 Response mechanism

Response mechanism is the arrangement of the valuables and their connections in a particular configuration and through an appropriate sequence of actions that create value for the involved actors. On the one hand, it refers to actions by which the DRP can influence the customer's behaviour, thus consumption and production patterns to obtain the desired load curve. On the other hand, it shows the capability of the DRP to respond accurately to DR purchaser's signals. (Table 33) illustrates the characteristics of this element.

BM element name	Response mechanism
Definition	Response mechanism is an established process, the arrangement of the valuables, and their connections and coordination in a particular configuration.
Part of	Activity system content
Inherits from	Timing-process
Related to	Response mechanism is related to Flexibility and Transaction characteristics The Response mechanism optimizes the flexibility to created value proposition
Set of	Timing-Process
Attributes	Valuables distribution level Valuables homogeneity degree

References	(Siano, 2014),(Samad and Kiliccote, 2012), (Motegi et al., 2007)
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Table 33 Response mechanism element characteristics

The Response mechanism has two attributes: valuables distribution level and valuables homogeneity degree. Distribution degree indicates the number of valuables that are aggregated to create enough capacity to be sold in the energy market. Having a small number makes the response mechanism less complicated and cost-efficient in contrast to having a large number of valuables. Homogeneity degree refers to the similarity between the employed valuables. Having heterogeneous valuables increases exploitation and operation costs.

The response mechanism translates the flexibility of a specific set of valuables into a commercial value proposition taking into considerations the transaction characteristics, such as the delivery time, the service duration and notification time which are all timing-processes that shape the value proposition (Figure 44). Response mechanism employs variant approaches that differ according to the service purpose and context. Eight response mechanisms approaches are addressed in the literature. The *Load reduction* refers to reduce consumption during the peak periods when prices are high, through curtailment strategies without changing consumption patterns during other periods. For example, the temporary change of the heating system temperature (Motegi et al., 2007). By *Load shift* customers can shift their consumption from peak periods to off-peak periods, for example, using the dishwasher just during off-peak hours (Motegi et al., 2007). In the *On-site generation* approach, customers can use on site-distributed generation during load curtailments to compensate the load losses; thus no significant behavioural change is required. In the *Direct load control approach*, the DRP installs a control device at the consumer-site by which the load can be curtailed without engaging the consumer. The *Micro-grid* is a network of distributed generations, storage units and multiple load types that can function off the grid. Micro-grids approach includes monitoring, control and optimization capabilities. *Storage* as a response mechanism can have variant forms. The electrical storage that is based on the battery. The thermal storage, which refers to using electricity for heating or cooling in advance to be used later in the form of thermal effect (e.g. pre-cooling or heating a building). Finally, inventory storage can be employed in industrial processes by producing intermediate products in advance to be used later in electricity peak periods (Samad and Kiliccote, 2012). The *Virtual power plant* is a single entity that uses ICT to connect and manage a portfolio of distributed generations (Plancke et al., 2015). In the *Aggregation approach*, an intermediate actor often called “aggregator” brings together consumers and aggregates their available flexibilities to be offered in the energy and ancillary service markets. Two major types of aggregator are defined (Wang et al., 2015). Production aggregator that pools a group of small generators in order to get economy of scale. The demand aggregator is an intermediary between small consumers and DR purchasers e.g. TSO or retailers.

DR valuables, their connections and coordination in a defined configuration for balancing demand and supply in real-time must be coupled with time. Therefore, the response mechanism element consists of timing-processes.

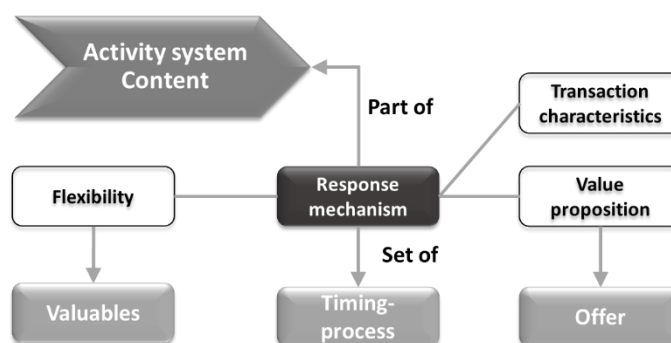


Figure 44 Response mechanism element in the demand response ontology

4.4.2.1.4 Timing-Process

Having a proper mechanism requires mastering clock timing and coupling the chosen mechanisms with time. The response mechanism is centred on the capability of timing supply and demand in a very short interval. Herein, the timing-process is the link between the deployed valuables and the offer through coupling the valuables function with timing (Figure 44). Each DR product and service has its own characteristics in terms of timing that should be considered in the offer's design. Any deviation in timing-processes (e.g. delivery time) would lead to a penalty. Timing-process is a process of coordinating in a very short time-spans when and at what capacity each micro-level of individual resource should operate (Helms et al., 2016). Therefore, timing-process requires reliable ICT. The elements characteristics are showed in (Table 34).

BM element name	Timing-process
Definition	Timing-process is the determination of when to act and at what capacity to act.
Element of	Response mechanism
Related to	Timing-process is related to Parameters
Attributes	Related to time: when to act
References	(Helms et al., 2016)

Table 34 Timing-process element characteristics

One of the core functions of Timing-process is the synchronisation of valuables. Synchronisation of many distributed generations requires coordination, communication and a specific degree of automation and centralised control. However, the synchronisation of many consumers requires a higher level of coordination and automation. Timing-process is related to the parameters of the transaction characteristic; these parameters are set by the system regulator and will be explained in the demand response business model structure in the (Subsection 4.4.2.2).

4.4.2.1.5 Demand response value proposition

On the one hand, DR value proposition is designed to satisfy the energy system actors needs for flexibility and security. On the other hand, it is also designed in a way that is attractive for customers' participation or even to satisfy their need to lower electricity cost (Figure 45). The value proposition is made up of flexible valuables and proper mechanism. For example, a heater system of a large building (valuables) in a particular region can be exploited to reduce the capacity overload in the distribution network (value proposition) for the DSO (DR purchaser) by aggregating (aggregation mechanism) and taking advantage of thermal effect

storage of the heat inside the buildings (storage mechanism) and remunerating (value proposition) buildings' residents (DR customers) for their participation.

The Demand Response value proposition can be divided into values for the DR purchaser and values for the DR customers (owner of generation, storage system or load user). The main characteristics of the value proposition elements are described in (Table 35). The value proposition can be divided into two benefits: the economic and reliability. Customer's economic benefits are gained from the incentives that the provider offers, or from the savings that they obtain as results of shifting consumption to low price periods. Energy system actors can have economic benefits, such as low-cost balancing, deferring network reinforcement investment and reduction in energy price. Power grid reliability is the ability of the power system to deliver electricity in the quantity and with the quality demanded by users and is generally measured by interruption indices.

BM element name	Value proposition
Definition	Value proposition is the demand response products and services that can generate economic value and contribute to the system flexibility.
Part of	Activity system content
Inherits from	Offer
Related to	Value proposition is related to Market segment The value proposition comprises Valuables and Response mechanism
Set of	Offers
Attributes	System level benefits (Reliability and security) Individual level benefits (customer incentives)
References	(Behrangrad, 2015), (Sisinni et al., 2017), (Paterakis et al., 2017)

Table 35 Value proposition element characteristics

DR service can create values for different stakeholders including the TSO, DSO, generation units, retailer, customer/load (Behrangrad, 2015) (Table 36). Regarding the System Operator/TSO, the DRP can enhance system reliability by delivering ancillary and frequency regulation services. DRP can reduce the future peak hours and increases grid adequacy by delivering capacity provision service and can improve the economic operation/ scheduling of the SO by increasing market efficiency through energy consumption reduction, thus spot electricity price reduction. The DRP creates value for generation stakeholders which can benefit from lower variable generation unit by increasing the flexibility of the intermittent energy resources through the installation of energy storage or other DR resources. They can reduce generations loss by maintaining their balance schedule in each transmission region through DR generation-load balancing service. The load shaping service can create a desirable load profile for generation stakeholders, which increases their operational efficiency.

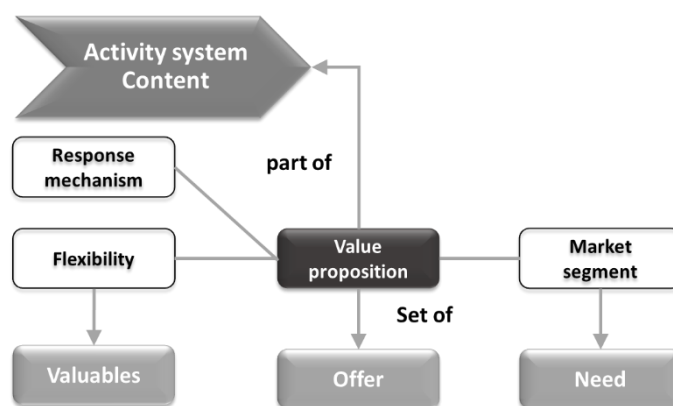


Figure 45 Demand response value proposition element in the demand response ontology

TSO/DSOs can benefit from DR congestion management service and mitigate the transmission and distribution congestion, thus help to delay or reduce investment in the infrastructure. Concerning the retailing stakeholders, they can decrease the energy consumption in case they face energy supply shortfalls or price mismatch through DR procurement improvement service. They can increase profitability and purchasing during inexpensive periods through load shaping service. For load stakeholders, DRP creates value by shifting the load when the kWh prices are high thus creating bill savings for consumers.

Stakeholder	Value proposition	Definition	Benefits
System operator	Ancillary service	The services necessary to maintain the reliability operation of the transmission system (Ikäheimo et al., 2010)	Purchaser: higher reserve margin, higher market competition, lower ancillary cost Customer: incentives
	Interruptible load	This Demand-Side Management category represents the consumer load that, in accordance with contractual arrangements, can be interrupted at the time of annual peak load by the action of the consumer at the direct request of the system operator. This type of control usually involves large-volume commercial and industrial consumer (EIA, 2019)	Purchaser: lower reliability provision cost and more reliability buffer Customer: incentives
	Direct load control	DR programs where the utility pays the customer to install a switch (typically radio operated) which allows the utility to control the customers' equipment (air conditioners, water heaters, pool pumps, etc.) as a way of reducing demand during peak periods (New York DPS, 2019).	Purchaser: reliable and controllable resource and Lower reliability provision cost Customer: incentives
	Frequency-controlled load curtailment	DRP would install devices that automatically curtail the load in response to the deviation of a grid indicator, generally frequency (Behrangrad, 2015).	Purchaser: Inexpensive implementation (no communication infrastructure) and fast reaction, low cost and high reliability resource Customer: incentives
	Frequency regulation	The speed and power of which can be quickly and continuously adjusted, following the regulation signal provided by the system operator in order to provide regulation reserve (Paterakis et al., 2017).	Purchaser: lower cost frequency resource and freeing generator capacity, fast response Customer: high incentives
	Decrease capacity provision	Reducing capacity provision cost by participating in auctions to commit to demand reduction during future load peaks in	Purchaser: lower cost for system maintenance and lower generation capacity requirement

		exchange with some incentives from the TSO (Behrangrad, 2015).	Customer: incentives for future commitment to peak reduction and energy payment
	Market efficiency enhancement	Helping the TSO to have more efficient and economic operation scheduling, thus customer can generate saving in the wholesale market (Behrangrad, 2015).	Purchaser: efficient price signals Customer: incentives or energy-based payment
Generation	Reduce intermittency cost	By increasing generation controllability the generation stakeholders, can reduce the imbalance cost from having less deviation from the dispatch schedule and increase the capacity factor by matching generation peaks production with load peaks (Behrangrad, 2015).	Purchaser: less imbalance cost and more capacity factor Customer: incentives
	Generation-load balance	Maintain the generation stakeholders expected injections and withdrawals within the schedule in each transmission region or network (Behrangrad, 2015).	Purchaser: reduce imbalance charges from the transmission regions Customer: incentives
	Generation load shaping	Reducing generation stakeholders costs, such as unit shut down and start-up cost and generation at a non-optimal operation point due to the load factor (Behrangrad, 2015)	Purchaser: reduce cost operation Customer: incentive
TSO/DSO	Congestion management	Enhancing distribution system operation and eliminating congestions through mitigating capacity overload and voltage deviations (Paterakis et al., 2017).	Purchaser: Lower congestion cost, higher network stability, investment delay and high ramping response. Customer: incentive
	Energy procurement improvement	Avoiding retailer to purchase electricity from energy market during shortfalls or error forecast by changing customer the energy consumption patterns (Behrangrad, 2015).	Purchaser: lower energy cost Customer: incentive or discount
Retailers	Capacity management	Avoiding retailer to goes over its provided capacity, thus having override penalties and decrease its capacity obligation through future peak reductions (Behrangrad, 2015).	Purchaser: Lower capacity cost Customer: incentive
	Retailer Load shaping	Reducing the retailer procurement cost through reduce load in some period and increase it in another periods when procurement is inexpensive (Behrangrad, 2015).	Purchaser: Lower procurement cost Customer: incentive
Consumers /load	Optimize energy consumption	Reducing electricity cost of the load tapping on electricity price variations by providing information or control system (Behrangrad, 2015).	Purchaser: lower peak capacity Customer: lower electricity bill
	Grid cost reduction	Reducing the grid cost of the user by reducing demand at suitable times (Behrangrad, 2015).	Purchaser: lower grid cost Customer: lower electricity bill
	Incentive sharing	Customer will receive some incentive in return to allow DRP to use its flexibility (Behrangrad, 2015).	Purchaser: various balancing and reliability services Customer: incentives lower electricity
	Grid independence support	Helping standalone or semi-standalone system to achieve generation-load local balance (Behrangrad, 2015).	Customer: lower electricity bill

Table 36 Demand Response value propositions. Source: (Behrangrad, 2015)

A value proposition might include several offers that cover the market need's variations in terms of price, DR purchaser and quality.

4.4.2.1.6 Demand response offer

In the offer, the DRP integrates all the aspects of the BM content and evaluates them in terms of the customer needs to design a proper value proposition. Therefore, the offer's design

should include suitable valuables and an appropriate response mechanism. The offer must be able to add value and satisfy the need of one of the DR market segments. However, the BM can consist of several offers that create values for different stakeholders. Furthermore, a significant consideration should be paid for the market rules and transaction characteristics that are set by the System Operator. (Table 37) illustrates the main characteristics of this element.

BM element name	Offer
Definition	Demand response offer is part of the value proposition and it's designed to serve specific customer segment.
Part of	Activity system content
Related to	Offer for the market segment
Reference	(Ikäheimo et al., 2010)

Table 37 The Offer element characteristics

DR offer can serve not just the energy market purchasers but also other stakeholders. By using the same valuables and the same infrastructure, the DRP can design multi-type offers that can target different market segments: TSO needs for reliability and security, the DSO needs for congestion management, the retailers need for lower cost procurements and the generation needs for cost-efficient operations. The offer design can contain a portfolio of different valuables, (Figure 45). For example, DRP can complement a wind farm with a storage system in order to deliver energy and spinning reserve (Rodrigues et al., 2016). Innovative offer may use integrated valuables, for example, the combination of the ice storage and refrigerators is used to deliver a consistent load reduction and providing active power services for the DSO (Rahnama et al., 2017). The offer depends on a viable response mechanism, like the case of using the micro-grid, which could be used to mitigate voltage congestion for the DSO (Amicarelli et al., 2017).

After presenting all the elements of the activity system content applied to the demand response business model, the next subsections illustrate the activity system structure elements.

4.4.2.2 Demand response BM structure

Based on activity system perspective on BM, the BM structure refers to the engaged parties, their relationships and links, the exchange order and sequence, and the exchange mechanism (Amit and Zott, 2001). Accordingly, the author proposes the demand response business model structure that consists of three elements: the “Transaction characteristics” and its associated parameters, the “Market segment”, which is related to purchaser’s needs and the “Communication infrastructure”, which refers to the infrastructure used to link the main parties (Figure 46).

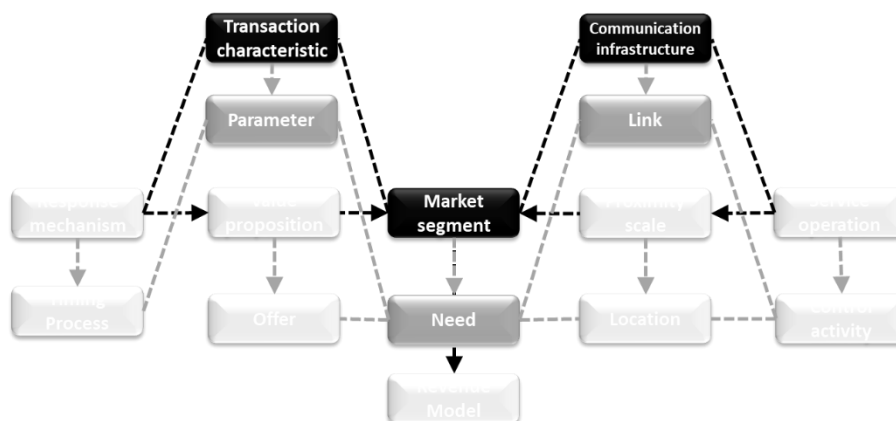


Figure 46 The Demand Response Business Model Structure Elements and sub-elements

4.4.2.2.1 Transaction characteristics

Although DR services main aim is to balance the grid and maintaining its security, these services differ in their objectives, thus in their characteristics. For example, some services are designed to maintain the energy system reliability in the short terms by reacting to emergency events (e.g. interruptible load or direct control) while others have long-term strategic objectives and provide capacity provision for peak reduction and demand increase. Some services should be maintained for a long time up to many hours (e.g. replacement reserve) while other services serve minutes (e.g. spinning reserve). The transaction characteristics are external factors set by the market regulators and DR purchasers; therefore, the transaction of the demand response service should be matched with each service characteristics. Usually, the DRP, the DR purchaser and the DR customer agree on these characteristics and refer to them in the contract or any market deal. Designing DR value proposition embeds these characteristics and should be aligned with the response mechanism (Figure 47). For example, the frequency regulation is a symmetric and bi-lateral service that requires up and down power supply; thus the “storage mechanism” is suitable for this service. A summary of the element details is given in (Table 38).

BM element name	Transaction characteristics
Definition	Transaction characteristics are the telemetry, performance standards and advanced planned parameters that define and set conditions of the DR service delivery.
Part of	Activity system structure
Inherits from	Parameter
Related to	Response mechanism and Value proposition Market segment
Set of	Parameters
References	(Shoreh et al., 2016), (Eid et al., 2016), (Villar et al., 2018), (Behrangrad, 2015)

Table 38 Transaction characteristics element characteristics

What determines the characteristic of each service is a set of parameters, which are used to evaluate the capability of the available DR valuables.

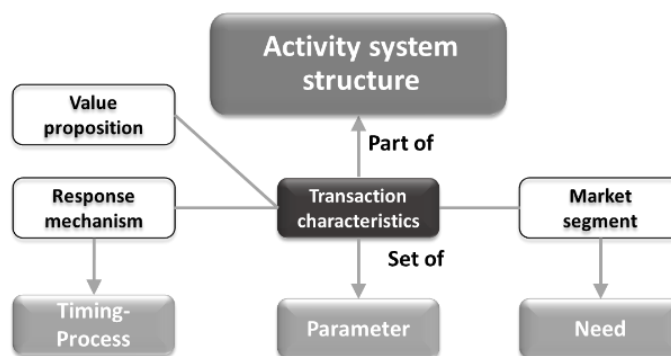


Figure 47 Transaction characteristics element in the demand response ontology

4.4.2.2.2 Parameter

Energy system must always be in a balance statue where demand is equal to the supply. This matching process is critical and requires parameters that regulate the balance. In this regard, five parameters are proposed to measure and shape the demand response transactions: response speed, response duration, advance notice, actual usage rate and load direction (Behrangrad, 2015; Shoreh et al., 2016; Todd et al., 2008). (Table 39) explains the main characteristics of this element.

BM element name	Parameter
Definition	Parameter is a reference and standard that is used to measure and shape the demand response transactions in terms of time and size.
Element of	Transaction characteristics
Related to	Parameters are determined by the market segment.
Attributes	Response speed, response duration, advance notice, actual usage rate, load direction.
Reference	(Behrangrad, 2015), (Villar et al., 2018), (Todd et al., 2008)

Table 39 Parameter element characteristics.

Response speed addresses the interval time between receiving the signal and activating the DR. For example, contingency reserve must be activated very fast in few seconds or few minutes. *Response duration* defines the maximum and minimum activation duration. For example, in the replacement reserve, the load curtailment duration is long up to hours. The *Advance notice* indicates the time of the advanced notice prior to DR activation. For example, replacement reserve has an advanced notice of 30 minutes. *Actual usage rate* points out to the frequency of DR service which is exercised by the purchaser. For example, the frequency regulation is almost a continuous service, thus it has a very high frequency rate. Finally, the *load direction* indicates if the customer must provide asymmetric or symmetric service. The former means the ability of resources to offer either a decrease or increase of the power output. While the latter is about providing power output in both directions. For example, frequency regulation service must be running symmetrically providing regulation-up and regulation-down. To illustrate this element, some examples of the ancillary services transaction parameters are presented in (Table 40).

Service	Transaction parameters		
	Response speed	Duration	Usage rate

Regulation or regulation reserve	1 minute	30 min (Real time); 60 min (Day ahead)	Continuous
Spinning reserve	Seconds to < 10 min	10 to 120 min	Hours to days
Non-spinning reserve	< 10 min	10 to 120 min	Hours to days
Replacement or supplemental reserve	< 30 min	2 hours	Hours to days

Table 40 DR parameters of ancillary service, Source: : (Shoreh et al., 2016)

4.4.2.2.3 Communication infrastructure

DR service is a coordination service in which the co-providers activities alignment and timing play key roles. So that a robust communication system is required. On the one hand, this system is a customer interface where customers can have access for real-time data of consumption and prices, and where they can receive information about load curtailment actions (Siano, 2014). This interface allows the customer to operate and activate the service. On the other hand, communication infrastructure enables the DR purchaser or DRP to receive real-time feedback regarding consumer's action and performance (Shoreh et al., 2016) (Figure 48). The absence of a necessary metering infrastructure has been considered as a barrier for DR market participation (Good et al., 2017). The element's details are showed in (Table 41).

