A business model design framework for the viability of energy enterprises in a business ecosystem

Dsouza, Austin

A business model design framework for the viability of energy enterprises in a business ecosystem

Austin D'Souza

Publisher:	University of Groningen Groningen, the Netherlands
Printed by:	Ipskamp Printing, Proefschriften.net
Layout by:	Alex Wesselink, PersoonlijkProefschrift.nl
ISBN:	978-94-034-0353-3 (printed version) 978-94-034-0352-6 (electronic version)

Austin D'Souza
A Business Model Design Framework for the Viability of Energy Enterprises in a Business Ecosystem
Doctoral Dissertation, University of Groningen, The Netherlands

Keywords: business model design, energy business model, business model evaluation, business model ontology, viable business model

A business model design framework for the viability of energy enterprises in a business ecosystem

PhD thesis

to obtain the degree of PhD at the
University of Groningen
on the authority of the
Rector Magnificus Prof. E. Sterken
and in accordance with
the decision by the College of Deans.

This thesis will be defended in public on

Monday 15 January 2018 at 14.30 hours

by

Austin Dsouza

born on 18 May 1981
in Dharwad
India

Supervisors
Prof. J.C. Wortmann
Prof. G.B. Huitema

Co-supervisor
Dr. H. Velthuijsen

Assessment Committee
Prof. C. Nielsen
Prof. C.T.B. Ahaus
Prof. J.M. Akkermans

Preface and Acknowledgements

The thesis before you is the result of 6 years of work. I embarked on this journey in December 2011, knowing well it was not going to be easy. It has been a challenging, exciting, exhilarating, humbling, enlightening, and frustrating process. Now that I am at the end of this journey, I would like to thank everyone who stood by me.

I thank my supervisors prof. dr. ir. Hans Wortmann, prof. dr. George Huitema, and dr. Hugo Velthuijsen. Hans, I am grateful to you for believing in me and helping me find a PhD position. Your enthusiasm, involvement, and commitment as a supervisor are much appreciated. George, you have helped me structure my thoughts, which helped me a great deal. Your remarkable eye for detail assisted me as well. Hugo, you are an excellent mentor and have inspired my thoughts and actions. And a special thank you for keeping me and my fellow PhD candidates company when we were working on our dissertations during our summer holidays. Over the years I have relied on your collective wisdom and experience, and it has never failed me. At times, your foresight and wisdom were hard to fathom, but in time all made sense. Above all, thank you for your constructive criticism. Your criticism has made me a better person, both personally and professionally.

I thank dr. Nick van Beest, Kathelijne Bouw, and Christian van Someren for collaborating with me and for your constructive criticism. Nick and Kathelijne helped me further crystalise my work. I also thank Trijnie Faber-Remmelts, Marianne Eggermont, Lies Oldenhof, Jeroen van den Berg, and dr. Wim van Gemert for facilitating my research. Special thanks to Irene Ravenhorst, who did an excellent job at organising meetings with my supervisors. I also thank Steven Volkers and Marco Kwak for facilitating my research at Grunneger Power and Attero. I thank Hanze University of Applied Sciences for making this research possible.

I would especially like to thank my family. My wife, Wendy, was incredibly supportive of me through this process. Her unwavering support, encouragement, love, patience, and commitment have anchored me through this challenging period. I could not have done it without Wendy's support. My children, Larah and Jonas, provided me with the much-needed perspective and motivation to complete this endeavour. My parents, Joseph and Catherine, taught me life lessons that have bolstered me and will continue to do so, and I thank them for standing by me and encouraging me through this challenging journey. I also appreciate my extended family's support in this endeavour.