BM element name	Communication infrastructure
Definition	Communication infrastructure is the network that supports connection, communication and alignment of the involved actors.
Part of	Activity system structure
Inherits from	Links
Related to	Market segments and Service operation
Set of	Links
Attributes	Customer interface Communication channel
References	(Paterakis et al., 2017), (Siano, 2014), (Good et al., 2017)

Table 41 The Communication infrastructure element characteristics

Communication infrastructure indicates the way the involved actors communicate and exchange information and transactions. It should facilitate the flow of electricity, information (e.g. prices, consumption measurement, etc.) and flexibility. The pace of flow of these three elements can vary from second to a few minutes to hours, which depends on the type of the service. The communication activities are a core activity for providing a reliable service. If any delay occurs, it entails a penalty, thus additional cost. In some cases, a granular sensing is needed in order to identify flexibility (household's appliances level), to certify the market's auction and to measure related factors, such as comfort (Good et al., 2017). Three domains have been considered in the DR service implementation: the smart meters, the internet and customer interface. Firstly, the smart meter domain and its capability of bi-directional communication. The internet domain as information and calculation platform and customer interface that enables the interaction with customers and appliances control (Paterakis et al., 2017). The communication infrastructure element can be broken down into links that explain the information flow between BM parties.

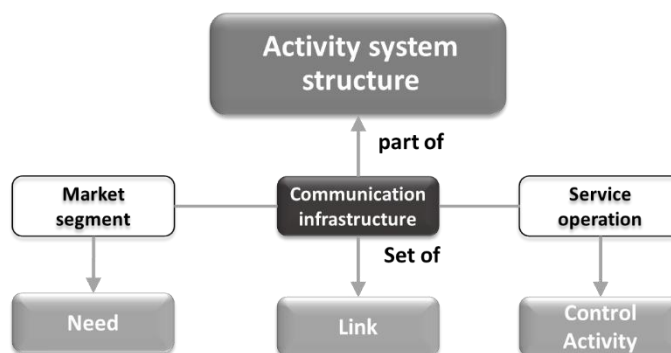


Figure 48 Communication infrastructure element in the demand response ontology

4.4.2.2.4 Link

An essential requirement for an effective DR service is the capability to deal with a significant amount of data transfer (Paterakis et al., 2017). The communication infrastructure mainly creates a link between the purchaser, the customer and DRP. Two significantly important attributes distinguish the DR links which are the low-latency and moderate bandwidth (Brooks et al., 2010). Latency refers to the delay between the time that a request is sent by the purchaser and the time at which the customer receives it and act accordingly. Modern bandwidth refers to the data transfer rate required by each connected device. The Link element is explained in (Table 42).

BM element name	Link
Definition	Link is a reliable and fast connecting structure and is a flow of information, electricity and flexibility
Element of	Communication infrastructure
Related to	Link is related to the need of the Market segment Link is related to the Control Activity
Attributes	Latency degree Bandwidth size
Reference	(Brooks et al., 2010),

Table 42 The Link element characteristics

Links are made by actors, such as an aggregator or TSO/DSO. Large industrial plants are often connected directly to purchasers while small consumers are usually pooled by aggregators. However, in the direct load control, the TSO controls and communicates directly with the customer.

4.4.2.2.5 Market segments

Market segment element distinguishes between the variant DR purchaser's drivers and needs. Market segments can support the DRP to recognize potential market opportunities. This element's characteristics are described in (Table 43). Besides the value proposition, two elements are considered in the segmentation process (Figure 49). First, the "Proximity scale" in which some needs are system level, but others are local level. Second, "Transaction characteristics" element in which a group of services, which have similar transaction parameters, forms a segment. As a result, five market segments are addressed: wholesale electricity market, capacity market, ancillary market service, prices-responsive market, and congestion management for DSOs. For example, the ancillary market, in the U.S including both frequency regulation and spinning reserves markets, has a volume size that can be evaluated

based on the market clearing price and the total capacity procurement volumes (MacDonald et al., 2012).

BM element name	Market segment
Definition	Market segment refers to the categorisation of the demand response products and services based on their drivers and needs.
Part of	Activity system structure
Inherits from	Need
Related to	Market segment is related to Transaction characteristics and Value proposition Market segment is related to Proximity scale and Service operation
Set of	Needs
Attributes	Different types
References	(Wang et al., 2015), (Behrangrad, 2015), (Villar et al., 2018), (macdonald et al., 2012)

Table 43 The Market segment element characteristics

DR market segments can be explained as following:

- 1) **Capacity market:** the capacity markets have been set up in order to ensure that there is enough supply when it's needed most. In this market, a provider, such as power plant or DRP, is incentivized to guarantee the availability of specific capacity where the price signal alone would not.

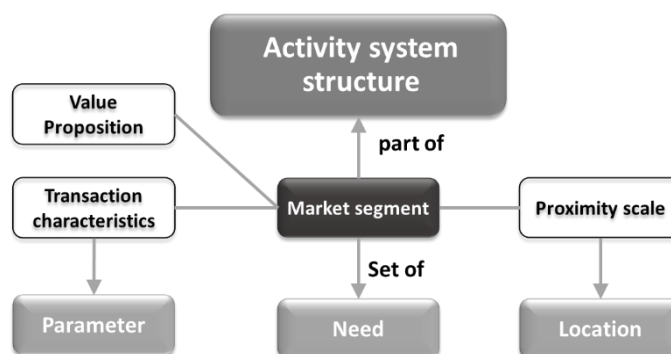


Figure 49 Market Segment element in the demand response ontology

- 2) **Electricity wholesale market:** in general, the wholesale electricity market consists of three blocks according to the time horizon (Wang et al., 2015):
 - a. *Day ahead market (DA)* allows participants to bid, before each operating day, to make sure that their commitments are met.
 - b. *Intra-day markets* are continuous markets to handle uncertainties (e.g. weather changes) after closing the DA market. It enables the market participants to correct their day ahead capacity bids. They are important to respond to renewable generation changes. In Europe, it happens every one hour.
 - c. *Real-time (RT)* (Balancing market) markets send dispatch and prices signal to market participants in every short interval (e.g. 5 minutes) to balance system load, maintain system reserve and resolve system congestion. The balancing market can be split into procurement and activation of reserve.
- 3) **The ancillary service market** (Reserve market) are markets that deal with short-term imbalance by dispatching resources within minutes or seconds. Ancillary markets consist of three types of reserves (KU Leuven, 2015):

- a. *Frequency Containment Reserves (FCR)* (Primary reserves) are used to stabilise the frequency with the time frame of seconds using automatic control and local activated reserve.
- b. *Frequency Restoration Reserves (FRR)* (*Secondary reserves*) are used to restore the system balance within an activation interval of seconds to 15 minutes, through automatic and central control.
- c. *Replacement Reserves (RR)* (*Tertiary reserves*) are used to restore the system balance and compensate the FRRs, thus allow them to be ready for the next short-term imbalance intervention. Replacement reserves are controlled manually and activate locally with a range of minutes to hours.

Ancillary services have different classification across countries. In the USA, they can be represented in three categories: frequency regulation, contingency reserve including spinning and non-spinning reserve and replacement reserve (Shoreh et al., 2016). Frequency regulation is defined as a very fast and accurate control or capacity service that provides near real-time continuous balancing of generation and load in normal conditions. The contingency reserve is the capacity that is available to recover from a loss of generation and it includes two types of reserves, the spinning reserve and non-spinning reserve. Spinning reserve is part of the operating reserve, which is the reserved and available capacity to cover the network operation in case a generator goes down or disruption of supply, this capacity should be delivered within a short interval of time (10 minutes) and operate continuously for at least two hours. The non-spinning reserve is the generating capacity that is off-line and can be brought online within a short interval of time (10 minutes) and can maintain for at least 2 hours. (Figure 50) shows the differences in terms of ancillary service and its major services categories in both the European Union for the Coordination of Transmission of Electricity (UCTE) and the Federal Energy Regulatory Commission (FERC) in the U.S.

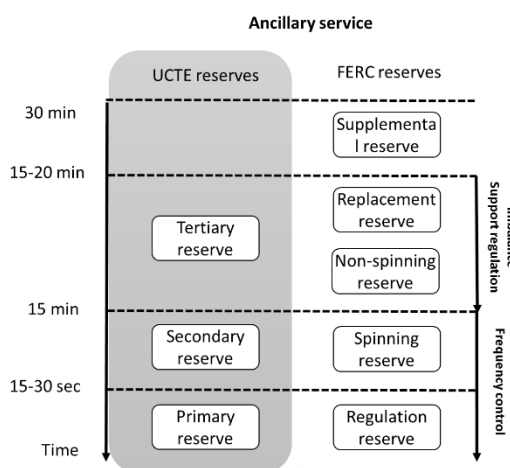


Figure 50 General ancillary market architecture, source (Wang et al., 2015)

- 4) **Congestion management market segment:** are services that are set up in congestion areas to avoid grid reinforcements or blackouts as long as grid reinforcement is not reinforced. Flexibility is provided for DSO for local balancing, voltage and congestion constraint issues or losses reduction. Often the proposals combine these services with balancing services for the TSO in coordinated transactions. Yet there is no real market for these services because

it has low liquidity and are rarely being competitive (Amicarelli et al., 2017; Villar et al., 2018).

- 5) **Price-responsive markets**: this market segment allows DR customers to voluntarily respond to changes in the electricity prices and limit their overall consumption when it is economically viable and attractive. In this regard, the Price-based DR programs are based on dynamic pricing mechanisms in which the price fluctuates and reflects the real-time electricity cost. Usually, the price is increased during the peak hours and is reduced during off-peak hours. This scheme has three general distinct mechanisms (Meyabadi and Deihimi, 2017). First, Time of Use (TOU) in which the rates of electricity per unit consumption differ in different blocks times (e.g. peak and off-peak blocks). Second, Critical Peak Pricing (CPP) in which higher rates for critical periods are imposed. Consumers are informed in advance, usually day-ahead. Finally, the Real-Time Pricing (RTP) mechanism charges consumers on an hourly basis with pre-defined rates announced a day-ahead or hour-ahead.

Each market segment has distinct needs and understanding those needs is an essential part of BM value creation.

4.4.2.2.6 Need

Customers' needs constitute a central pillar of the business model and knowledge about customers is an essential resource. The final goal of any DR's offer is to maintain the grid balance in real-time in an economic and cost-efficient way. However, the system actors have various objectives and tasks, thus different needs can be identified to reflect the main market segmentation. More details of the element are described in (Table 44). The DR service consists of paradoxical needs. On the one hand, it aims at maintaining the load stability and reducing peaks of consumption and on the other hand it should not reduce customers' comfort. The successful implementation requires being able to combine the two needs, the needs to have comfort and the need to mitigate peaks of consumption.

BM element name	Need
Definition	Need is a set of issues in the energy system that should be resolved to maintain the reliability and balance of the system in economic and cost-efficient way.
Element of	Market segment
Related to	Need is related to the Offer
Attributes	Paradoxical requirements
References	(Chunyu Zhang et al., 2013), (Samuelsson et al., 2013)

Table 44 The Need element characteristics

The energy system needs for flexibilities vary in nature, ranging from the need for solving local issues, such as the capability of the Distributed Energy Resources (DER) to solve local problems, to the needs for solving broad system issues. The main energy system stakeholders are DSO, TSO, and BRP in addition to the retailers, generations and customers. TSO is usually a monopoly, responsible for the operation of the transmission system and the stability of the overall system. DSO is usually a monopoly too, responsible for the operation of the distribution network and delivery of electricity to the end-user without disturbing the transmission system. The BRP is a private legal entity that takes up the responsibility to compose a balanced portfolio and need for balance generation and consumption from generators, suppliers and consumers. Usually DRBMs focus on the aforementioned stakeholders' needs (Hansen et al., 2013; Ikäheimo et al., 2010).

The DSO needs include different type of needs (Chunyu Zhang et al., 2013). The need for “*Peak shaving*” aims at flattening the load peak during high consumption period (e.g. evening). These peaks might cause a given network component (Feeder, cable, transformer etc.) to exceed its capacity and be overloaded due to the high power transfer during the peak period (Samuelsson et al., 2013). One of its common problems is the “*Feeder Overload*”, which is caused by demand growth that threatens the feeder security margin (30%) and could be the result of demand responding to very low electricity prices or regulation service located in the distribution network. The solution could be the Planned or Urgent power cut. The Power Cap (determined by the DSO) which ensures the capacity limit will not be violated and the Power Max service by an aggregator that guarantees the local power portfolio will not be exceeded a predefined limit (Rahnama et al., 2017). The need for *Power quality* is a local problem and it refers to aspects, such as harmonic currents and phase imbalance (Samuelsson et al., 2013). The need for *Local voltage control* refers to handling the local voltage levels as it entails great importance due to its effect on power flow in the distribution grid and the ability of local assets to provide services (Samuelsson et al., 2013). One of the prominent issues regarding the local voltage is *Feeder voltage*, which is caused by a higher or lower voltage of the distribution grid. Voltage variation can be solved by Voltage Support by the aggregators who ensures that the voltage will not go beyond its limit or by Var Support in which aggregator cooperate with reactive power control of the DSOs (Chunyu Zhang et al., 2013).

TSO needs can be summarised by the need for frequency control and voltage support. The need for frequency control, is about maintaining the frequency within its specific limit. This service, it is handled through the capacity or reserve market (Samuelsson et al., 2013). The need for voltage support is about maintaining the overall voltage balance for the entire power system (Samuelsson et al., 2013).

The BRP needs can be described by the need for imbalance issues and the need for handling congestion problems. In the need for imbalance issues, the BRP may face an imbalance between the contracted amount of electricity and the actual production/ consumption, which imposes a penalty. To avoid imbalance, BRP might purchase balancing service from another BRP or an aggregator. The need for handling congestion problem. Due to the bottleneck situation, a BRP might not be able to deliver his contract amount because it is cut-off by the bottleneck.

4.4.2.3 Demand response BM governance

Activity system perspective on BM describes BM governance as the ways in which flow of information, resources and goods are controlled. It emphasises the participants’ incentives for making BM transactions (Amit and Zott, 2001). The DR governance is described by three main elements “Service operation”, “Valuables availability” and “Proximity scale” (Figure 51). The service operation refers to who controls the valuables; the valuables availability outlines the incentive of the participating customers and proximity scale determines the location where the service is taken place and is implemented.

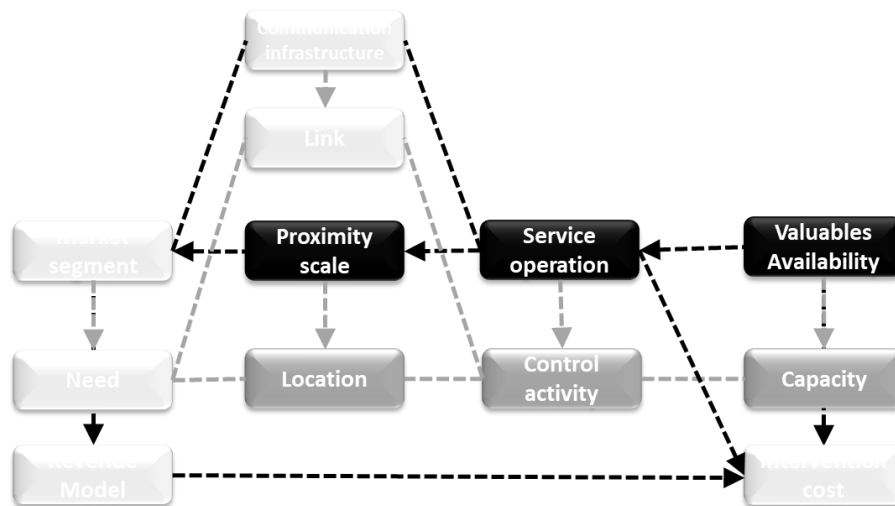


Figure 51 Demand Response Business Model Governance elements and sub-elements

4.4.2.3.1 Valuables availability

Valuables availability refers to the available capacity of the DR valuables' capacity and its correlation with the need of the energy system (O'Connell et al., 2014). The presence of sufficient capacity is not enough unless it is available at critical balancing need time (Figure 52). (Table 45) gives more details regarding the element characteristics.

Often the employed DR valuables, both assets (e.g. CHP) and loads (e.g. appliances), have a primary use and a function of fulfilling the customer's needs. For example, the EV's battery is sized to serve driver mobility needs (O'Connell et al., 2014). In a similar vein, the activation of DR demand-valuables confronts behavioural changes and interruptions for the consumers. This disruption may make the flexibility a hard-achievable task. Consequently, and from an economic point of view, customers usually evaluate the opportunity cost, which is the cost that the participants would miss out when choosing to participate in the DR service. This cost is prominent for industrial DR services where the production line's operations could be affected and led to generate additional cost during the DR service activation. In another case, this cost may not be explicit, such as the case of discomfort for the residential consumers.

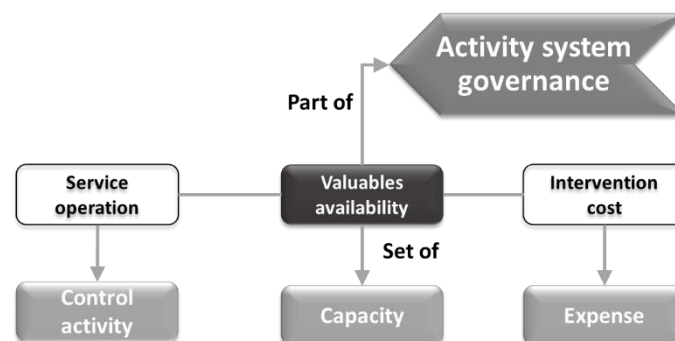


Figure 52 Valuables availability element in the demand response ontology

In the EVs DR service, customers compromise between using the vehicle and commit to DR services. They may also compromise between the DR service return and the long term effects on the battery deterioration (Bhandari et al., 2018). In the aggregated refrigerators DR service, the owner compromises between the risk of food deterioration and commitment

expectation (Lakshmanan et al., 2017). In the case of a wind farm with a storage system, the owner should find a middle ground between reserving the battery capacity for reducing imbalance cost of the wind farm or participating in a DR service in the energy markets (Rodrigues et al., 2016). In that case, the valuables availability is related to the intervention cost element which deals with the customer incentives or remuneration for participating in the DR service.

The industrial customers have few specifications for DR services. First, some production processes of a manufacturing plant can be highly dependent on each other, thus any load curtailment event on one process would generate effects on another related process. Second, some electrical equipment requires high timing precision; thus, special meters are needed on the level of subsecond-scale monitoring and control. Finally, industrial plants have concerns regarding their usage data, which can reveal confidential information and competition-sensitive costs (Samad and Kiliccote, 2012). Therefore, this element is associated with the “Service operation” element and having available capacity depends on the way the valuables are controlled and the interaction between the DRP and the customers.

In addition to the opportunity cost, which is an economic variable that can be improved by maximising participating customers remuneration, valuables availability also includes the valuables’ constraints. Valuables’ constraints refer to non-economic factors, irrational behaviour and different consumer priorities that constrain customers’ participation in the DR services (O’Connell et al., 2014). This irrational economic behaviour is associated with two factors. First, most consumers view electricity as a service rather than a commodity that reduces the received attention to prices variation and the need for flexible consumption. Second, the lack of understanding of the demand response need and electricity consumption in general (O’Connell et al., 2014). Valuables’ constraints can be explicit and measurable, such as the case of industrial consumer or implicit, such as the discomfort for residential consumers.

BM element name	Valuables availability
Definition	Valuables availability refers the available capacity of an asset or a load that can be provided without diminish the valuables efficiency or consumer comfort.
Part of	Activity system governance
Inherits from	Capacity
Related to	Valuables availability is related to Service operation and Intervention cost
Set of	Capacities
Attributes	Opportunity cost Valuables’ constraints
Reference	(O’Connell et al., 2014)

Table 45 The Valuables availability element characteristics

The valuables availability is the sum of the available capacities that are transformed into flexibility products, so that they can be decomposed into available capacities.

4.4.2.3.2 Capacity

The energy system available capacity must be always greater than the system maximum potential demand to guarantee the security of supply under contingencies or demand variations. Capacity refers to the maximum amount of power that valuables can provide. DR can be employed to compensate for relatively small energy deficits. Herein, the author distinguishes between small capacity and large capacity valuables. While large industries have direct access

to the energy market due to their economies of scale of their large capacities, the commercial and residential consumer have limited access due to their small capacities. Thus, intermediate commercial actors, such as an aggregator, can play a key role in expanding market access and allows small and distributed capacities to be pooled and participate in this market. (Table 46) explains the main characteristics of this element.

BM element name	Capacity
Definition	Capacity refers to the maximum amount of power that valuables can provide.
Element of	Valuables availability
Attributes	Capacity size (small, large)
References	(Paterakis et al., 2017), (Helms et al., 2016)

Table 46 The Capacity element characteristics

DR participants in energy and reserve market require having a minimum capacity. This capacity might also be allowed to be aggregated.

4.4.2.3.3 Service operation

This element discusses the operational activities of DR implementations, actor's roles and their responsibility. Service operation is the management of valuables' capacity and process of transforming flexibility to DR purchasers (Figure 53). It refers to the operational activities and efforts required to activate the DR service at the customer-site or off-customer site. The major task, in this element, is the operational control. Some operations, such as in the industrial plants, require complex operational actions that are delivered by experts. Other operations are very simple and can be activated by switching On/Off such the case of HVAC of commercial buildings. Operations might be managed directly by the provider, such as the case of direct load control BMs. (Table 47) illustrates the main characteristics of this element.

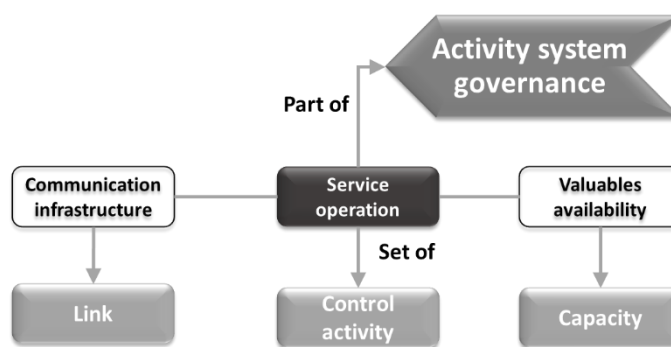


Figure 53 Service operation element in the demand response ontology

The providers have many operational responsibilities. Not all the customers are able to evaluate their flexibility and their DR profitability so that the DRPs have to evaluate customer's profitability. The DRPs have to provide communication and control devices. Furthermore, the DRPs have to provide financial incentives to customers (Ikäheimo et al., 2010). To achieve all these operational tasks, the DRPs need to have control and monitoring devices, such as load control switches and smart thermostat and, moreover, they need to determine the control strategy (e.g. remote control, automated, etc.) (Motegi et al., 2007). In some cases, the customers' roles often are limited to accept/ not accept the proposed actions by the DRP. In other cases, they have no operational task, such as the case of automated DR.

BM element name	Service operation
Definition	Service operation refers to the operational activities and efforts on- and off-site that are needed to activate the demand response service.
Part of	Activity system governance
Inherits from	Valuable availability and Communication infrastructure
Related to	Service operation is related to Valuables availability Service operation is related to Communication infrastructure
Set of	Control Activity
References	(Ikäheimo et al., 2010), (Motegi et al., 2007)

Table 47 Service operation element characteristics

The load control by remotely dispatching thousands of consumers devices and appliances has the potential to be extraordinarily useful to the grid operation. This turning loads on and off, in real-time falls into two broad categories. The first one refers to the load that causes inconvenience or discomfort (turn the air conditioning off). The second one corresponding to the load that would be mostly unnoticed by the customer (e.g. charging EV) (Brooks et al., 2010). The service operation consists of Control activities that are illustrated in the next subsection.

4.4.2.3.4 Control activity

Control activity refers to the actions that are needed to achieve the response plan. These activities aim at activating the DR at the customer's premises. In this regard, some authors distinguishes between three control activities: manual, semi-automated and full-automated (Samad and Kiliccote, 2012). The manual response involves a labour-intensive approach, such as manually switch off and may not come up with a fast response thus limiting the available market services. Semi-automated is pre-programmed in the system but still, need human to trigger the activation. Fully automated response receives the communication signals and translates them into a sequence of operations which enables fast and reliable service (Motegi et al., 2007). Summary of the element details is given in (Table 48).

BM element name	Control Activity
Definition	Control Activity refers to the actions required for activation and implementation of the service at the customer site.
Element of	Service operation
Attributes	Automation level: Manual, semi-automated and automated
References	(Motegi et al., 2007), (Samad and Kiliccote, 2012)

Table 48 The Control activity element characteristics

Customers are not always rational in their consumption decisions, and in some cases, the conventional economic models cannot explain the consumer behaviour in response to different electricity prices. Using automation for demand response can overcome this issue. Automation can reduce the burden of price response on consumers and guarantee a more predictable and efficient response. In this case, the consumer role can be limited to on/off of appliances and temperature limits selection (O'Connell et al., 2014).

4.4.2.3.5 Proximity scale

DR can be used to reduce both the local peaks in a particular area and the system peaks (Siano, 2014). Often, DR response services are not local services and have no constraints regarding the geographical area. However, some services must be implemented closer to or on

the site where DR service is needed. What determines the location of the service is the market segments (Figure 54). The DR services for maintaining the distribution network security are often local services provided to the DSO. Congestion management of the distribution network is one of these services and must be implemented in the region where congestion is expected (O'Connell et al., 2014). In another service, DSOs usually face high load during specific months of the year (e.g. unusual cold winter month), during these periods, the risk of the feeders to be overloaded is higher (Hansen et al., 2013). Thus, limiting the average maximum load of local consumers is a service that can be provided by the DRP or by the DSO. Furthermore, DR services that aim at reducing the customer energy bill cost are also services that implemented on the consumer site. (Table 49) explains the main characteristics of this element.

BM element name	Proximity scale
Definition	Proximity scale refers to distance between the implemented service and the energy system needs and whether it serves a local grid issues or a system issue
Part of	Activity system governance
Inherits from	Location
Related to	Proximity scale is related to type of Market segment and Service operation
Set of	Locations
References	(Hansen et al., 2013), (Siano, 2014)

Table 49 The Proximity scale element characteristics

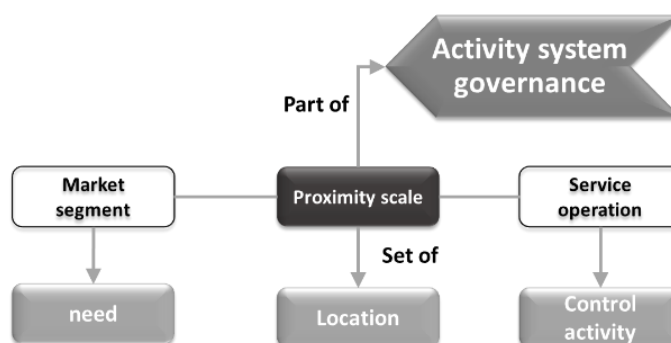


Figure 54 Proximity scale element in the demand response ontology

4.4.2.3.6 Location

Based on the Location (Table 50), the flexibility products can be identified and classified as follows (Villar et al., 2018):

- **Balancing flexibility at the transmission grid:** flexibility products are offered to the TSO for balancing purposes and through fully developed markets, such as reserve market and intraday.
- **Balancing flexibility at the distribution grid:** flexibility products are offered to the TSO for balancing service but provided at the distribution grid. TSO and DOS coordination is essential to ensure that the provided services for the TSO do not generate additional problems to the DSO.
- **Flexibilities for the DSO:** flexibility products are provided to the DSO for local balancing. Often these services are combined with balancing services for the TSO.

BM element name	Location
-----------------	----------

Definition	Location refers to position where flexibility is generated along the energy system network.
Element of	Proximity scale
Attributes	Effects on transmission grid Effects on distribution grid
Reference	(Villar et al., 2018)

Table 50 The Location element characteristics

4.4.2.4 Demand Response BM value capture

Value capture refers to the revenue that the firm generates from providing goods, information and services to the customer (Teece, 2010). Values can be captured from developing new products, addressing a new market opportunity or coming with new transaction mechanisms. In the DRBM, value capture includes the revenue and the firm's costs. In this regard, three elements are proposed the "Transaction cost", the "Intervention cost" and the "Revenue model".

4.4.2.4.1 The transaction cost

Transaction cost is the cost of identifying, activating, connecting and communicating with the demand response valuables (Helms et al., 2016). This element represents the activity system content cost; therefore, it is related to DR valuables, their capacity size and the response mechanism (Figure 55). Transaction cost is correlated with the number of the timing-processes that are required to coordinate and deliver flexibilities, and it increases with the intensification of these timing-processes.

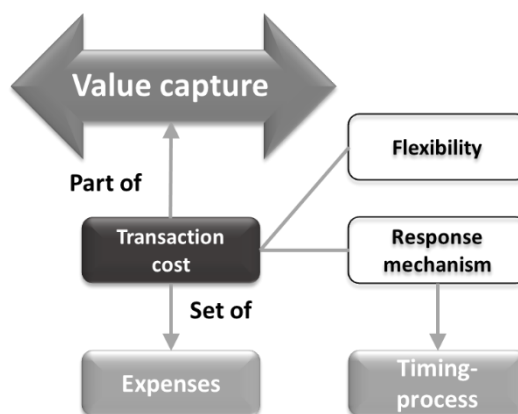


Figure 55 Transaction cost element in the demand response ontology

Large capacity size valuables require single or fewer processes, therefore they have low transaction cost. For example, low transaction cost DRBM might employ large power plant (e.g. Wind farm or gas plant) or load-based large-scale demand response units (e.g. chemical or cement plant). On the contrary, a virtual power plant, which consists of considerable number of CHPs, as well as load-based small scale demand response units (e.g. residential customers) require multiple timing-process (Helms et al., 2016) (Figure 56). (Table 51) shows the main characteristics of this element.

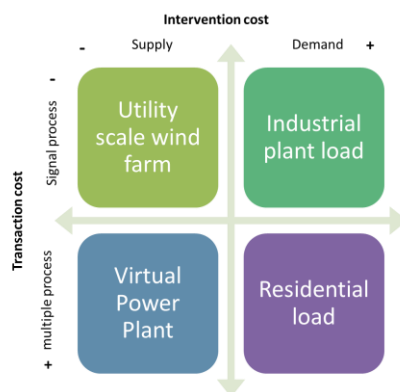


Figure 56 Transaction cost and intervention cost characteristics. Adopted from (Helms et al., 2016)

DR service involves a different kind of costs. It entails the enabling technology, metering and communication, customer education and billing (Albadi and El-Saadany, 2008). The enabling technology consists of technologies that are installed on the customer site, such as energy management system, thermostat, storage and generation unit.

Most of DR services need communication and metering that measure, store and transmit electricity at the required intervals. For example, the typical cost for preparing a site for participating in fast DR service (e.g. regulation service) is between \$50k and \$80k in the U.S. However, this cost can be reduced significantly to \$5k by using the telemetry via the internet for large commercial and to \$1k for small commercial and \$100 for residential (Kiliccote et al., 2014). An upgraded billing system is necessary, especially for Price-based programs. Some DR programs depend heavily on the customer's actions; therefore an education program for service explanation is significant (Albadi and El-Saadany, 2008).

BM element name	Transaction cost
Definition	Transaction cost is the cost of identifying, activating, connecting and communicating with the demand response valuables
Part of	Value capture
Inherits from	Expense
Related to	Transaction cost is related to Flexibility Transaction cost is related to Response mechanism
Set of	Expenses
Reference	(Helms et al., 2016)

Table 51 Transaction cost element characteristics

4.4.2.4.2 The intervention cost

The intervention cost is the cost of exploring the different, variant and specific consumption patterns, designing their relevant intervention mechanism and remunerating the customers for their behavioural change (Helms et al., 2016). This cost is devoted to understanding the customer's consumption behaviour and patterns and intervening in or changing these patterns. This element is related to valuables availability and service operation (Figure 57), and it is illustrated in (Table 52). The intervention cost consists of the cost of the response plan and the cost of customer remuneration.

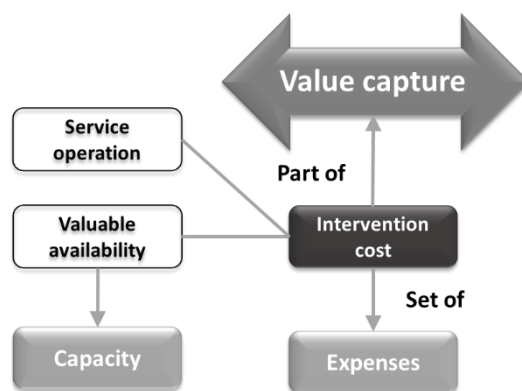


Figure 57 Intervention cost element in the demand response ontology

The response plan is the plan that the DRP will go ahead with for an expected event. However, because of the uncertainty of demand and supply, different scenarios should be expected. An expected event might have different size, duration etc. Part of this variation can be explained by the unexpected customers' behaviour, thus unexpected valuables availability. The intervention cost is correlated with customer behavioural adaptations because the customers' behaviours were traditionally not foreseen. Herein it has been distinguished between BMs that depend on supply-valuables (e.g. wind farm) and BMs that employs demand-valuables (e.g. commercial heating system) (Helms et al., 2016) (Figure 56). The employment of demand-valuables, such as a commercial heating load adjustment imposes higher intervention cost than the usage of supply-valuables, such as the CHPs. While the former depends on the consumer's behaviour adaptation (feeling cold, building occupancy, commercial season, etc.), the latter is always available and can be controlled only by switching on the "start" bottom (Figure 57).

Furthermore, this cost is also associated with the degree of heterogeneity of consumption patterns. Higher heterogeneity level means customised operational activities and thus higher intervention cost. The cost of aggregating and operating of identical or similar consumption patterns, for example aggregating few cement plants, is low. In contrast, the aggregation of different kind of customers, with variant load profiles, embeds high cost (e.g. aggregating a group of chemical, food and steel industrials).

Finally, the customer's remuneration is the financial incentives paid for customers in return for their participation in DR services. Remuneration might take many forms. Customers might be incentivised by "Availability payment" which is the payment for being available for load shift or reduction at the time the DRP or TSO demand and is also called standing by or capacity payment. "Call" is a payment for energy flexibility provided for actual electricity reduction and is based on agreed kWhs. Finally, "Percentage" is the percentage that the customer would take from the aggregator's profits for being participating and is based on customer's performance (Ikäheimo et al., 2010) (Figure 58).

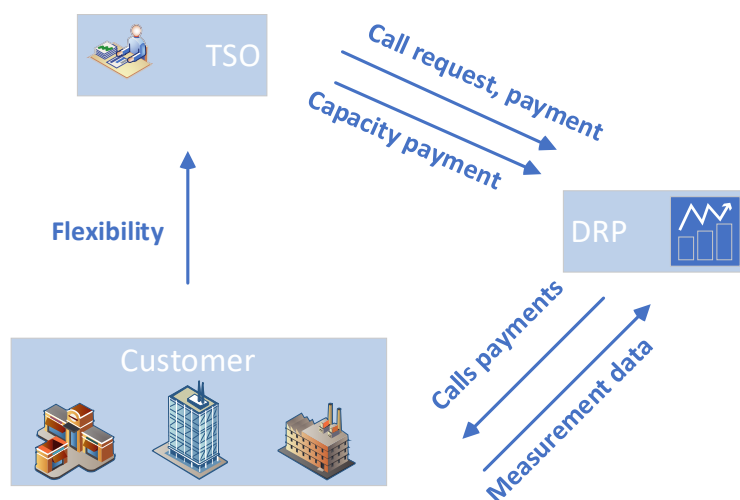


Figure 58 Payments flow between DRP, Customers and DR Purchaser, source: (Ikäheimo et al., 2010)

BM element name	Intervention cost
Definition	Intervention cost is the cost of exploring the different, variant and specific consumption patterns, designing their relevant intervention mechanism and remunerating the customer for their behavioural change.
Part of	Value capture
Inherits from	Expense
Related to	Intervention cost is related to Valuables availability Intervention cost is related to Service operation
Set of	Expenses
Reference	(Helms et al., 2016; Ikäheimo et al., 2010)

Table 52 The Intervention element characteristics

4.4.2.4.3 Expense

Expenses are the expenditures that a business incurs to engage in any activities of the firm related to value creation. Generally, expenses can be divided into variable and fixed. The fixed costs are the expenses that are paid one time (capital cost, rent, salaries, etc.). The variable costs are expenses associated with the production process volume and they increase with the increase of produced units. (Table 53) explains the main element's characteristics.

In the DRBMs, the fixed expenses associated with used technology (e.g. smart meters, CHP, etc.), the response plan, billing system and customer education programs. The variable expenses are related to customer's interruptions or inconvenience cost, commercial and industrial customer production loss, rescheduling and on-site generation (Albadi and El-Saadany, 2008).

BM element name	Expense
Definition	Expense is the money that is payed to cover all the transactions between the DRP and the involved actors.
Element of	Transaction cost and intervention cost
Related to	Expense is related to transaction cost Expense is related to intervention cost
Attributes	Fixed cost Variable cost

Reference	(Albadi and El-Saadany, 2008)
------------------	-------------------------------

Table 53 The Expense element characteristics

4.4.2.4.4 Revenue model

In general, DR services generate benefits for multiple actors. Consumers benefit from the DR service in different ways (e.g. bill saving, direct payment, etc.). If an intermediate firm, such as an aggregator provides the service, then a portion of the remuneration will be maintained for its service operation. The element's characteristics are illustrated in (Table 54). The revenue streams depend on the market segment and whether the DRP participates in the market or having a direct contract with the purchaser. While the former is highly associated with market fluctuations and demand and supply, the latter could provide stable source of income. The revenue stream also depends on the both intervention and transaction costs which have been discussed earlier (Figure 59).

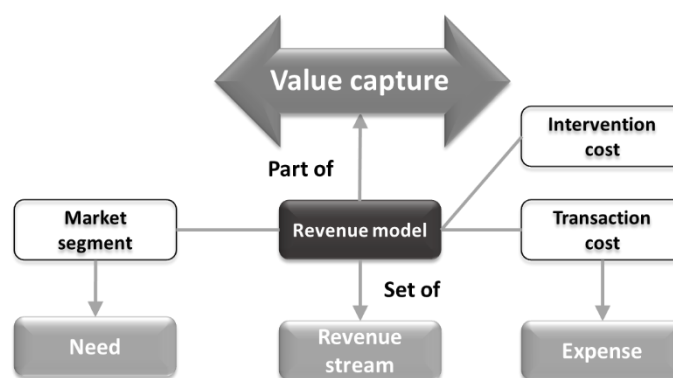


Figure 59 Revenue model element in the demand response ontology

System actors have a significant benefit from DR applications. The TSO can reduce the market prices due to the efficient use of infrastructure and reducing demand from the expensive electricity units (e.g. gas turbine). DR can support price stability and reduce volatility. The DSO and TSO benefit from the avoided or deferred need for additional distribution and transmission infrastructure reinforcement and upgrades (Amicarelli et al., 2017).

BM element name	Revenue model
Definition	DR revenue is the monetized benefits that generated from providing the DR service. DR revenue has two parts, one belongs to the provider (e.g. Aggregator) and the second is distributed on the customer (e.g. Load).
Part of	Value capture
Inherits from	Revenue stream
Related to	Revenue model is related to Market segment
Set of	Revenue streams
Attributes	Inherited from Revenue stream
Reference	(Albadi and El-Saadany, 2008).

Table 54 The Revenue model element characteristics

4.4.2.4.5 Revenue stream

Revenue stream describes the flow of money from the provider to the purchase and payment methods (Table 55). In DRBM, the payments flow from energy system actors (e.g. TSO) to the customer. Aggregators, as an intermediate, would share part of the revenue with the customer, when they are involved. In the classical DR, customers are paid for being

participating. In the market-based DR participants' remuneration is based on performance evaluation (Albadi and El-Saadany, 2008).

Furthermore, similar to the customer remuneration model, the DRP (e.g. aggregators) revenue also falls into two categories: "Availability" and "Call". The former is a fee that is given to the DRP who has customers that position their equipment or/and generation in the standby state to be controlled when there is system stress. The latter is a payment followed by a call from the TSO demanding curtailment during an event (Ikäheimo et al., 2010).

Besides incentives, customers might have savings on electricity bill from their electricity consumption reduction during the peak hours. In some cases, customers can have those savings without consumption patterns changes if they usually consume during off-peak hours. Customers can also increase their consumption without increasing their electricity bill if their additional load takes place during cheap electricity prices (Albadi and El-Saadany, 2008).

BM element name	Revenue stream
Definition	Revenue stream describes payment methods and the flow of money from the demand response purchaser to the DRP.
Element of	Revenue model
Attributes	Having two types: Availability, Call
References	(Ikäheimo et al., 2010), (Albadi and El-Saadany, 2008).

Table 55 Revenue stream element characteristics

4.5 Demand response business model Canvas

This subsection explains the process of translating the demand response ontology into a demand response business model canvas. First, the author draws on the cognitive literature on business model and visualisation tools. Then, the author illustrates the development process, referring to the main parts of the canvas and finally the use process is outlined.

4.5.1 Business model visualisation

In this subsection, the author first outlines and explains the cognitive perspective on business model, the challenges associated with the development of a visualisation tool taking in consideration the cognitive approach and finally illustrates the dimensions of designing a visualisation tools and their different types.

4.5.1.1 Cognitive perspective on business model

In general the business model theory can be seen from two theoretical perspectives (Furnari, 2015): an *activity-based perspective*, conceptualising the business model as a system of activities that firms employs to create, deliver and capture value (Casadesus-Masanell and Ricart, 2010; Zott and Amit, 2010) and a *cognitive perspective*, conceptualising BM as a cognitive device that represents those activities (Aversa et al., 2015; Baden-Fuller and Morgan, 2010; Martins et al., 2015). The latter can be found in several BM definitions (Table 56). The cognitive perspective recognizes the business model as a tangible framework or tool (Gassmann et al., 2016), it reflects the managerial mental representations or models and support decision makers to develop somewhat a unique view of the reality (Martins et al., 2015). Business modelling has been defined as "*The set of cognitive actions aimed at representing (complex) business activities in a parsimonious, simplified form (e.g. business model), as well as the set of activities that cognitively manipulate the business model to evaluate alternative ways in which it could be designed*" (Aversa et al., 2015). In this sense, manipulation refers to the

different ways in which models can be manipulated to assist in changing existing business models, in playing with alternative scenarios and in modelling various possible outcomes for decision making.

The cognitive nature of the business model emphasises being a mediator between the technical input and the economic outputs by having interconnected elements as: market segment, value chain, value proposition, cost and profit, value network and competitive strategy (Chesbrough and Rosenbloom, 2002). Baden-Fuller and Morgan (2010) have described the business model as ideal types that can be copied from one industry to another taking in consideration variation and innovation. They are classifying instruments that provide valuable ways to expand the business phenomena understanding and develop ideal types (Ambrosino and Legardeur, 2016). Martins et al. (2015) have proposed generative cognitive processes that assist managers in decision making and innovation. The first process is based on the “*Conceptual combination*” which aims at creating new concepts that are different from the existing ones by examining the differences rather than similarities between two business models. The second process relies on the “*Analogical reasoning*” in which a comparison is drawn to find similarities between two business models in two different industries. Aversa et al. (2015) have examined the business model from modularity perspective and argue that business models have the property of decomposability, that is to be subdivided into loosely coupled sub-elements. Two processes have been proposed from this perspective: “*modularization and manipulation*”. *Modularization* is the cognitive activity aimed at conceiving of a complex system, such as a business as simplified model of interconnected elements, while *manipulation* refers to the processes of changing a business model’s elements, their linkages, their order at the cognitive level. Furnari (2015) employs the cognitive mapping approach for analysing the causal structures embedded in the business models, this map allows managers to see how the components of a business model relate to each other in a network of cause-effect relationships.

This cognitive approach can complement the activity system perspective. The author focuses in this subsection on the cognitive perspective aiming to develop a visualisation tool that consists of a business model canvas and supportive cards.

Article	Business model definition
(Chesbrough and Rosenbloom, 2002)	“The business model is “the heuristic logic that connects technical potential with the realization of economic value”
(Baden-Fuller and Morgan, 2010)	“Business models are models”
(Aversa et al., 2015)	“The set of cognitive actions aimed at representing (complex) business activities in a parsimonious, simplified form (e.g. business model), as well as the set of activities that cognitively manipulate the business model to evaluate alternative ways in which it could be designed”
(Furnari, 2015)	“A business model’s cognitive map is a graphical representation of an entrepreneur or top manager’s beliefs about the causal relationships inherent in that business model”
(Martins et al., 2015)	Business model schemas can be defined as cognitive structures that consist of concepts and relations among them that organised managerial understand-structures about the design of activities and exchanges that reflect the critical interdependencies and value-creation relations in their firms’ exchange networks.

Table 56 Business model definitions that are based on the cognitive perspective

4.5.1.2 Visualisation challenges

The literature on demand response and business indicates that scholars focus on the demand response markets (Albadi and El-Saadany, 2008), its application in the different industries (Shoreh et al., 2016), its various programs types (Paterakis et al., 2017), and its benefits on both the system and individual level (O'Connell et al., 2014). However, scholars have paid a little attention for the research on the intersection between the business model concept and the demand response (Behrangrad, 2015) and the literature shows that demand response lacks a business model framework that can describes its logic and represents all its different components. The author, in this piece of work, seeks to close this gap by developing a Demand Response Business Model Canvas (DRBMC) that can represent the main DR aspects required for creating an economic value.

Visualisation is a key approach in designing and analysing business models (Osterwalder, 2004). Visualisation can support firms in better understanding and communicating their business models, developing and generating new ideas and overcoming organisational innovation barriers, they can stimulate collaborative innovation, reduce complexity and enable better knowledge sharing (Täuscher and Abdelkafi, 2017).

Designing a visualisation tool, in the management sciences, poses several challenges, such as dealing with complexity, the business dominant logic and knowledge (Eppler and Hoffmann, 2013).

Visualisation enables the communication of complex information. Aggregated demand response has been described as a complex business model in the European electricity market and this complexity stems from three aspects: “*Timing*”, “*Volume requirements*” and “*Program specifications*” (Koliou et al., 2015). The timing aspects have been integrated within the developed ontology in the “*Transaction characteristics*” where timing dimension are represented, such as time to respond, duration of the DR, frequency of the events etc. The volume requirements have been also addressed in the “*Market segments*” through the minimum and maximum of each service. Thirdly, program specifications, such as measurement and verification and response methods are also addressed in the “*Communication infrastructure*” and “*service operation*” respectively.

Given that business model supports innovations, visualisation tools challenge managers to change the status quo of the business and overcome the influence of the dominant logic. The goal of the intended canvas is to reinforce the business flexibility on the demand side rather than to rely on the supply side. DRBM tool can support managers to think about the latent load flexibility businesses. Given that, load flexibility might be exploited in various industrial, commercial and residential electrical activities, each activity could contribute, according to its capacity, to the flexibility of the grid (Eppler and Hoffmann, 2013).

Visualisation tools support knowledge creation. According to (Eppler and Hoffmann, 2013) they generally stimulate thinking, foster shared thinking and trigger memory. The intended canvas can trigger knowledge not just by having 12 elements but also by a set of 52 cards. The cards either show the enclosed possibilities (e.g. demand response mechanisms) or give more granular elements that detail the element.

Given the attribute of being an interactive tool, the visualisation tool has the capabilities to support managers for idea generation, decision making, planning and knowledge sharing.

This collaborative feature of the visual representations are illustrated in seven collaborative dimensions showed in (Figure 60): *visual impact*, *clarity*, *perceived finishedness*, *inference support*, *modifiability*, *discourse management* (Eppler and Bresciani, 2013). Visual impact describes to which degree the visualisation framework is attractive and capturing attention. Clarity refers to the capability of self-explanatory and the requirement of low cognitive effort to easily understand the framework. Perceived finishedness outlines to which extent the visualisation framework resembles a final, polish product, thus it invites modifications. Direct focus indicates the capability of the structure to keep the attention on a specific issue. Inference support is the capability of the visualisation framework to generate new insights. Modifiability refers to which extent the structure can be dynamically altered in response to the dynamic of a discussion. Discourse management indicates the control degree of a visualisation over a discussion flow.

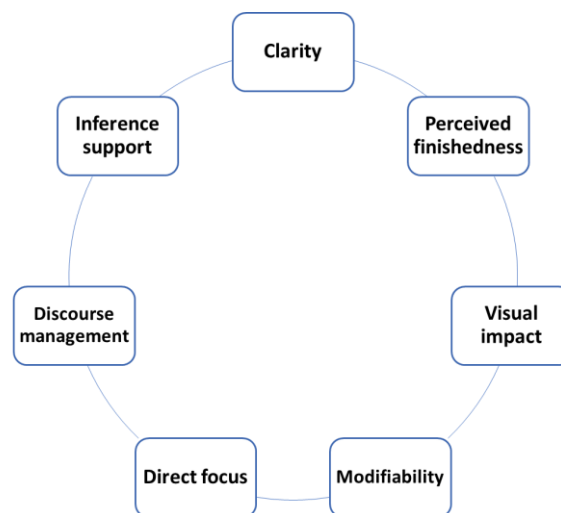


Figure 60 The visual representation collaborative dimensions. Source: (Eppler and Bresciani, 2013)

4.5.1.3 Business model visualisation dimensions

The visualisation of a business model can be described in dimensions of content and graphic (Täuscher and Abdelkafi, 2017). The content contains symbols and notational elements that represents visually the information. It may be organised differently and may be divided in elements (Elements view), can indicate the transaction between actors (Transactional view) or signifies the causal relations (Causal view).

Graphic design may also follow different logics. Graphic could be based on a predefined form to allow the arrangement of specific textual content so that aims at organising the business model innovation process (Graphic organisers) e.g. Business Model Canvas (Osterwalder et al., 2011). Graphic could be based on open-ended with no explicit design, so it facilitates the brainstorming and thinking out of the box (Brainstorming webs) e.g. (Gavrilova et al., 2014; Real, 2015). Finally, graphic may combine two analytic approaches and supports cognitive structuring as well as creative processes by being open ended (Conceptual map) e.g. (Casadesus-Masanell and Ricart, 2010). (Figure 61) shows the three different types of business model graphics.



Figure 61 Three types of business model graphics. Source: (Täuscher and Abdelkafi, 2017)

Following the ontology and the classification of the main demand response business model activities and the characteristics of the business model visualisation (Täuscher and Abdelkafi, 2017), the intended canvas first, should have pre-defined visual arrangements. Thus, the user will have in hand all the elements that the demand response business model might have. Second, should provide a guide thought, focus attention on the frame and the scope of the demand response. Third, should support learning about new concepts. Given the unfamiliarity of the concept demand response. Accordingly, the representation of the ontology in a practical and useful virtualisation canvas will be a type of graphic that is “Graphic organiser” and a content that follows the “elements view”.

Moreover, a set of cards that can support and illustrate the canvas elements, will be of great value for users. Finally, the intended canvas should support the integration phase of the business development. In this phase, managers transform the generated ideas into complete and consistent business model. However, it may contribute to the initiation phase and frame the innovation problem as well as to the ideation in terms of the innovation output.

4.5.2 Development of the DRBM canvas

The development of the DRBMC is grounded in the demand response business model ontology (section 4.4.2) and is aligned with the findings presented in former sections.

First, there is a common agreement in the literature that there is a need for energy transition innovation based on demand response, considering its environmental and social value and its economic benefit for both customer and purchaser. Second, the technological advances permit entrepreneurs to exploit ICT, such as the smart meters, real-time measurement and control to create efficient demand response business models. Third there are limited tools that can be used by entrepreneurs to develop demand response business models. Fourth, innovation in the demand response depends on experimentation rather than using a prescriptive process. Fifth, most of the start-ups are not aware of the demand response and its benefits, thus it confirms the lack of familiarity with this concept. Finally, innovation often goes beyond the firm’s boundaries and involves new actor from other industry sectors, similarly, DRBMC aims at capturing flexibility of different industrial, commercial and residential activities, aggregating and monetizing them in the energy market.

4.5.2.1 First version of DRBM canvas

Based on the ontology described in the former section, a first proposition of the canvas was developed that contains twelve elements: Valuables, Transaction characteristics, Mechanisms, Value proposition, Market segments, Communication infrastructure, Proximity scale, Service operation, Availability, intervention cost, transaction cost and revenue model (Figure 62).

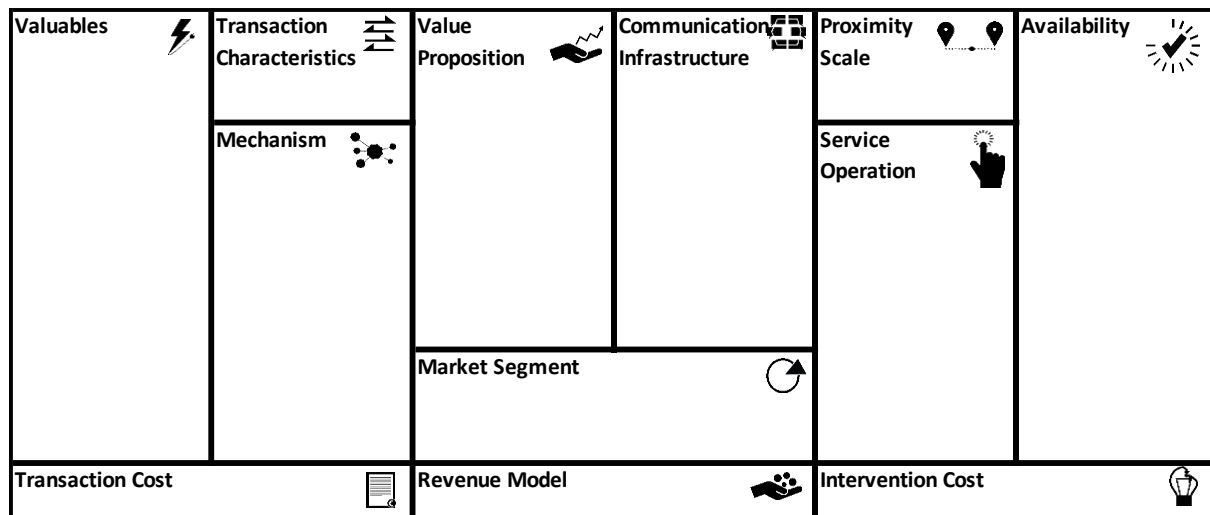


Figure 62 First version of the DRBM canvas

The first version of the canvas was tested with a start up in order to receive the first feedbacks concerning the use of the canvas. This first test highlighted several issues to be improved:

- The participants lack knowledge about the ecosystem where the DR could be used. Thus, an introductory phase should be put in place. This phase's objectives are to allocate the firm's position among the key stakeholders in the electricity value chain: TSO, DSO, BRP, DRP, retailers, and customers and show their relationships.
- The choices made by the participant can be visualized by putting on corresponding icons on the template for each choice (Figure 63).
- The market segment elements should be reallocated and be put beside the value proposition. This change enables direct matching between the value and its customer.
- The variation of the value propositions cards can be simplified by referring to whom the value is created. Therefore, an additional graphical illustration that shows which stakeholders benefit from the value proposition.

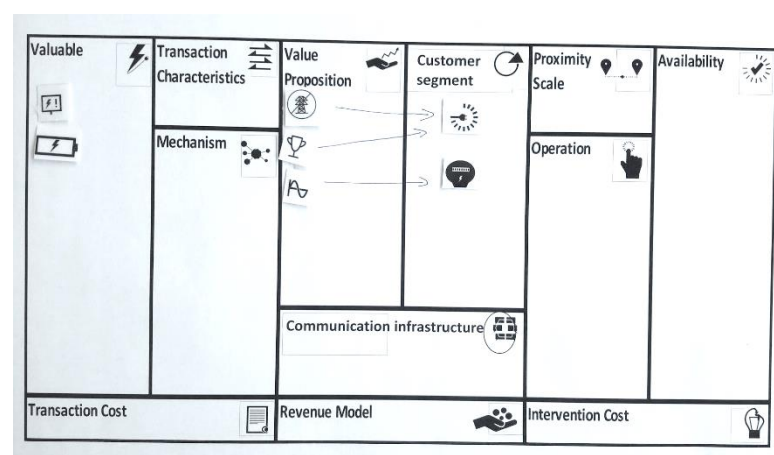


Figure 63 The DRBM template: participant choices representation by icons

4.5.2.2 The DRBM pre-usage phase

The integration of customers, suppliers, investors, communities, government and other stakeholders is highlighted in the business model innovation (Laudien and Daxböck, 2015;

Real, 2015). It is generally accepted that business model innovation is not limited to the firms defined boundaries. Instead, it goes beyond the boundaries of the firm (Amit and Zott, 2001). Therefore, and before the use of DRBMC, a preparation phase has been addressed in order to define the value network of the demand response. Sustainable business model seeks to go beyond delivering an economic value and integrates a range of stakeholders in particular environment and society (Stubbs and Cocklin, 2008).

Stakeholder mapping is a helpful and practical approach to assess the various parties' interests in a system in respect of each stakeholder's position. Stakeholders analysis can be considered "*as a holistic approach or procedure for gaining an understanding of a system*" (Grimble and Wellard, 1997). This approach allows to have deep understanding of and make a comparison between the particular sets of interests, influences and roles, and the illustration of relationship between them (Reed et al., 2009).

To do so, the author relies on the stakeholder theory to better formalize the context. This theory tends to explain and to guide the structure and operation of the enterprise and it describes the stakeholders as all persons or groups with legitimate interests participating in an enterprise to obtain benefits (Donaldson and Preston, 1995). Shared values and shared attitudes are core parts of the shareholder theory. The integration of the environmental values within the product design during the early phase business model development requires stakeholders engagement (Lizarralde and Tyl, 2018).

To better understanding the role of stakeholders in the visualisation tool design. The author have reviewed few articles that have a visualisation tool and stakeholders perspective. (Lim et al., 2012) have proposed a PSS visualisation tool, which is a matrix board indicates the PSS components relevant to customer needs fulfilment and customer activities in rows and the general PSS process steps in the intersecting columns. As a result, the processes of companies and customers along with general PSS process are visualized on the intersecting cells. (O'Hare et al., 2014) have proposed "*Life cycle stakeholders*" representative tool that support firms in identifying all key stakeholders and their contribution to eco-innovation. The tool consists of four types of stakeholders: value chain, professional interests, personal interest and customer. The "*Value Mapping tool*" is a tool that assists firms in embedding sustainability into the business model by improving the understanding of the value proposition and analysing sustainable value creation opportunities from a multi-stakeholder perspective, it includes four types of stakeholders: Environmental, Customer, Society and Network actor (Bocken et al., 2013). Another way to illustrate the stakeholders role is by creating an "*Interaction Map*" between the PSS actors in the system which indicates the interaction scenarios, the direct and indirect relationships between the actors in the system, and their dependence of the system from infrastructural conditions (Morelli, 2006). In the energy system, in particularly, the distributed renewable PSS a "*System Map*" can show the stakeholders configuration design and indicating their interaction and exchange of material, financial and information flows (Vezzoli et al., 2018) (Figure 64).

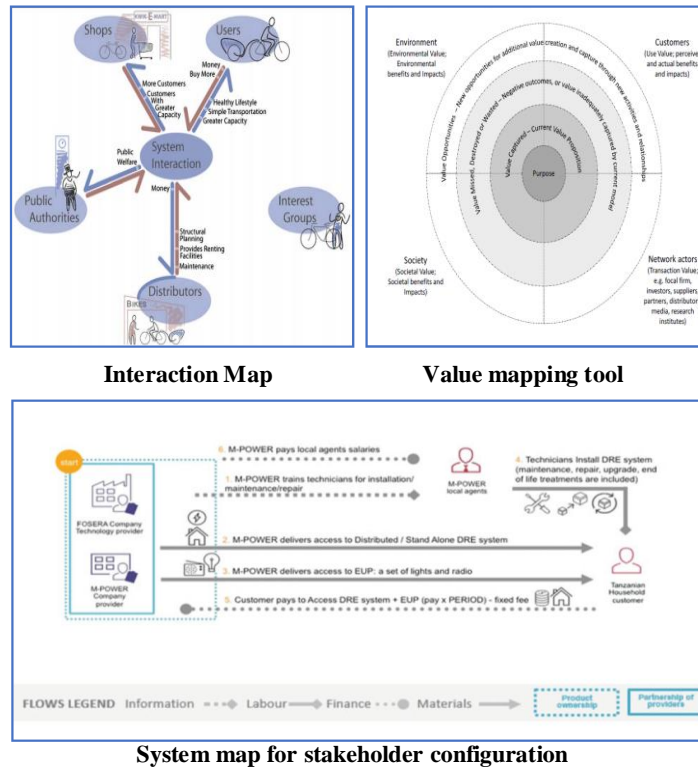


Figure 64 Stakeholders mapping tools from the literature

The energy value chain consists of generation, transmission, distribution, retailing and consumption (Figure 65) and any demand response value propositions should be embedded in and integrated with the energy system where DRP should deal with key stakeholders, such as energy utility, TSO, DSOs, retailers and energy consumers. These stakeholders have different interests that have been addressed in (subsection 4.4.2.1.5) and have different positions along the energy value chain.



Figure 65 Energy value chain

4.5.2.3 The DRBM canvas tool

The “DRBM canvas” is a practical tool that supports managers during ideating and design phases of new business models. The tool adopts a qualitative approach for value creation. The use of the tool does not require such quantitative details, because its prime aim is to explore new opportunities, highlights main business model aspects and stimulates discussion and communication. However, once the user defines his market opportunity and its potential business model, some quantitative indicators are required for validating the business model, specifically the economic measures (flexibility unit cost, income per unit, customer remuneration, market price, etc) and operational measures (response duration of DR services, frequency of demand services, minimum and maximum capacity, etc).

This research contributes for research on business models and demand response by developing an exhaustive and generic business model visualisation tool that fits into the demand response business requirements (Figure 66). The DRBMC provides a standardised representation for describing the elements of demand response BMs and support BM description. The purpose of this tool is not only to assist in DR value creation but also to contribute on the research on energy transition by highlighting the importance of the development of demand response businesses that can expand the flexibility capacity of the power system in an ecological way.

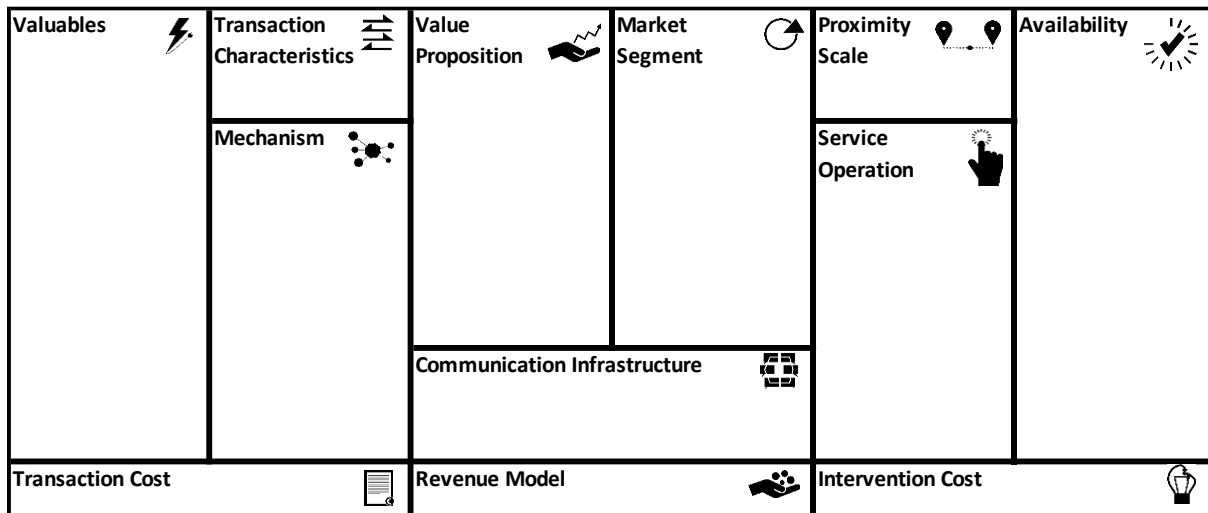


Figure 66 Demand response business model visualisation tool

The proposed tool combines the three aspects of the activity system: content, structure and governance, in addition to the value capture aspect in a unified tool as illustrated in (Figure 67).

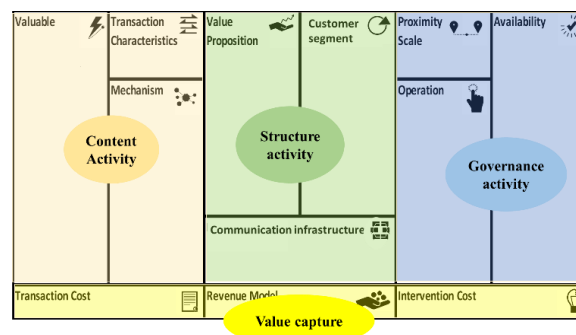


Figure 67 Four parts of the Demand Response Business Model Canvas

The tool simplifies the value creation processes through twelve elements and 52 cards (Table 57). The card design consists of four parts: the title, the representative icon, the BM element and description (Figure 68). Each element explains and points out an essential part of DRBM and each card belongs to one of these elements (Figure 69). The cards are designed to give further information on each element and expand the mindset horizon and probable scenarios.

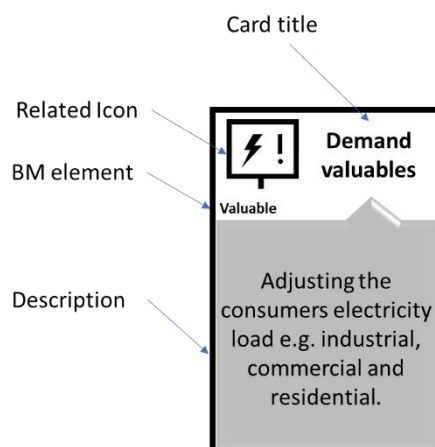


Figure 68 Example of a card "Supply-Valuables"

One of the main addressed difference from the common and general BM visualisation tools (e.g. BM canvas), is in the right part, which is the integration of governance and control aspects and participant incentives. This part shows the responsibilities and roles of the involved actors. As it has been mentioned before, the customer's load or the customer's generation are the main sources of the DR value creation. Herein, the customer is a co-provider. Managers may develop new incentives that attract new participants or purchasers. The middle part, which deals with BM structure, shows the possible configurations of the involved actors including their needs, motivation and drivers. These configurations are explained in the different market segments and their different requirements, the way this value is transferred, and the condition or characteristic of a successful transaction between those involved actors. Managers may explore the possibility of involving untraditional actors that might have interest as a customer or a purchaser. For example, there is a great potential to engage the energy communities and the energy cooperatives. The left part represents the required resources and capabilities. It shows what the BM requirements are. Managers may think about novel valuables (e.g. ice storage) or integrate more than individual resource (e.g. thermal storage and load management), or they may figure out a more effective response mechanism. Finally, the last part illustrates the main source of revenue and the major cost of a DRBMC divided into transaction cost and intervention cost.

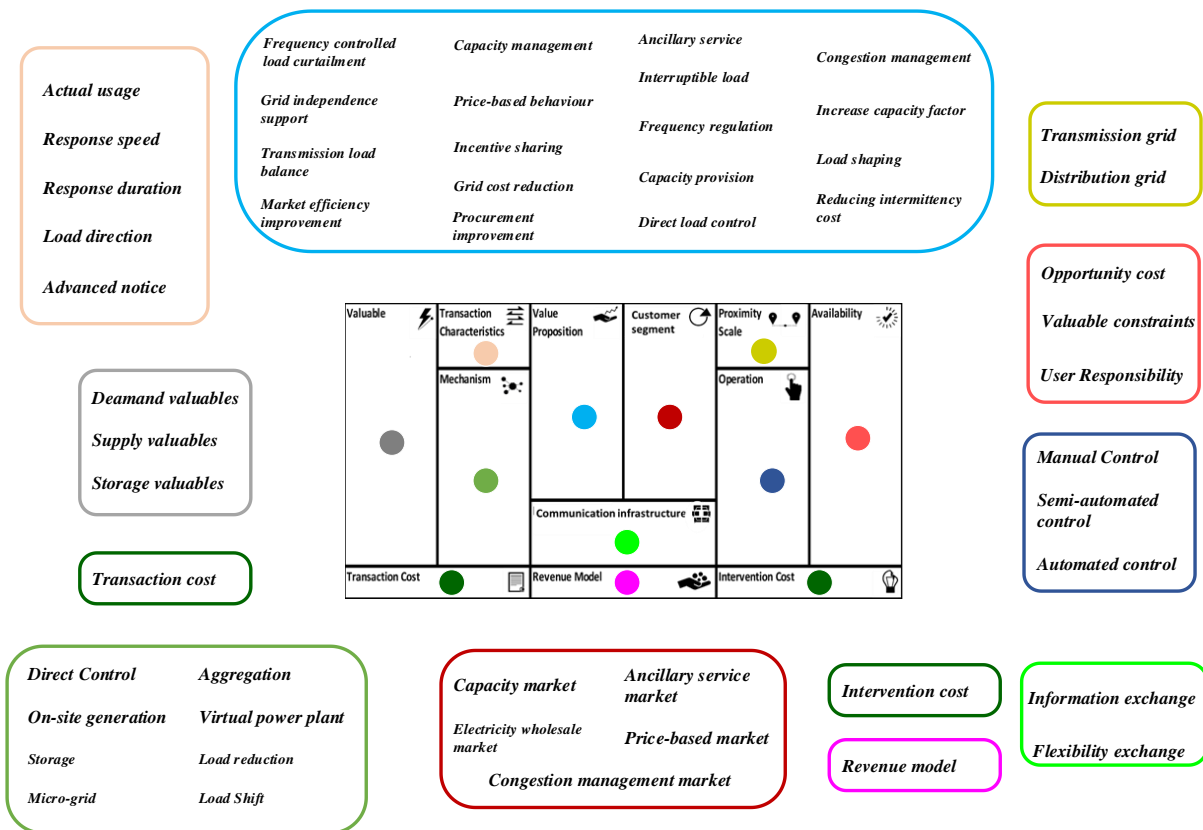


Figure 69 The supportive cards allocation to the DRBM elements

The DRBMC compose of the canvas, a set of cards and a stakeholder identification map:

- **The canvas** is a model constituted by twelve interrelated elements. Identifying separated elements permits a detailed exploration of the current business models and assists in identifying aspects of change or improvements.
- **52 cards** that form different sets of cards, each set belongs to one of the canvas elements. The cards are designed to explain the elements and show possible scenarios. Each set of cards has a unique colour and each card has an icon. The icon of each card has been used as a physical symbol that can be inserted on the canvas during usage. The definitions of the cards are taken from the demand response ontology and are illustrated in (Table 57). Additionally, 7 cards have been added that representing the different stakeholders. The cards figures are presented in the Appendix.
- **Stakeholder identification map** emphasis the system level focus rather than firm centric perspective, thus encouraging energy transition business activities. Before the use phase, pre-use phase is done including the identification of the key stakeholders (e.g. TSO, DSO, Energy Utility, customer, etc.). Given the demand response is part of regulated markets and established energy system, this phase is very important as it shows the function and position of the intersected stakeholders.

#	Element	Card	Description
1	Valuables	Demand valuables	Adjusting the consumer electricity load
2		Supply valuables	Using a distributed generation on the customer site
3		Storage valuables	Using electric, thermal or inventory storage system
4		Aggregation	Aggregating many loads to obtain the required capability

5	Response mechanism	Virtual power plant	Coordinating many distributed generations
6		Load reduction	Reducing consumers consumption during the activation of the DR service
7		Load shift	Shifting consumers consumption during the activation of the DR service
8		Direct control	A third-party takes the control of the consumer's appliances
9		On-site generation	Using on-site generation during the DR service
10		Storage	Employing storage system to provide flexibility
11		Micro-grid	Creating a network of generations, storage units and loads that function autonomously
12	Transaction characteristics	Actual usage	The service frequency exercised by the purchaser
13		Response speed	The time between receiving the signal and activate the service
14		Advance notice	Time of the advanced notice prior to service activation
15		Response duration	Minimum and maximum of service duration
16		Load direction	Symmetric or asymmetric of the power output
17	Value proposition	Ancillary service	Reducing the TSO operational cost and maintain the reserve margin at low cost, improving scheduling efficiency
18		Interruptible load	Providing reliability for the TSO through a contract that contains number of hours per activation
19		Direct control	The TSO will control the consumer's appliance directly and automatically to maintain system reliability
20		Frequency-controlled load curtailment	Preventing system frequency drops by automatically curtail the load in response to deviation in the grid frequency
21		Frequency regulation	Maintaining the system frequency stable level through increase/ decrease load based on frequency signal
22		Capacity provision	Reducing the capacity provision cost by committing to reducing demand during future peak time
23		Market efficiency improvement	Reducing the spot electricity price by bidding using the DR
24		Congestion management	Lower congestion cost, higher network stability, investment delay and high ramping response
25		Increase the capacity factor	Increase the capacity of the renewable generation during peak hours
26		Load shaping	Creating a desired load for generations to reduce operational cost, such as shut down/ start-up cost
27		Reducing intermittency cost	Decrease renewable energy intermittency cost and by decreasing its deviation from its dispatch schedule or increase the capacity factor
28		Transmission Load balance	Maintain generation injection/ withdrawal balance and schedule in each transmission region and avoid penalties
29		Procurement improvement	Avoiding retailers from purchasing electricity from the spot market during shortfall
30		Capacity management	Reducing retailers' peak contribution, thus the capacity obligation for future procurements
31		Price-based behaviour	Provide consumers with information or a system about the variation in the electricity prices
32		Incentive sharing	Using the flexibility of large capacity consumers to be sold in the energy market
33		Grid cost reduction	Committing to reduce peak load at suitable times, thereby the grid cost of reinforcement
34	Grid independence support	Balancing the load locally in remote area due to the limited capacity and to avoid blackout	
35	Market segment	Ancillary service	Consisting of frequency containment reserve, frequency restoration reserve and replacement reserve
36		Wholesale market	Consisting of day-ahead market, intra-day market and real-time market
37		Congestion management	Consisting of services that corresponding to the DSO and local distribution network issues
38		Capacity market	Committing to provide particular capacity in the future
39		Price-response market	Enables energy consumers to having energy bill savings by voluntary response to electricity price changes when it is economically viable
40	Valuables availability	Opportunity cost	The cost that the participants would miss out when choosing to participate in the DR service
41		Valuables' constraints	The non-economic factor and irrational behaviour of the customer
42		User responsibility	User voluntary commitment to provide DR service as part of the ecological and sustainability responsibility
43		Manual control	Consumer manual control to respond to the DR signals

44	Service operation	Semi-automated control	Consumer provides its approval to the DR signals
45		Automated control	Action is automatically operated, and consumer does not intervene in the control action
46	Proximity scale	Distribution grid	Flexibility that has its effect on the distribution grid
47		Transmission grid	Flexibility that has its effect on the transmission grid
48	Communication infrastructure	Information exchange	Sending and receiving information related to consumption measurement, electricity prices etc.
49		Flexibility exchange	Sending and receiving information related to curtailment duration, curtailment frequency, curtailment price etc.
50	Transition cost	Transition cost	The cost of identifying activating, connecting and communicating with the demand response valuables
51	Intervention cost	Intervention cost	The cost of exploring the different, variant and specific consumption patterns and remunerating the customer
52	Revenue model	Revenue model	Identification of the revenue resources: energy bill savings, availability, capacity, etc.

Table 57 The DRBM cards definitions

4.5.3 The DRBM tool usage process

The demand response is rather a new concept, so that the potential canvas users may not be familiar with how DR service is established and what the benefits are. In Europe, DR implementation is limited to some countries due to either the unsuitable regulations or its limitation to the industrial plants. The current version of the DRBMC requires an expert who has knowledge about the demand response domain. For that reason, the use of the tool is done through a process of several steps that follows the general business mode logic: opportunity identification, value proposition, value creation, value delivery and value capture and with a supervision of a facilitator (Figure 70).

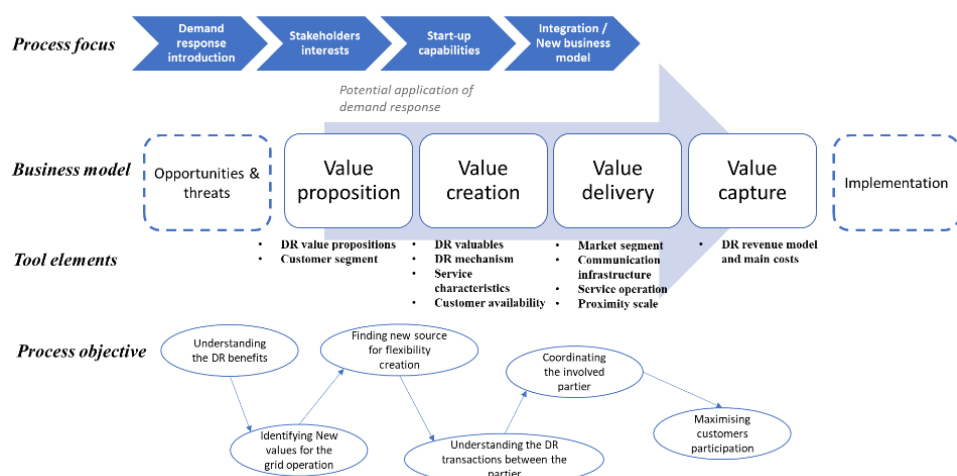


Figure 70 DRBM tool usage phase and focus of each phase

Following the explained path of business models, the sequence of steps; for DRBMC, is organised as illustrated in (Figure 71). It begins with identifying potential market segments and their distinct value propositions, then it indicates the required valuables to fulfil the market segments' needs, then the appropriate mechanisms. After that, an evaluation process of each value proposition characteristics is done taking into consideration the five parameters of the "Service characteristics" and the necessitate "Communication infrastructure". The next step is to choose the proper operational model taking into consideration the provider and the customer capabilities. Next, the location where the service connection with the grid is indicated. After

that, the customers behavioural aspects, such as its motivation, incentives and their available time are evaluated. Finally, the income model and transaction and intervention costs are listed.

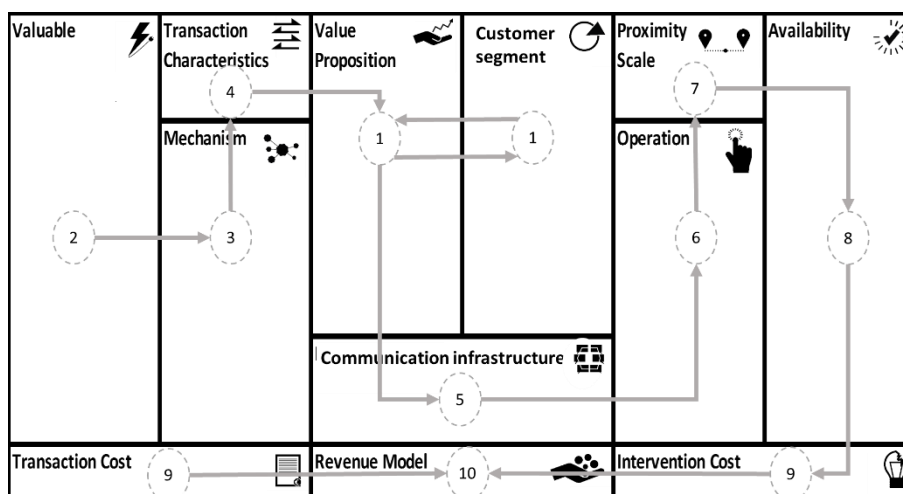


Figure 71 DRBM sequence of usage steps

The use of the DRBMC can be described as following:

- 1- **Opportunity and threat:** is an initial phase that consists of preliminary and introductory discussion about the emergence of the demand response, the benefits of the demand response, potential market threat (e.g. increase of electricity prices, different pricing schemes, etc.) and the start-up's value propositions beyond the demand response domain. This phase highlights main stakeholders' interests and their position in the demand response ecosystem and value chain, their roles, and the start-up position.

Brown cards have been initiated to represent the key stakeholders, such as the TSO, DSO, DRP, BRP, retailer, generation stakeholder. Other empty cards have been proposed to add other potential stakeholders. This step allows the participants to represent the demand response ecosystem (Figure 72). By that the function of each stakeholder and the relationships between them are identified.



Figure 72 Stakeholders of the demand response ecosystem

The DRP, as has been illustrated before, is the actor who transforms the demand response actions into a viable business model and monetises the customer flexibilities in the energy market. Its position among the power system actors is an intermediate between the customers, who generates flexibilities and, DR purchasers, who have demand for flexibilities. The later could be the generation stakeholder, the transmission and distribution stakeholder or the retailing stakeholder. Often, the DRP is an aggregator which aggregates multiple customers

in order to maximizing the flexibility product size, generate competitive advantages and get access to the energy market.

The canvas user might have the intention to be an energy aggregator providing flexibilities on the system level to the TSO or through the energy market. It might want to work on local level and aggregates the flexibilities on local level to be products that delivered to the distribution system operators in the region. Users might think about being a platform that mediating the customers and the purchaser, thus their role is limited to put the two side in connection (Figure 73).

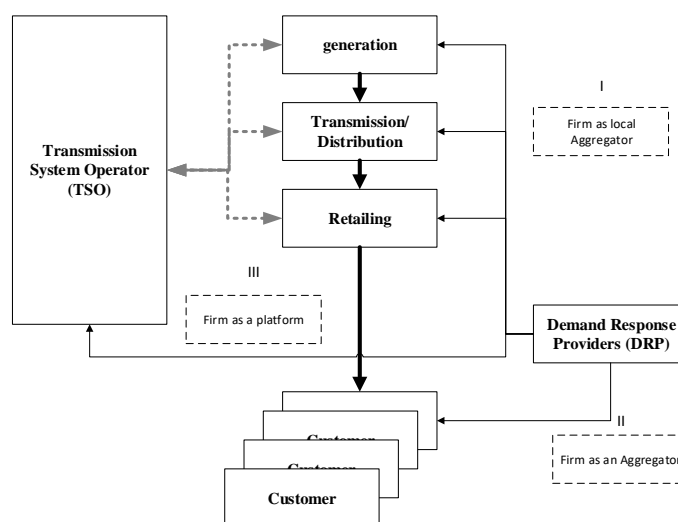


Figure 73 Users example position along the power system demand response Map

- 2- **Value proposition:** at the start, the facilitator, which its role is to introduce the tool and manage its use, clarifies the meaning of the “value proposition” and the existing demand response “market segments”. Then, the participants begin to explore the potential value propositions, the benefits of customers and purchasers. The value proposition cards have been divided into five groups according to who benefits from the demand response services as following: Generation, TSO, DSO, Retailing, and Load. This classification allows the participants to determine directly who is the potential purchaser (Figure 74).

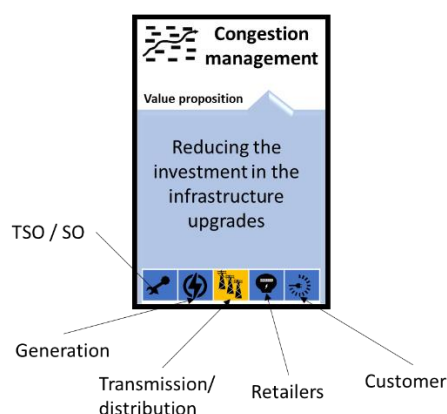


Figure 74 Value proposition cards with indication of the main interested stakeholder

Each value proposition, on a card, holds a unique benefit for one or more market segments. The participant picks up a value proposition card and evaluates its potential to be

exercised and achieved. In some cases, the DR value proposition have strong synergies with the core value proposition of the company and can be deployed as a complementary activity (e.g. retailer & DRP). In other cases, the DR value proposition is part of a diversification strategy of the company and needs to be treated as a development of a new activity (e.g. commercial building benefits from DR).

- 3- **Value creation:** after going through all the value propositions, the participants start to think about how they could translate these values into benefits for their customers. The facilitator describes the value creation path which begins by identifying applicable “DR valuables”. For each value proposition, what could be the tangible and intangible assets that have the potential to generate flexibility. The facilitator specifies that the DR valuables (demand-valuables, supply-valuables and storage-valuables). Furthermore, few DR valuables cards are designed with empty spaces in order to enable the participants to think about their particular DR valuables that they can use.

Directly after having a list of DR valuables, the facilitator describes the available mechanism to exploit efficiently the existing flexibility within the DR valuables. The participants try to match between the value propositions, the DR valuables and the mechanisms they would use. They evaluate each mechanism and its requirements. Some mechanisms require expensive assets, such as using on-site generation or having a storage system. Other require a high level of coordination and communication, such as aggregation. The participants could also combine more than one mechanism to maximise their values.

Afterwards, with regard of each DR service identified in the market segment element, the participants evaluate the capability of providing these services in terms of five characteristics that have been set by the energy market regulator. This step details under which condition each service must be delivered to the purchaser. This element permits the participants to evaluate their capability to provide each selected service. Service, such as “Frequency regulation” necessitates fast and accurate response within interval of seconds to maintain the frequency with a very small margin. On the contrary, the tertiary reserve, for example, permits to respond in an interval of 15 to 20 minutes. Following that, the participants indicate the way they can communicate with the engaged parties.

- 4- **Value delivery:** in this phase, the focus is on transferring the created value to the end-user. To do this, first, all the parties need to be put on contact with a communication network. the “communication infrastructure” shows the links between parties, the flow of information (consumption, signals, energy prices, etc), electricity (power and energy) and flexibility (consumption reduction; consumption shift, power-up, power-down, etc.). Communication requirements such smart meters, internet connection, etc. are discussed.

The afterward step is the discussion on the operational aspects. First part of the operation allows the participants to figure out the way the service is operated. The responsibilities of the de DR provider and the purchaser, in addition to the customer role. The second part indicates the place where flexibility effects occur. Some flexibility products are delivered for the TSOs through the transmission lines, thus flexibilities should connect and have access to this grid. Other services are delivered to the TSOs but can be also delivered through the distribution grid. Finally, there are services for the DSOs, thus they must be delivered through the distribution network. Next, the process continues by evaluating the customer availability for providing the

flexibility: Customer time, consumption patterns, their incentives and the generated externalities on the customer activities.

- 5- **Value capture:** The process is finalized by indicating the main cost and the revenue model. Firstly, the cost of transaction includes the equipment, administrative cost, communication and customer service cost. Secondly, the cost of intervention that involves the cost of coordinating and interrupting the traditional customer loads from their normal patterns. Lastly, the revenue model is discussed, the way the start-up generates income and has a profit from selling the flexibility products.

4.6 Usability evaluation

In 2019 the author conducted three workshops of 90 to 120 minutes long with three start-ups to evaluate the usability of the DRBMC tool.

4.6.1 Workshops on demand response business model tool

Each workshop begins with an introduction on the tool purpose and usage. Then the participants, with the support of a facilitator, use the tool to explore potential opportunities that might be exploited in the demand response domain.

Before the start, the stakeholders identification and visualisation have been done and an ecosystem map has been made describing the position of each stakeholder in the energy value network. The participants assess the different value propositions that they could offer, the firm's capabilities to offer the potential value proposition identified in DRBMC (Figure 75).

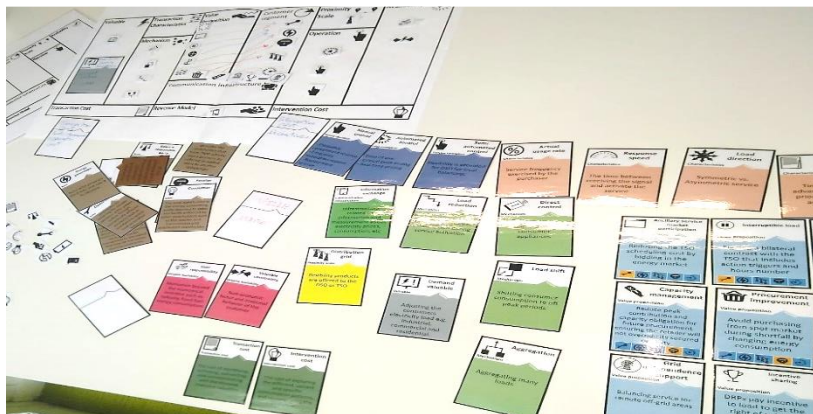


Figure 75 Usage of the DRBMC Tool during one of the workshops

After each workshop, each participant has been received a questionnaire to fill in. The purpose was to get their opinion and evaluation regarding the tool usage. The participants were one manager of energy retailer cooperative, one manager of energy efficiency start-up and one manager of a big data process start-up.

4.6.2 Workshops cases description

This subsection describes the three start-ups chosen. The objective was to select start-ups from both the energy sector and other sectors that might offer a value proposition to the demand response domain. To do so, three main criteria for the selection were adopted: (1) early stage companies, (2) main value proposition not related to the demand response domain, and (3) not limited to the energy sector.

The participants of the workshops were the director of an energy retailer cooperative, the founder of an energy efficiency start-up and the founder of a big data management start-up.

1. Energy retailer

Enargia (<https://www.enargia.eus>) is an energy retailer found in 2018 that proposes a 100% local and renewable electricity in the Basque region in France. It is an energy cooperative with 336 subscribers (February 2019). End of November 2018, the cooperative campaign managed to raise up 250,000 euros from local individuals and businesses. The cooperative will start retailer activity in 2019, as soon as it receives the administrative approval (Sudouest, 2019). Enargia has a local and sustainable vision of the electricity production and consumption. The objectives are to promote local jobs, mobilize local actors' capabilities, and to bring consumers closer to the generation points.

2. Energy Efficiency

Founded in 2011, eGreen (<https://www.egreen.fr>) is a French company based on Paris that aims at changing energy consumption patterns by supporting the reduction of energy consumption of individuals, businesses and communities through behavioural aspects. To do this, it relies on sensors for the consumption of electricity, water, and gas, which make possible to measure energy consumption in real time. Once installed, they transmit user data via GPRS or the Internet. eGreen offers users a platform with many fun, social and incentive features to motivate behavioural changes to reduce energy consumption. It allows them to compare their results with friends or neighbours, through a social network module (L'usine digital, 2014).

3. Big data

Created in December 2014 within the Izabel Technopole in Bidart (France), and initially incubated within ESTIA Entreprendre, HUPI (www.hupi.fr) is a company specializing in "Big Data" and "Cloud" management. HUPI is a technology platform operating in SaaS mode dedicated to the analytical processing of data flows. Using Machine Learning statistical algorithms, their solution is able to recommend a set of actions based on all types of accessible data. The platform proposes, in real time and automatically, recommendations corresponding to the "Best" action to be performed, then transmits these recommendations to the system in charge of executing it (Agglo Cotebasque, 2016).

4.6.3 The tool use

The evaluation of the workshop and the analysis of the data during and after the workshops, in addition to the feedback from the evaluation questionnaire, demonstrate that the DRBM canvas is useful in the following aspects (Table 58):

- 1- **Recognizing market opportunity:** The start-ups have emphasised the role of the tool in the exploration of many new market opportunities. the DRBMC supports users to find new positions along the energy value chain. For example, the Energy Efficiency start-up which works close to the consumer, has found that it can work with the retailers and generations actors to provide them with services, such as "load shaping" or "procurement improvement" (Figure 76). The big data start-up founder has evaluated its start-up in the case where it can handle concrete local energy problems. For example, taking the value proposition "Grid independent support", applied to zone located on the edge of the distribution grid, the start-

up can do monitoring and prediction of energy consumption, thus reducing the operational cost through big data analysis and predictions. The Energy Retailer cooperative can also go beyond just being a retailer and can provide services to the DSOs. Cooperatives have a close relationship with their customers, thus and benefiting from this advantage, the Energy Retailer can adjust its energy customers consumption patterns in order to provide services to the DSO (e.g. capacity overload, voltage regulation, etc.).

- 2- **Comparison:** during the workshop, the participants have mentioned some firms that already exercise some DR mechanism and they made comparisons. The analogical reasoning allows to examine other companies' BM in new situations or related to new value propositions.

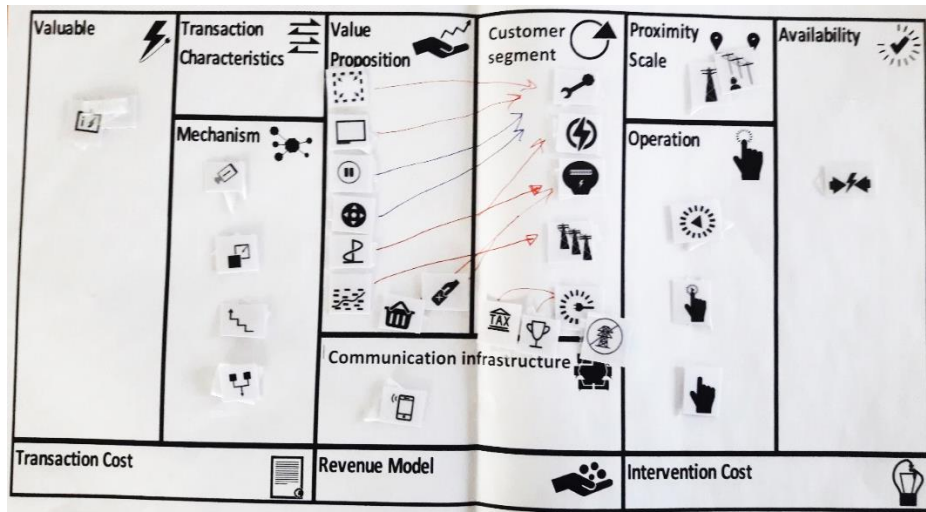


Figure 76 The Energy Efficiency Start-up presenting potential demand response business model

- 3- **Increasing innovation:** the participants have proposed other DR mechanisms to create value based on their own experience. For example, the Energy Efficiency start-up has referred to gamification processes as new mechanisms that can be used to create DR value propositions. It has been noticed that the discussions include many “what if”. By that, the participants imagine the situation when they would change or replace part of their BMs. For example, the Energy Retailer director; has suggested to use the cooperative organisational form to provide DR service. Another aspect that has been found is that the tool allows to define a specific problem and therefore set the scope of a brainstorming experience where the participants contribute collectively.
- 4- **Representative:** from both the questionnaire and the workshop analysis, the participants have consensus on the representative role of the tool. They stress that the business model can be seen at a glance with all its various elements (Figure 77).
- 5- **Facilitating Communication:** the tool improves the efficiency in communication. The DRBMC is seen as a tool to work in teams and improve team discussion.
- 6- **Systematic approach:** the tool promotes and enriches discussion within a frame that allows not to miss out any issue related to the demand response domain.

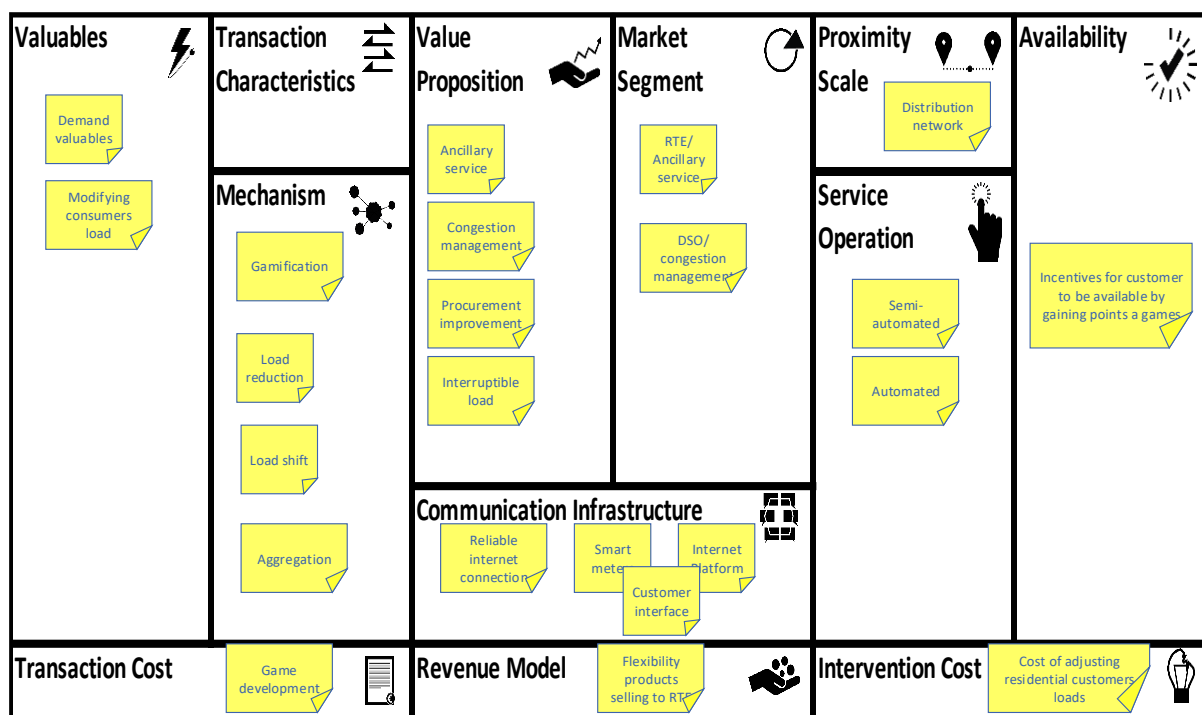


Figure 77 Example of eGreen BM modelling with the DRBM Tool during the workshop

- 7- **Strategic planning:** The participants have indicated that while some value propositions are out of their scope due to the lack of capabilities, they have selected some value propositions as strategic choices that they can develop in the future. For example, nowadays the Energy Retailer does not have enough customers to have a sufficient capacity, thus a sufficient flexibility to be traded. The Energy Retailer has found that the current electricity price might not incentivise big consumers to participate in some services. However, they think that it might be interesting for those consumers to participate once the electricity price would be higher. The big data start-up was able to identify potential opportunities for its industrial clients, as new ways to optimise energy consumption. During the test, the founder confirmed that by employing “Inventory storage valuables” in the processing of an industrial plant data, he is able to give indicators to the client to sell flexibility products to the TSO, by modifying the product line schedule and shifting consumption to low off-peak hours.
- 8- **Increase familiarity with demand response:** the participants did not have a clear idea about the concept of demand response. Questions have been raised at the beginning of the workshops, such as “who is the client, who would pay us for this service?”, “What is the demand response provider?”. However, the discussion has contributed to clarify the DR concept, the role of key energy system actors and their relationship with a DRP, such as TSO, DSO, retailers, BRP, generations actors.

Evaluation points	Energy Efficiency	Energy retailer	Big data
	<i>participants profile</i>		
Familiarity with DR	0 – not familiar	3- Familiar	0 – not familiar
Familiarity with BM	3- Familiar	3- Familiar	0 – not familiar
<i>Tool usage evaluation (0) bad – (5) very good</i>			
Starting using the tool	2 – difficult	4 – easy	4 – easy
Role of animator	4 – Very involved	4 – Involved	4 – Involved

Promoting discussion	5- Highly Promote discussion	5- Highly Promote discussion	4- Promote discussion
Covering main dimension of DR	5- Highly Comprehensive	5- Highly Comprehensive	4- Comprehensive
Systematic approach	5- highly Have systematic approach	4- Have systematic approach	4- Have systematic approach
Opportunity exploration	4- assess in opportunity exploration	4- assess in opportunity exploration	4- assess in opportunity exploration
Tool usage	4 – Easy to easy	4 – Easy to easy	4 – Easy to easy
Average	4,14	4,42	4

Table 58 Indicators from the evaluation of the DRBMC

4.6.4 Improvements and suggestions

The participants have suggested some improvements that can be added to the tool:

- 1- **Feasibility evaluation:** the participants have expressed their need to evaluate the value proposition potential opportunities in terms of its economic viability. Therefore, it is necessary to organise a second phase with a quantitative approach. Depending of the country, the DSO or TSO might have specific offers that could be used for a detailed economical evaluation. Due to the dynamic nature of these offers, it is not valuable to include this data in the canvas. As an example, the Energy Retailer and Energy Efficiency manger has expressed: *“May be some examples can be useful. Demand response business opportunities need to be quantified; mainly for small companies like us. In order to see if the business opportunity is really made for us or if the barriers are too big to start a new business in that domain”*.
- 2- **Lack of simplicity:** the participants have emphasised that the usage of the tool requires a lot of explanation for each part of the BM. They indicated that there are many pictograms and icons in the cards. This has disturbed the participants. Therefore, one suggestion was to simplify the tool and reduce its complexity by avoiding using many pictograms
- 3- **Expert usage:** one of the suggestions is not to limit the use of the tool to the start-ups but to promote the tool for energy experts and actors (e.g. TSO, DSO) who might be interested in identifying new value propositions.
- 4- **facilitator support:** most of the participants has referred to the important role that the facilitator plays in the tool usage *“It is quite easy but it is necessary to be supported”*, *“The animator has an important role to explain all the basic knowledge”*. This reduces the autonomy of the user who associates its usage with the presence of a facilitator.

4.7 Conclusion

Previous research has suggested that the business model concept can explain how value is created and captured (Zott et al., 2011) and has emphasised that a business model is a set of elements/ components that are put together as a whole in order to detail and explain what BMs are made of (Amit and Zott, 2001; Chesbrough and Rosenbloom, 2002; Demil and Lecocq, 2010; Morris et al., 2005; Osterwalder, 2004). The literature has evolved further and has introduced the concept of business model innovation. BMI cannot be separated from the BM concept. However, BMI embeds various views, BMI has the systematic view of BM (Zott and Amit, 2010), the dynamic view of BM (Demil and Lecocq, 2010), the cognitive perspective of BM (Martins et al., 2015) and the strategic entrepreneurship view (Schneider and Spieth, 2013).

Also, the business model is clearly recognised as a useful tool for fostering innovation and explaining the logic of a firm's value creation and capture. However, current research on demand response presents a limited perspective on how firms create and capture value.

Since the changes in the power system do not just involve more renewable energy resources, but also a flexible grid, it poses further challenges to the grid's operators and renewable energy BMs. These changes generate opportunities for DRBMs with increased real-time communication and customer participation.

This chapter discusses and examines the DRBM which is considered as a "Key" BM given its potential for providing better integration of renewable energy technologies and environmental balance mechanisms. Because of its multiple values, the author expects DRBM to increasingly act as critical drivers of energy transition. The DRBMC is a visualisation tool that describes and reflects the demand response BM design. Given the lack of familiarity of the demand response business model, our assumption highlights the capability of the tool to unlock hidden values in this field to generate business model innovation and uncover a novel source of efficiency and green electric grid balancing approaches to move towards the energy transition.

The DRBMC's components have been investigated. The author taps into the conceptualisation of elements and relationships that consist of several levels of decomposition with increasing level of depth and complexity (Osterwalder, 2004). The author also uses conceptualisation of the activity system perspective based on the content, structure and governance of transactions (Zott and Amit, 2010). By analysing the business model of France's first independent aggregator, in which the demand response is the core activity of the business model, and by scrutinising reviews of the literature, this chapter's research specifies the main elements of demand response business model ontology and shows the relationships between them. As a result, the author was able to create the demand response business model ontology which has been translated into the demand response business model canvas and 52 supportive cards (Figure 78). The cards' list and figures are presented in Appendix

The DRBMC consists of twelve distinct elements that describe four business model activity types: activity content, activity structure, activity governance and value capture. Activity content highlights the required resources and indicates some mechanisms to efficiently exploit the available resources. Activity content is significant for understanding where the latent value of demand response can be found and how to deploy it. Activity structure shows the links between the parties involved and their interests, outlining purchaser benefits, required communication and the provider's value proposition. As main demand response resources are owned and used by customers, the activity's governance addresses the customer's role, availability for participating, incentive and operational activities. Finally, value capture describes the way the demand response provider makes money.

DRBM is quite a new business model and has not been given sufficient attention by academics (Behrangrad, 2015). The author argues that there is a lack of familiarity with DRBMs, among both practitioners and researchers. This lack of familiarity could be explained by the complexity of the business model. Complex value proposition has been defined as the social, environmental, financial and, developmental benefits for different parties, across multiple spaces and times, and through several systems (Hall and Roelich, 2016). As the author mentioned earlier, demand response, which is often organised by DRP, depends on the energy

consumers' ability to adjust their consumption patterns during particular times in response to grid operator signals, also generating economic, social and environmental benefits. This chapter's outcome acknowledges this lack of familiarity and complexity of the demand response business model and answers the call for an energy transition by proposing a demand response tool.

Developing demand response BMs is a key path in the energy transition roadmap. Significant research has been found to emphasise the importance of renewable energy resources (Juntunen and Hyysalo, 2015; Richter, 2012; Strupeit and Palm, 2016). However, renewables greatly affect the grid's balance, which is a serious issue that DRBMs can handle and resolve. Thus, DRBMs can be considered as the wheels of the energy transition vehicle. The more flexibility the system has, the more renewables would be in the power grid and the faster the transition. Besides the economic values that the demand response BMs leverage, they also contribute to better social welfare by decreasing the cost of the electrical network and generating benefits for both the power system and society.

Using a visualisation tool based on BM with a focus on the cognitive aspects has proven to be useful in fostering innovation and creating new business models (Martins et al., 2015). The author suggests that creation of new BMs, therefore, should assume an increasingly important role in future research on the energy transition. In return, this chapter shows how the business model ontology is useful for understanding the application of demand response concepts in the power system. In other words, integrating the BM theory into the DR concept allows for a better understanding of how emerging green concepts intersect with the innovative aspects of BM. In fact, this research encourages further study of the following suggestion, which embeds meaningful implications for both entrepreneurs and policymakers: 'If the power system's conditions facilitate the participation and development of demand response business model in the energy markets, and provide greater incentive to reward customer participation, then DRBM innovation and competitiveness will accelerate the growth of ecological flexibility products, thus its transformation to a decarbonised and resilient state'.

The implications for national policymakers include setting out the corresponding regulatory schemes that support the access and growth of DRBMs. Implications for entrepreneurs and managers include understanding the DRBM's logic, its importance to the power system and its various latent resources allocated with regard to consumption and production on multiple levels.

This work, therefore, brings about favourable opportunities for a research agenda about the business model in the context of energy transition studies. In fact, DRBMs could have a fundamental and disruptive role in the power system's shift towards a flexible, responsive and renewable grid. This fact raises new questions that show the importance of integrating DRBMs as drivers of a low carbon energy transition. How would different regulatory schemes influence demand response business models? What barriers do that DRBMs face in terms of customer participation and what will be the potential of active customer? Finally, to what extent can small customers participate in an economically viable DRBM?

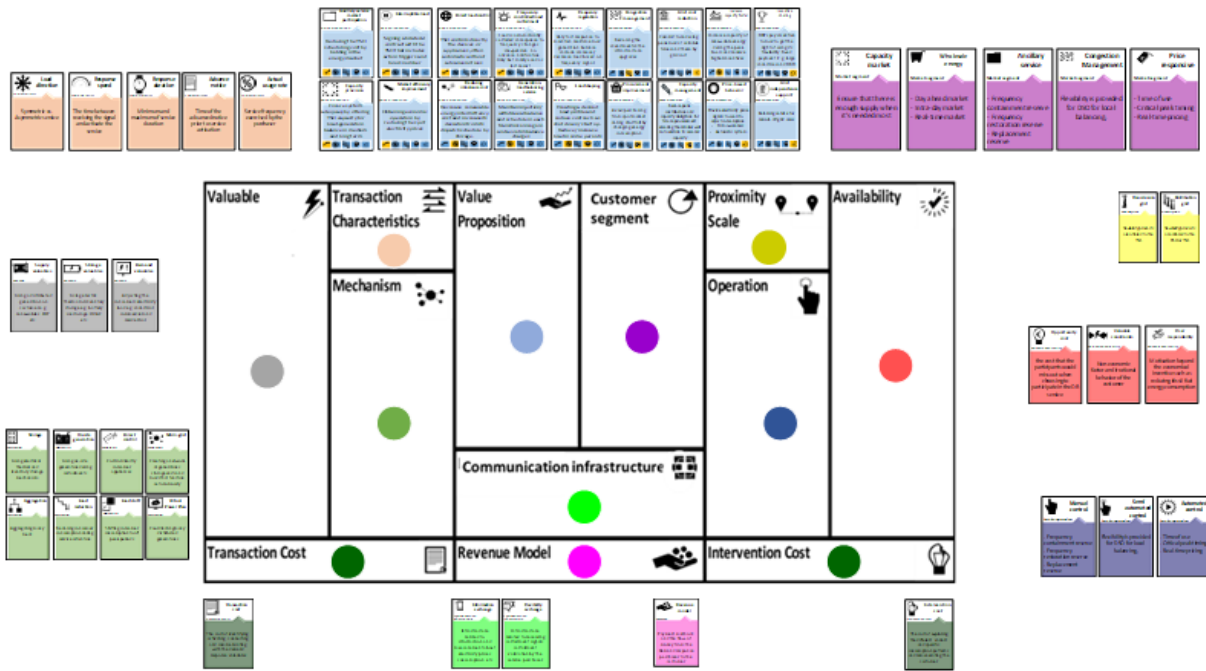


Figure 78 DRBMC and the supportive cards

4.8 Summary of the major contribution of Chapter 4

- Chapter 3 has introduced various business model innovations brought by energy entrepreneurs. One of the major business models that is investigated and is found in several start-ups is the demand response.
- This chapter identifies the importance of having demand response business models in the power system and its significant impact on grid flexibility. It explains the concept of demand response business models and introduces different approaches that are scrutinized in the literature.
- These approaches indicate that demand response business model is a multi-value service that can generate value for many stakeholders: energy utilities, transmission system operators, distribution system operators, retailers, and energy consumers etc.
- These approaches demonstrate that several resources and mechanisms can be deployed to create flexibility products that can be sold in the energy markets or directly to an interested stakeholder.
- This variation led the author for a research question about how the demand response can be represented and explained in a business model framework.
- Besides the literature review, a single case study method has been used to investigate what could be the demand response business model: the first independent energy aggregator and demand response provider in France.
- A business model ontology on demand response has been introduced. The ontology has four main parts: demand response content, demand response structure, demand response governance and value capture.
- The ontology consists of twelve elements that explains and details the demand response business logics: value proposition, response mechanism, valuables, transaction characteristics, market segments communication infrastructure, proximity scale, service operation, valuable availability, transaction cost, intervention cost and revenue model.
- This chapter highlights the visualisation and the cognitive approach of the business model and transfer the ontology into a business model visualisation tool.
- 52 supportive cards have been integrated with the visualisation tool. Each identified card belongs to one element. The main goal of the cards is to show possible scenarios, examples and definitions associated with the elements.
- The visualisation tool has been tested with three start-ups. The objective was to examine the usability of the tool and its capability to support and assist entrepreneur in the creation of new business model in the demand response domain.
- This chapter contributes to the research community on business model, specifically to activity system perspective and the cognitive approach on business models. This work adds value to the demand response research by providing, besides the analytical and descriptive framework, a prescriptive conceptual tool.
- For managers and entrepreneurs, this chapter introduces a conceptual tool that can be used in the demand response domain to analyse, ideate, explore new opportunity, as well as represent and communicate new ideas.

Chapter 5

5. Conclusion

As argued in the introduction of this manuscript, the world needs new power systems. New actors that integrate this sector are already developing original socio-economic practices for this transition. Despite the opening up of energy markets and the emergence of advanced technologies, for example in ICT domain, the energy sector has not yet reached its full potential in terms of the active participation of the stakeholders within this domain. Although these markets have been liberalised, there is still an ambiguity and lack of familiarity surrounding latent market opportunities and the potential for launching new business models. This thesis aims to provide a new knowledge about business models that can contribute to the energy transition.

Focusing on the growing need for the flexibility of the electric system:

In this thesis the author defends the following: *in the context of the energy transition, the business model concept is a useful approach to explore, innovate and create novel socio-economic practices in demand response markets, thus developing the flexibility, increasing the robustness and decreasing the environmental impact of current power systems.*

Creating a new business model in a complex system, such as energy system, requires both support and innovation. This thesis has been developed on three pillars of: the existing business model patterns, business model processes and business models as a tool. The fundamental potential for business model patterns is its ease of use and understanding. Business model processes are designed to enable managers to change or discover new business models by following systematic steps. Finally, a business model as a tool supports firms in decision-making strategically, whether to and if so how to explore new opportunities, develop and manage new technologies in the firm or existing venture. Entrepreneurs can follow different strategies to create new business models and dealing with a lack of familiarity of emerging energy markets, ranging from understanding the current business model patterns and practices, to following a business model innovation process and finally, to use the demand response business model canvas to explore, exploit and evaluate the potential of launching a demand response business model in specific market. Therefore, the following main research question has been defined:

How can the business model concept contribute to assisting entrepreneurs in the context of the energy transition?

For this thesis, fifteen start-up business models were analysed. They were selected according to their diversity, market type, start-up business model validity, which was justified by being InnoEnergy partners, and its high quality criteria for the start-up selection process. Additionally, the business model demand response tool was tested with three start-ups in order to assess the tool's usefulness and implications. The thesis thus provides an empirical contribution by studying recently developed business models in the framework of the energy transition. It also delivers a theoretical contribution by enriching both business model literature and energy transition studies. Next, an overall conclusion to the thesis will be given by reflecting on the key findings and important implications applied in practice, contribution to

the literature gap and advances of past research, the impact and significance of the thesis' findings.

5.1 The emerging business model patterns

RQ1: What are the emerging business models in the energy domain and how can they be analysed and classified? (Chapter 2)

This thesis identifies the main business model patterns in the energy domain. 22 business model and eight patterns have been defined and mapped using the well-known business model framework of activity system perspective (Zott and Amit, 2010). The patterns development introduces the recent advancement in the academic realm regarding business models in the energy transition field. This classification can be used by scholars to evaluate new practices within the energy transition activities. Furthermore, practitioners can use the business model patterns to better understand the extant business practices, and give strategic insights

Entrepreneurs, decision-makers or practitioners can map their business model over the business model framework and compare them with other patterns. By raising the question of “what if” they can discover new potential market segment by relocating the business model in one of the distinct design themes and design elements (Figure 79). Entrepreneurs can proactively discuss the possibility of moving their business model in the content column, thus evaluating the current products and services offerings, or they might move to the structure column and evaluate their current business partnerships, alliances, stakeholder roles and customer engagement.

Moreover, they might assess how a new governance model, such as community building, local actors' participation or customer decision-making empowerment, might contribute to their business model practices. Entrepreneurs could also review their current design theme of a BM, the main source of value. They could also evaluate the potential of four themes: novelty, e.g. replacing with recently developed technology, lock-in e.g. a payment model that retains customers and reduces customer acquisition cost, complementarities, e.g. adding more services to support product-service functionalities or differentiating the market offers. Finally, by evaluating operation efficiency, they could determine the activities that increase or decrease the transaction cost in comparison with other business models.

Business model elements Business models themes	Content (What activities should be performed?)	Structure (How should be linked and sequenced?)	Governance (Who should perform the activities and where?)
Novelty (Adapting innovative content, structure or governance)	Going green	?	Building energy community
Lock-in (Building in elements to attract and keep customers)	?	Offering functionality	
Complementarities (Bundling activities to generate more value)	?	Optimizing grid operation Cross-selling	Acting locally New business model
Efficiency (Reorganizing activities to reduce transaction costs)		Running platforms Scaling-up	

Figure 79 Energy Business Model Patterns. Adopted from (Zott and Amit, 2010)

5.2 Energy start-up business models process

RQ2: How do energy start-ups pursue business model innovation? (Chapter 3)

This research reveals new practices that can overcome barriers and contribute to business model innovation processes. Some business models depend on introducing new products (Product-oriented) while others depend on a software-based system (software-oriented), which integrates the digital and the energy domain. Finally, “Network-oriented” business models provide intermediate models between the involved parties. The created value propositions are not just for the energy customers but also for energy system operators (e.g. DSO, TSO), and new market players (e.g. Energy trading companies).

Chapter 3 focuses on the business model creation process that is described in three main phases: opportunity exploration, business model seizing, business model impact (Figure 80). The process is dismantled into twelve elements that explain and fulfil the requirements of each phase.

In the opportunity exploration, the findings emphasise the importance of having a motivation for changing the status quo of at least one aspect of the power system. This motivation should tackle one of the market imperfections and can be transformed into a new value proposition.

In the second phase, the elements required for constructing a business model are described in the business model seizing. Key elements are discussed including customer’s benefits in the energy domain, customer types, the required capabilities for the value creation, the economic model and finally the expansion and the growth model. New value propositions are noticed such as the integration of renewable energy technologies within the grid by real-time capacity management and the optimization of grid flexibility by using demand response approaches. Distinct growth models are observed, for example, influence of a partner from the power system (e.g. DSO) or creating a platform that connects the energy consumers and grid

operators to optimise the grid operations. Finally, the deployed capabilities of the energy entrepreneurs are grouped and illustrated.

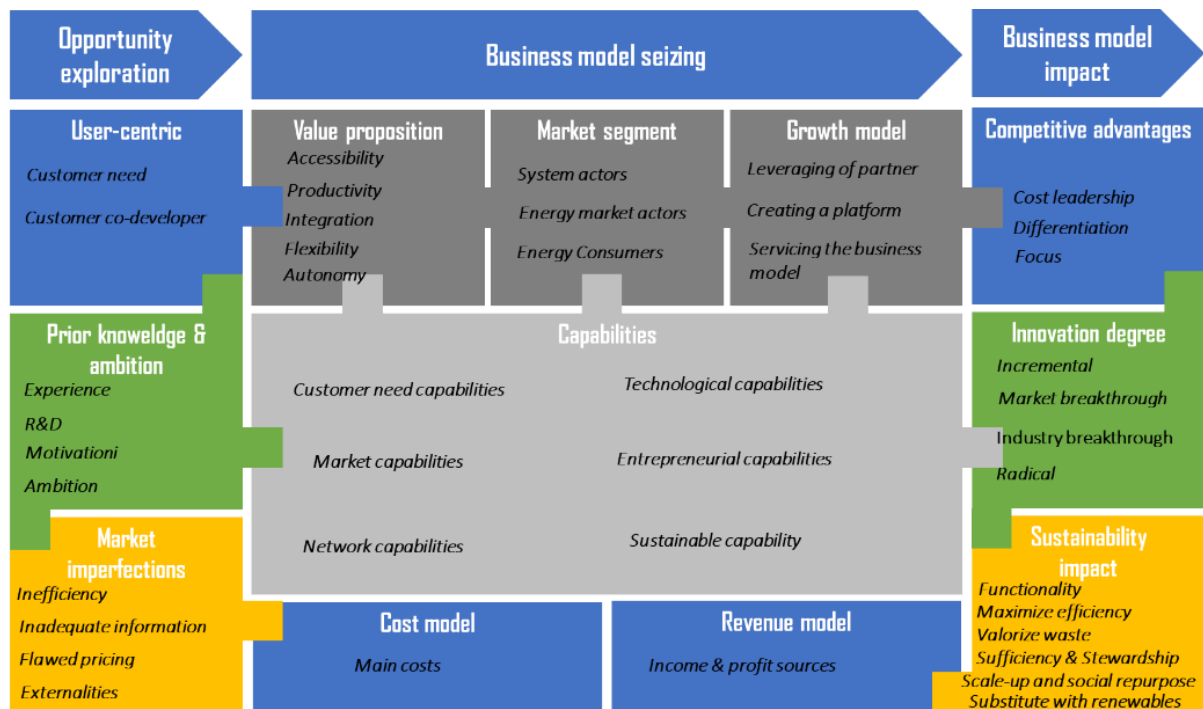


Figure 80 Energy Start-up Business Model Innovation Process

In the third phase, the findings outline the continuous need for business model evaluation. This evaluation allows the entrepreneurs to strength their competitive advantages, reconsidering their business model location in terms of both the degree of market innovation and the industry innovation.

In the energy transition and business model literature, theoretical frameworks that support energy transition have been proposed (Richter, 2013; Wainstein and Bumpus, 2016), as well as business model mechanisms (Hellström et al., 2015; Strupeit and Palm, 2016). While these contributions are useful descriptions, Chapter 3 goes further and proposes a framework that support energy start-ups in exploring, exploiting and evaluating new business models. The novelty embedded in BMs brought to the power system by the energy starts addresses some aspect of so-called new industrial revolution of Jeremy Rifkin’s vision which is based on firstly, new cycle of internet and secondly on green energies. While the former allowing easy access to information and easy trade of products and services, the latter reducing energy impact on the environment (Rifkin, 2016).

The empirical data from real-life novel business cases contribute to the research on BMI by providing some insight regarding BMI examples and patterns from the energy sector. The outcome of examining these cases, represented in the BMI, adds new knowledge on business models research. These outcomes can also assist entrepreneurs in identifying new market opportunities and the corresponding potential BMs. This BMI process can support existing companies in analysing and representing the competitor’s business model and mapping strength and withdraws, enhancing firm’s strategic position.

5.3 Business model tool for demand response

RQ3 How can the business model concept contribute to the development of innovative demand response activities? (Chapter 4)

After introducing a general business model innovation process corresponding to Research Question 2. The author has focused on an emerging business models termed “demand response business model”. This convergence has emerged due to the innovative aspects of this domain and the research gap identified as a result of the accumulated experience of the author about the demand response and business model field

This choice was the result of two main factors: the research gap identified during the first part of the thesis, and the critical evolvement of the energy system needs for electrical flexibility. Regarding the first factor, it can be explained by the intersection between the comprehensive academic knowledge obtained from the EBMs literature review (e.g. Demand response, virtual power plant, E-balancing, local pool and sleeve) and the knowledge acquired from some cases where demand response is part of its BM (e.g. Energy Pool, EP Tender, Coturnix, Cloud Energy Optimizer). Concerning the second factor, the demand response business model tool can contribute to the evolution of the flexibility in energy systems by influencing the following issues (Villar et al., 2018):

- Increase the share of renewable technology resources connected to the grid and its influence on the demand and supply curve.
- Increase uncertainty of supply because of the multiplication of the connected renewables.
- Increase distributed generation is posing new requirements for balancing the grid and frequency regulation.
- The potential role of energy storage systems in system balancing.
- The electrical vehicle potential for grid services.
- Increase consumer awareness regarding the threat of climate change.

The outcome of chapter 4 contributes to the emergent field of research in demand response business models (Behrangrad, 2015). Indeed, this chapter specifies the main elements of the demand response business model ontology and translates this ontology into the Demand Response Business Model Canvas (DRBMC). This canvas aims at discovering demand response resources where there is a potential of flexibility and at transforming these resources into value propositions. It also models the demand response operations as well as customer behaviour and incentives.

The research in this chapter stresses on the following implications. First, with its twelve elements, the tool can prepare managers to be more familiar with the concept of DR. It improves the BM design and decreases the risk of new BM implementation. Second, the simplified representation of the DRBMC can be used by managers for shaping their original idea into a comprehensive BM; furthermore, it can help to find new configurations for the existing DRBMs, making adjustments on the proposed elements and coming up with an innovative alternative path. Third, the tool can be used to analyse and identify the inefficiencies and the competitive advantages of new BMs. It also allows firms to compare their BM of their

competitors and identifies areas of improvements. Fourth, the tool can be useful to make the relationships and interdependencies between elements more explicitly (e.g. a customer segment and a DR valuables). Finally, it supports the identification of roles and the responsibilities of the involved parties, especially the role of the customer, which is a key aspect in the demand response service. Potential applications of the tool comprise developing a common understanding of the DRBM among the involved stakeholders, the integration of novel ideas, and insight gains.

This tool has some limitations as it is developed from the literature and only one case study. Therefore, a multiple case study approach can be used to future improvements of the tool. Another limitation is that the tool can provide general guidance on DRBM value creation process. However, the outcomes might be different based on the context and factor such as market regulation and market structure. The author recommends having some knowledge about energy regulations, which can be different among the studied countries, before using the tool.

Future research on the business model and energy transition may examine the potential of DRBMC in the incumbent firms such as energy utilities, TSO and DSO. Herein, the objective is to analyse the potential of collaboration with other stakeholders of the DR domain. Another essential field of research is the research on energy community and energy cooperative BMs. These entities have a different business model logic and incorporate social and environmental dimensions.

5.4 General conclusion

This thesis relates to the context of a low carbon energy transition in which the power system has a growing need for ecological flexibility to accommodate the high share of renewable energy resources.

In this dissertation the author argues that the business model as a conceptual tool is necessary in order to increase demand response offers and assist entrepreneurs in exploration of ecological opportunities and creating innovative business models for power system flexibility. Fundamentally, if one thinks of contributing to worldwide efforts to mitigate the power system's carbon emissions by creating a sustainable business, a structured representation describing the elements of the business model is a prerequisite. Based on this need, the main contribution of this thesis is a demand response business model canvas. Building on the intersection of knowledge with regard to the business model and demand response, an ontology, which describes the terms, elements, attributes and relationships of the business model concept, is proposed in this thesis to represent a summary of the overall literature on what could be a demand response business model.

Firstly, the author identified and categorised all the observed business models in the literature that contribute to the energy transition in 8 patterns and 22 energy BMs. The identified energy business model patterns can support future endeavours particularly in the ecological and social transition of the power system. This summary has significant potential to lead to substantial benefits for both system efficiency and social gains. The innovative architectures of the presented patterns stem from the way they differ from the traditional architectures of fossil-fuel based BMs. The analysis shows that innovations are driven by changes in the content activities, structure activities or governance activities. Content activity innovations are captured by key changes rooted in the product-service on offer, the resources used and the infrastructure or the business activity. Structure activity innovations are explained through critical changes in

the relationships and linkages between the involved parties and stakeholders. Governance activity innovations are presented as changes in the governance models. This cluster can support policy makers in the evaluation of the current business practices in terms of their economic and social benefits. This contribution produces a set of business models that may be applicable in different international contexts.

The second contribution is the description of business model innovation for energy start-ups which can support future research on business model innovation and entrepreneurship. A constituted theoretical framework from the BMI literature is applied to an empirical case study of start-ups in the energy sector. The framework used consists of three phase process. “Opportunity exploration” describes start-ups’ opportunity recognise, the need they can fulfil, the required capabilities and the way they resolve ecological and social issues, and imperfections in the power system; “business model seizing” indicates the key elements of the business model including what has been offered as a value proposition, for whom and customer segments, the required capabilities and growth models and finally, the economic value derived from the offerings; the “business model impact” evaluates the generated competitive advantages and the degree of innovativeness and refers to the value of sustainability value. The main aim has been to emphasise technological and business model innovations brought by new market actors, the drivers beyond them, by modelling the way they have been created with their results and contribution to the power system.

The BMI process contributes to expanding and enriching the literature on BMI in the context of energy transition by presenting new conceptualisation value propositions that incumbent companies are unable or reluctant to propose (Hannon et al., 2013; Huijben and Verbong, 2013; Wainstein and Bumpus, 2016). The energy entrepreneur’s capabilities in the BMI process can be transformed into concrete activities that can facilitate new BM development and overcome energy system barriers related to an unsuitable regulation framework, technological uncertainty, and market credibility (Inigo et al., 2017; Mezger, 2014). Carrying out these activities gives managers the chance to gain experience and develop distinct capabilities. Explaining BMI through specific, real-life cases that have been applied in the energy markets for the purpose of the energy transition, contributes to better understanding BMI and reduces the complexity of innovation (Amit and Zott, 2012; Bucherer et al., 2012; Chesbrough and Rosenbloom, 2002). By disaggregating the BMI process, the author provides insights for manager and enablers for replicating and imitating the defined BM logics.

The third contribution of this thesis is embedded in the development of the demand response business model canvas, a conceptual tool. This research outcome aims to address the lack of any comprehensive business model conceptual tool able to capture all the most important dimensions characterising demand response business models. This new conceptual tool encompasses 12 elements that describe the demand response main concepts and the relationships between these concepts. The tool contains four dimensions that cover the main aspects of a business model. The first dimension represents BM content activities of a business model and emphasises the required resources and infrastructure and the DR products on offer. This research outcome shows that some resources have been deployed because of its market potentiality or because of the regulatory scheme. However, many other resources have been highlighted and have great potential to be exploited because of its latent capacity to provide a DR service. The second dimension is based on BM structure activities and illustrates the links between the involved stakeholders and their interests. The focus has been on the market

transactions and their main characteristics. The diverse services and variety of stakeholders' needs that a DR service can fulfil are addressed. Typically, DR services are designed to serve system operator and grid reliability issues. However, the result indicates that other stakeholders such as energy retailers, renewable electricity suppliers, aggregators and end-users also have an interest in this kind of services, mostly when the power system can accommodate a higher percentage of renewable energy resources. The third dimension explains the governance and management aspects of the DR service, and embraces elements related to the role of customers and their responsibilities, and the way the DR service is operated. Notably, most of the demand response service relies on the customer's participation and commitment. Prevalent BMs use industrial plant loads to generate flexibility which have a low risk. However, operating other loads, such as residential and commercial loads, is complex, less profitable and therefore has a higher risk. This is mainly because irrational behavioural and human aspects can influence BM management.

By testing and evaluating the tool with a number of start-ups and practitioners, the author has demonstrated several applications: to understand the DRBM landscape and visualise all the possible business scenarios; to explore new potential value propositions by activating the latent electrical consumer's flexibility; to analyse current DR business practices according to its basic elements, thus understanding the invisible relationships between elements; to facilitate brain storming among participants and communication between the involved stakeholders by providing a systematic path for developing a DRBM; to represent in one picture the demand response business model, thus supporting managers' and entrepreneurs' cognitive and mental innovation processes.

The developed DRBMC can support energy entrepreneurs who are not very familiar with the concept demand response. The developed knowledge may add value to entrepreneurs who mainly work with renewable energy generation and neglect other essential parts related to reliability and grid balancing. As the energy transition greatly depends on having a flexible energy system, the author aims to facilitate the integration of renewable energy resources and contribute to research on the increase in power system flexibility capacity. This thesis provides knowledge related to DRBM components, its potential opportunities and a description of its markets. Having a tool available may encourage entrepreneurs to ask "what if?". Providing entrepreneurs with the right business model perspectives through a simple and practical tool could help to achieve ambitious European and World Energy targets.

Finally, the author looks for the emergence of the "eco-products" and "eco-flexibilities" concept that may replace traditional fossil fuel-based products currently used in balancing the electrical grid. The author emphasises the importance of having eco-flexibility because without flexibility in the energy system, the integration of both electric vehicles as well as renewable energy resources seems a very difficult and complex task. The present shows that the future would be highly dependent on renewables.

To conclude,

In this manuscript the author defends the following thesis: *in the context of the energy transition, the business model concept is a useful approach to explore, innovate and create novel socio-economic practices in demand response markets, thus developing the flexibility, increasing the robustness and decreasing the environmental impact of current power systems.*

5.5 Limitation and future research

This thesis has only focused on energy entrepreneur's business model and more specifically on the demand response business models. The research did not consider the regulatory framework that a demand response business model is implemented in. The thesis is limited in that it focused on start-ups BMI rather than incumbent firms. Future research could analyse the demand response of these firms and how they create novel business models or integrate DR into the existing BMs.

This research did not consider the community perspective in the energy transition within the demand response. Future research could examine the demand response within these emerging BMs.

Future research could among other addresses the following limitation. First, the author invites scholars to include more cases in the research, so that they could develop taxonomies of energy start-ups BMI. Second, the focus mostly was on the demand response economic logic, thus other dimensions of social and environmental benefits within the business model could be an interesting research study. The author invites scholars to investigate the existing sustainable business models that are based on DR concept, their influence on the system power emissions, infrastructure investments and their social benefits for energy consumers. Herein a question of how these sustainability aspects can represent in business models. Third, the developed tool has been tested with just three start-ups. The development of this tool lacks experts' evaluation, and it will be more favourable to be evaluated by market experts. The author plans to overcome this limitation by practicing the tool with both experts and a number of energy start-ups within the InnoEnergy network.

Finally, general twelve elements have been illustrated within the DRBMC. However, each element can be a source of innovation itself. Changing one element (e.g. Availability), from its dominant model, can dramatically bring innovation to DR. Therefore, another theme of research could focus on the types of innovative BMs each element of the DRBMC could generate.

5.6 Management and policy recommendations

The outcomes of this research contain several important implications for entrepreneurs, managers and policymaker which will be further discussed below:

Entrepreneurs recommendations

The author recommends entrepreneurs who have the motivation and ambition to change the current power system towards low carbon energy transition to revise the extant business practices value propositions in terms of their capability of providing ecological products-services that balance the grid and stabilise its security. Each activity that consumes or produces electricity has the potential to be a demand response resource, thus has a potential for electricity flexibility.

Entrepreneurs might also get some insights from the business model innovation examples explained in the thesis. This allows to broaden the prevailing and mainstream business practices that are often correlated with new technological innovations. Because of the complexity of innovating in the business model, the author recommends managers to use analogical reasoning and to try to apply the business model logics explained in this thesis in other contexts. The business model innovation process could support entrepreneurs by having

a reference about what the markets imperfections that energy start-ups have exploited, what capabilities they have employed and how they have positioned the business model in the market.

Policy recommendations

Policy makers have great effects on the energy transition, thus on the stakeholders that are involved. Therefore, policymakers should consider maintaining a level of stability regarding the regulatory regime. Many cases have shown that frequent regulations changes have made difficult to accelerate business model creation. Policymakers should set regulations that support commercial and industrial companies and consumers to be engaged in the grid balancing services and energy markets. This support can be promoted through intermediate firms that aggregate those latent and small capacities. Policymakers should also create incentives for consumers to participate in the demand response services. Mass participation in the demand response programs embeds social and environmental values. This can reduce the cost of the expensive infrastructure that is used to transport and distribute the electricity and reduce significantly the need for fossil fuel plants in the balancing operations, thus creating environmentally friendly and low-cost electricity. Another driver for energy transition is the collaboration that energy start-ups have shown with R&D centres. This collaboration mechanism might be facilitated and incentivised by the regulations. Finally, some product-service developments have high initial capital requirement which is difficult to be funded through traditional financial mechanisms (e.g. private money, crowdsourcing, business angels, etc.).

Conclusion Générale en Français

Cette thèse se réfère au contexte de la transition énergétique à faibles émissions de carbone dans lequel le système électrique a un besoin croissant écologique de flexibilité pour accueillir la part élevée des ressources d'énergies renouvelables.

Dans cette thèse, l'auteur fait valoir que le modèle d'affaires de type CMARD comme un outil de conceptualisation est nécessaire pour augmenter la proportion d'offres de réponse à la demande et aider les entrepreneurs à explorer les opportunités écologiques et la création d'entreprises innovantes pour la flexibilité du système d'alimentation. Fondamentalement, si l'on pense résolument à contribuer aux efforts mondiaux pour atténuer les émissions de carbone du système d'électricité en créant une entreprise durable, une représentation structurée qui décrit les éléments du modèle d'affaires est une condition préalable pour imaginer les différentes alternatives. Sur la base de ce besoin, la principale contribution de cette thèse est un canevas de modèle d'affaires centré sur la réponse à la demande. S'appuyant sur l'intersection des connaissances entre celles des modèles d'affaires et celles sur le domaine de la réponse à la demande, une ontologie, qui décrit les termes, les éléments, les attributs et les relations du concept du modèle d'affaires, est proposé pour représenter une synthèse de la littérature globale de ce qui pourrait être le modèle d'entreprise de réponse à la demande. Dans cette thèse, trois contributions clés sont proposées.

Tout d'abord, l'auteur a identifié et catégorisé tous les modèles économiques sourcés dans la littérature en 8 modèles-types composés au total de 22 variantes de modèle d'affaires qui contribuent à la transition énergétique. Les modèles d'affaires énergétiques identifiés peuvent soutenir les efforts futurs en particulier dans la transition écologique et sociale du système d'électricité. Cette synthèse a un potentiel important de pour générer des avantages substantiels tant pour l'efficacité du système que pour les gains sociaux. Les architectures innovantes des modèles présentés découlent de leur différence avec les architectures traditionnelles des MA à base de combustibles fossiles. L'analyse montre que les innovations sont souvent impulsées par des changements dans les activités de contenu, les activités de structure ou les activités de gouvernance. Les innovations de l'activité de contenu sont soutenues par des changements clés ancrés dans le produit-service offert, les ressources employées et l'infrastructure ou l'activité commerciale. Les innovations des activités de la structure sont expliquées par des changements cruciaux dans les relations et les liens entre les parties concernées et les parties-prenantes. Les innovations des activités de gouvernance sont présentées comme des changements dans les modèles de gouvernance. Cette groupe des MA peut aider les décideurs et entrepreneurs dans l'évaluation de leurs pratiques actuelles en termes d'avantages économiques et sociaux. Cette contribution produit un ensemble de modèles d'affaires qui peuvent s'appliquer dans des contextes internationaux différents.

La deuxième contribution est la description des phases du modèle d'affaires des entreprises en démarrage qui peut soutenir la recherche future sur l'innovation du modèle d'affaires (IMA) et l'entrepreneuriat. Un cadre théorique constitué à partir de la littérature sur les IMA est appliqué à une étude de plusieurs cas empiriques de démarrage d'entreprises dans le domaine de l'énergie. Le cadre utilisé consiste en un processus en trois phases. L'« exploration des opportunités » décrit la reconnaissance des opportunités et occasions offertes aux entreprises en démarrage, les besoins qu'elles remplissent ou créé, les capacités requises et la façon dont elles règlent les problèmes écologiques et sociaux et/ou les imperfections dans le système d'électricité; « la saisie du modèle d'affaires » indique les éléments clés du modèle

d'affaires, y compris ce qui a été offert comme proposition de valeur, pour les différents segments de clients, les capacités nécessaires ainsi que les stratégies de croissance et la valeur économique dérivée des offres; l'« impact du modèle d'affaires » évalue les avantages concurrentiels générés et le degré d'innovation et fait référence à la valeur de durabilité. L'objectif principal a été de mettre l'accent sur les innovations technologiques et commerciales apportées par les nouveaux acteurs du marché, en modélisant la façon dont ils se sont créés avec leurs résultats et leurs contributions au système électrique.

Le processus de MAI contribue à l'expansion et à l'enrichissement de la littérature sur les MAI dans le contexte de la transition énergétique en présentant de nouvelles propositions de valeur de conceptualisation que les entreprises titulaires sont incapables ou réticentes à proposer (Hannon et al., 2013; Huijben et Verbong, 2013; Wainstein et Bumpus, 2016). Les capacités de l'entrepreneur en énergie dans le processus de l'MAI peuvent être transformés en activités concrètes qui peuvent faciliter le développement des nouveaux MA et surmonter les barrières du système énergétique liées au cadre réglementaire inadéquat, à l'incertitude technologique et à la crédibilité sur le marché (Inigo et coll., 2017; Mezger, 2014). Cette exécution des activités permet aux gestionnaires d'acquérir de l'expérience et de développer des capacités distinctes. Expliquer les MAI au moyen de cas précis et réels qui ont été appliqués dans les marchés de l'énergie à des fins de transition énergétique, contribue à une meilleure compréhension des MAI et réduit la complexité de l'innovation (Amit et Zott, 2012; Bucherer et coll., 2012; Chesbrough et Rosenbloom, 2002). En désagrégeant le processus des MAI, l'auteur fournit des renseignements aux gestionnaires d'entreprises, au startups et autres catalyseurs pour inventer ou reproduire et imiter les logiques de nouveaux MA ainsi redéfinies.

La troisième contribution de cette thèse est incorporée dans le développement d'un canevas de modèle d'affaires de réponse à la demande, qui doit être perçu comme un outil de conceptualisation des modèles d'affaires des entreprises souhaitant se positionner sur le secteur de la réponse à la demande. Ce résultat de recherche vise capturer toutes les dimensions les plus importantes caractérisant les modèles d'entreprise de réponse à la demande. Ce canevas englobe 12 éléments qui décrivent les concepts principaux et les relations entre ces concepts. L'outil contient quatre dimensions qui couvrent les aspects principaux d'un modèle d'entreprise. La première dimension représente les activités de contenu d'un modèle d'affaires et souligne les ressources nécessaires, l'infrastructure de l'offre proposée. Ce résultat de recherche montre que quelques ressources ont été déployées à cause de sa rentabilité ou à cause du plan réglementaire. Cependant, beaucoup d'autres ressources ont été mises en évidence et ont un grand potentiel à être exploité à cause de sa capacité latente pour fournir des services de RD. La deuxième dimension est basée sur les activités de structure du MA et illustre les liens entre les parties prenantes impliquées et leurs intérêts. Le point focal est centré ici sur le marché et ses caractéristiques principales. Les services associés et la variété des besoins des parties prenantes qu'une offre orientée réponse à la demande peut nécessiter sont adressés dans le document. Typiquement un service orienté réponse à la demande est conçu pour servir des opérateurs de systèmes et des questions de fiabilité de réseau de type smartgrid. Cependant, le résultat indique que d'autres parties prenantes comme des détaillants d'énergie, des fournisseurs d'électricité renouvelables, des assembleurs et des utilisateurs finaux peuvent être intéressés par ce type de services, surtout quand l'installation électrique satisfera un pourcentage plus haut de ressources d'énergie renouvelable. La troisième dimension explique la gouvernance et les aspects de gestion d'un service orienté RD et embrasse des éléments liés aux rôles et des aux responsabilités du client, la façon dont le RD le service RD est opéré. Notamment, la majeure

partie du service de réponse à la demande compte sur la participation du client et son engagement. Les MA les plus répandus emploient la charge des sites industriels pour produire la flexibilité, avec un risque faible. Opérer cependant d'autres charges comme les charges résidentiels ou commerciales est plus complexe, moins rentable et avec un risque plus haut. C'est principalement parce que les aspects comportementaux et humains irrationnels pourraient intervenir dans la gestion du MA.

En testant et en évaluant CMARD avec un certain nombre de start-ups et de praticiens, l'auteur a démontré plusieurs applications : comprendre le paysage d'une offre focalisée sur la RD et visualiser tous les scénarios d'affaires possibles ; explorer de nouvelles propositions de valeur potentielles découlant de l'activation de la flexibilité du consommateur électrique latent; analyser les pratiques commerciales actuelles de RD dans ses éléments de base, afin de comprendre les relations invisibles entre les éléments; faciliter le remue-méninges entre les participants et la communication entre les parties prenantes concernées en fournissant un cheminement systématique pour l'élaboration d'un MA; représenter en un seul tableau le modèle opérationnel de réponse à la demande, soutenir ainsi les processus d'innovation mentale et cognitive des décideurs et des entrepreneurs.

L'outil CMARD développé peut permettre de soutenir les entrepreneurs dans le domaine de l'énergie qui souhaitent innover dans le domaine de la réponse à la demande. Ainsi, les connaissances développées peuvent ajouter de la valeur aux entrepreneurs qui travaillent principalement à la production d'énergie renouvelable sans négliger une autre partie essentielle liée à la fiabilité et à l'équilibre du réseau. La transition énergétique étant fortement tributaire d'un système d'énergie flexible, l'auteur vise à faciliter l'intégration des ressources d'énergie renouvelable et à contribuer à la recherche sur l'augmentation de la capacité de flexibilité des systèmes d'énergie. Cette thèse fournit des connaissances relatives aux composantes de l'outil CMARD, à ses opportunités potentielles et une description de ses marchés potentiels. Le fait d'avoir un outil en main peut encourager les entrepreneurs à soulever la question du « et si » car nous pensons que fournir aux entrepreneurs les bonnes perspectives de modèle d'affaires à travers un outil simple et pratique pourrait aider à atteindre les objectifs ambitieux de l'énergie européenne et au niveau mondial.

De manière plus globale, l'auteur recherche l'émergence du concept d'« éco-produits » ou d'« éco-flexibilités » qui pourrait remplacer les produits traditionnels à base de combustibles fossiles utilisés actuellement pour équilibrer le réseau électrique. En effet, la poursuite de l'utilisation des combustibles fossiles (telles que les centrales à charbon par exemple) pour l'équilibre et la fiabilité du réseau ampute l'effort mondial en matière de durabilité. Ces travaux soulignent l'importance d'avoir des éco-flexibilités parce que, sans flexibilité dans le système énergétique, l'intégration des technologies actuelles telles que les véhicules électriques ainsi que des ressources d'énergie renouvelable semble une tâche très complexe sur les plans socio-économiques bien que le présent montre que l'avenir sera fortement tributaire des énergies renouvelables.

Pour conclure, au sein de ce manuscrit l'auteur défend la thèse suivante :

« Dans le contexte de la transition énergétique, le concept de modèle d'affaires en tant qu'outil conceptuel est une approche utile pour explorer, innover et créer de nouvelles pratiques dans les marchés de réponse à la demande, développant ainsi la flexibilité de la demande,

incrémentant la robustesse et diminuant l'impact sur l'environnement du système électrique actuel. »

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






















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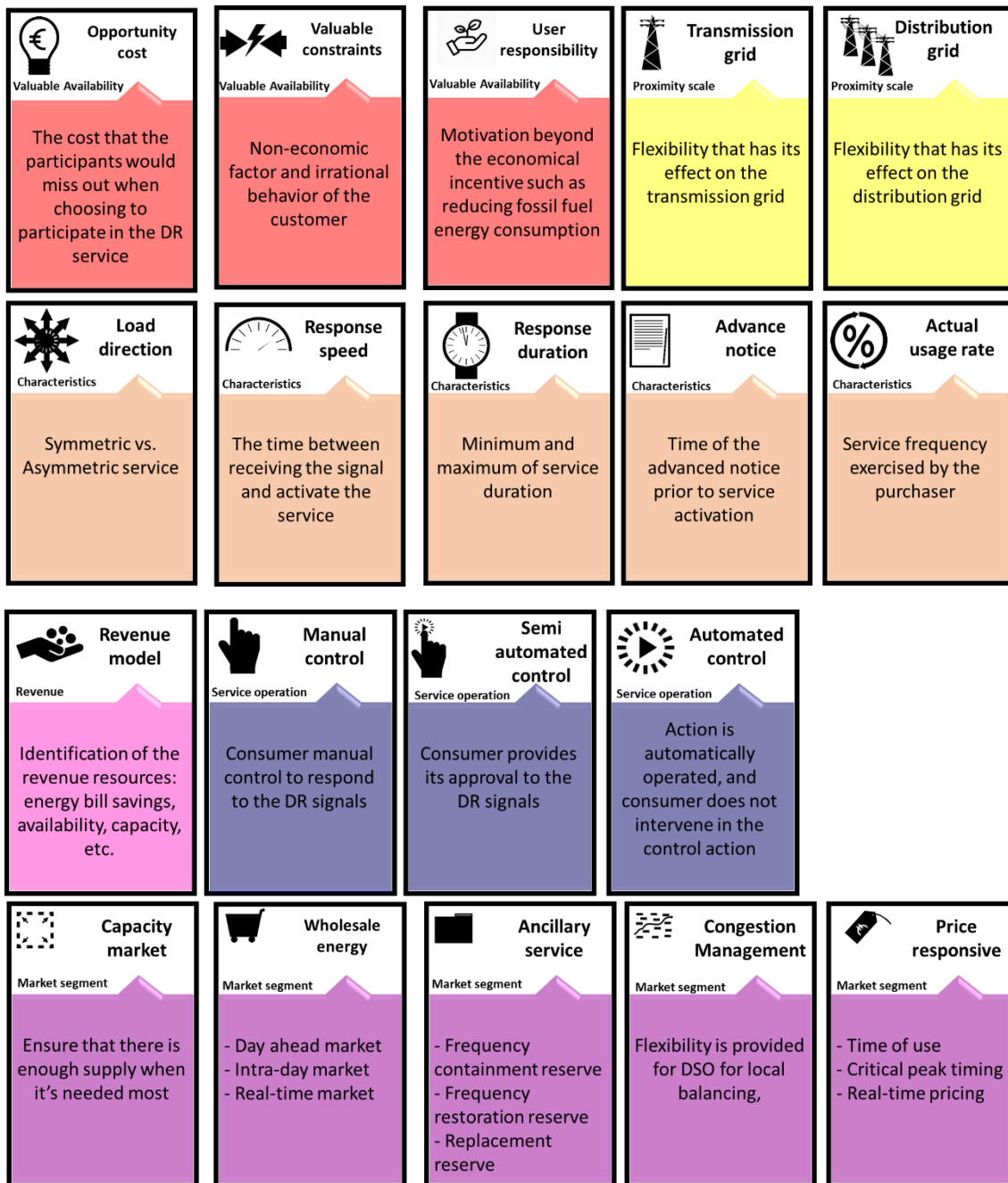
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Appendix

List of demand response tool cards

 <p>Retailer</p> <p>Actor</p> <p>Responsible for purchasing and electricity from generations and selling to the consumers</p>	 <p>System Operator/TSO</p> <p>Actor</p> <p>responsible for achieving the reliable operation of the power system through economically efficient measures such as maintaining system load-generation balance.</p>	 <p>Distribution System Operator</p> <p>Actor</p> <p>Responsible for maintaining the secure and reliable transmission and distribution of generated electricity while respecting electricity market transactions to the extent that they do not violate security constraints.</p>	 <p>Balance responsible party</p> <p>Actor</p> <p>BRP is responsible for its imbalances in the electricity market.</p>	 <p>Consumer</p> <p>Actor</p> <p>The load stakeholder is the energy consuming entity exposed to rates and tariffs enforced by other stakeholders such as the retailer and transmission and distribution stakeholder.</p>
 <p>Supply valuables</p> <p>Valuable</p> <p>Using a distributed generation on customer e.g. renewables, CHP, etc.</p>	 <p>Storage valuables</p> <p>Valuable</p> <p>Using electric, thermal or inventory storage e.g. battery, ice storage, HVAC, etc.</p>	 <p>Demand valuables</p> <p>Valuable</p> <p>Adjusting the consumers electricity load e.g. industrial, commercial and residential.</p>	 <p>Demand Response provider</p> <p>Actor</p> <p>A firm that turns DSM activity into a business by offering its added value to another stakeholder</p>	 <p>Energy generation</p> <p>Actor</p> <p>Actor who generate electricity and sale it to retailers</p>
 <p>Ancillary service</p> <p>Value proposition</p> <p>Reducing the TSO operational cost and maintain the reserve margin at low cost, improving scheduling efficiency</p> 	 <p>Interruptible load</p> <p>Value proposition</p> <p>Signing a bilateral contract with the TSO that includes action triggers and hours number</p> 	 <p>Direct load control</p> <p>Value proposition</p> <p>TSO controls directly the devices or appliances, often automatic without advance notices</p> 	 <p>Frequency-controlled load curtailment</p> <p>Value proposition</p> <p>Load is automatically curtailed in response to frequency changes, inexpensive, no advance notification, risky but rarely used as last resort</p> 	 <p>Frequency regulation</p> <p>Value proposition</p> <p>Very fast response to maintain real-time load generation balance, include increase/decrease load based on frequency signal</p> 
 <p>Capacity provision</p> <p>Value proposition</p> <p>Reducing the capacity provision cost by committing to reducing demand during future peak time</p> 	 <p>Market efficiency improvement</p> <p>Value proposition</p> <p>Obtaining economic operation by reducing the spot electricity prices</p> 	 <p>Reducing imbalance cost</p> <p>Value proposition</p> <p>Decrease renewable energy intermittency cost and by decreasing its deviation from its dispatch schedule or increase the capacity factor</p> 	 <p>Transmission Load balance</p> <p>Value proposition</p> <p>Maintain injection/withdrawal balance and schedule in each transmission region and avoid imbalance charges</p> 	 <p>Load shaping</p> <p>Value proposition</p> <p>Creating a desired load profile and reduce cost such as shut down/ start up. Reduce/ increase load in some periods</p> 





Abstract

The accumulation of greenhouse gases in the atmosphere, produced by human activities in the energy sector is one of the main causes of climate change. Therefore, the decarbonization of power systems has become an urgent need to mitigate the effects of climate change and achieve the energy transition. The share of renewable energy technologies has been increasing mainly due to the participation of new market players. Today, however, one of the great challenges is to maintain the electricity system's balance and security despite the large amount of renewable energy resources connected to the grid. One of the approaches to deal with this issue and to increase power system flexibility is the Demand Response (DR). This thesis examines this new approach and shows the interest to rethink the relations between different stakeholders, to bring out new business models in order to deploy innovations for energy transition. The implemented research methodology in this thesis consists of a systematic literature review and an investigation of empirical data of 15 European energy start-ups. As a result, the thesis provides the research community with (1) a grouping method to classify different Energy Business Models (EBMs) and an initial synthesis of the EBMs identified in the literature; (2) a framework to analyse start ups in the energy sector, completed with the analysis of 15 energy start ups; (3) and a conceptual tool for DR innovation, known as the Demand Response Business Model Canvas (DRBMC), which includes 12 interrelated elements. This canvas aims at evaluating DR activities and supporting the emergence of new DR business models. These results can also help entrepreneurs explore new demand response market opportunities, enabling a better understanding and providing a simplified analytic framework of existing business practices.

Key words: Business model innovation, Energy entrepreneur, demand response, start-ups, energy transition.

Résumé

L'accumulation de gaz à effet de serre dans l'atmosphère, produite par des activités anthropiques notamment dans le secteur de l'énergie est une des causes principales du changement climatique. Par conséquent, réaliser une véritable transition énergétique par une décarbonisation des réseaux électriques est devenue un besoin urgent pour atténuer les effets du réchauffement climatique. Dans cette transition, l'introduction des énergies renouvelables a été initiée depuis plusieurs années, principalement en raison de la participation de nouveaux acteurs à ce marché. Aujourd'hui, l'un des grands défis est de maintenir l'équilibre et la sécurité du réseau électrique en tenant compte de la diversité et de la variabilité des ressources énergétiques renouvelables connectées au réseau. L'une des approches permettant de régler ce problème et d'accroître la flexibilité du réseau électrique par ce que l'on désigne comme la Réponse à la Demande (RD). Cette thèse examine précisément cette nouvelle approche et montre l'intérêt de repenser les relations entre les différentes parties prenantes pour faire émerger des nouveaux modèles d'affaires afin de déployer de nouvelles innovations au service de la transition énergétique. La méthodologie de recherche mise en œuvre de cette thèse consiste en une revue systématique de la littérature et une étude des données empiriques de 15 jeunes entreprises européennes du secteur de l'énergie. En conséquence, la thèse fournit à la communauté de la recherche (1) une méthode de classification pour catégoriser les différents modèles d'affaires de l'énergie (MAEs) et présente une première synthèse des MAE identifiés dans la littérature; (2) un cadre d'analyse des start-ups dans le secteur de l'énergie, complété par l'analyse de 15 start-ups de ce domaine; (3) un outil conceptuel pour l'innovation en matière de RD, appelé Canevas de Modèle d'Affaires de Réponse de Demande (CMARD), qui comprend 12 éléments interreliés. Ce canevas vise à évaluer les activités des offres de RD et à soutenir l'émergence de nouveaux modèles d'affaires de RD. Ces résultats permettent de proposer un cadre analytique simplifié des pratiques existantes et peuvent également aider des entrepreneurs ou décideurs à explorer et concevoir de nouvelles offres sur le marché de la réponse à la demande.

Mots clés : Innovation de modèle d'affaires, Entrepreneur en énergie, réponse à la demande, start-ups, transition énergétique