Austin D'Souza,
Groningen, January 2018

Contents

List of abbreviations

BMDFV – Business model design framework for viability
CO_2 – Carbon dioxide
ICT – Information communication technology
kWh – Kilowatt-hour
MSW – Municipal solid waste incinerator
NLD - Noordelijk lokaal duurzaam
PRP – Programme responsible party

Chapter 1

Introduction

1.1 The energy landscape

Energy is the backbone of our economy. It is one of the primary inputs necessary for nearly all economic activities. The International energy agency estimates a 48% increase in world energy consumption from 2012-2040 [1]. Yet because traditional energy systems are based primarily on fossil fuels, the energy industry faces several challenges. It is coming under increasing pressure to reduce pollution and create value not only for shareholders, but also for a broader set of stakeholders, such as governments and the local communities where they physically operate. To add to the complexity, the context within which the energy industry operates is changing rapidly, due to factors such as new technologies, shifting customer needs, and changing government policies.

1.1.1 Changing stakeholder needs require new services, products, and business models

Customers' needs are currently changing. More than just affordable, reliable energy, they now demand a broader set of value propositions, including clean energy. They also want businesses to create social value, such as jobs in the local communities where they operate [2], [3]. The business models of traditional energy conglomerates are not geared towards providing services and products that generate the above-mentioned broader set of value propositions sought by customers [2].

Government policies are also changing. The liberalisation of the energy industry decomposes the vertically integrated value chain into a network of organisations working in concert to generate and transport energy to customers. The liberalisation increases the number of industry stakeholders, such as energy producers, prosumers, transmission systems operators (TSOs), distribution system operators (DSOs), etc. The liberalisation also allows new players to enter the market.

As climate change intensifies, governments across the globe are increasingly setting ambitious goals to curb pollution and climate change. For example, the Paris climate deal sets out a global action plan to limit global warming below 2°C [4]. Consequently, governments are increasingly penalising polluters and incentivising green energy and measures to reduce energy consumption [2]. The above developments have a negative effect on the business models of energy companies based on traditional fossil fuels.

To ensure long-term survival, energy enterprises must develop new services and products that satisfy not only the needs of the end user but also those of the other stakeholders involved in the business ecosystem. They should also develop viable new business models that exploit the products and services that they develop. As a result, it is important to consider the service/product perspective while designing and evaluating viable business models for energy enterprises.

1.1.2 The advent of new technologies affects the business models of energy enterprises

Coupled with information communications technology (ICT), the emergence of affordable devices for renewable energy generation and storage challenge the traditional energy systems and business models used to exploit them. For example, previously passive consumers are increasingly installing energy generation and storage technologies on their premises. Thus, consumers not only consume energy but also produce it; such consumers are also known as prosumers. This shift from passive consumers to prosumers significantly affects the business models of energy retailers. Traditionally, they bought energy from large-scale producers and wholesale markets, and then retailed it to passive consumers. Now they are increasingly buying back energy from prosumers, and in many instances, the grid is used as a buffer to store excess electricity for use at a later time [5].

Another example of emerging business models in the energy industry is that of the aggregators. The increasing penetration of wind and solar energy increases the need for flexibility to balance the electricity grid. Flexibility refers to the ability of energy producers and consumers to increase or decrease energy production and consumption based on the supply-and-demand dynamics of electricity. The system operators and programme-responsible parties are always looking for affordable flexibility to balance the grid. On the one hand, the aggregators aggregate electricity producers and consumers who have the flexibility, but usually lack a feasible way of exploiting it on their own. On the other hand, the aggregators aggregate parties who are looking for flexibility, such as programme-responsible parties and system operators. The aggregators control the energy producers and energy consumers' assets remotely, based on the supply-and-demand dynamics and with the help of ICT. Parties looking for flexibility pay the aggregator for services received. In return, the flexible producers and consumers receive a fee.

The above discussion illustrates how technology plays an important role in enabling new business models. Consequently, it is important to consider the technology perspective while designing and evaluating viable business models.

1.1.3 Focal actor plays a vital role in designing a viable energy business ecosystem

A focal actor usually coordinates the energy business ecosystem to provide the services and products that the end user needs. This actor usually designs the products and services needed and crafts the appropriate business ecosystem for creating and delivering them [6], [7]. Obviously, it is an important and easy step to pay careful attention to the business model of the focal actor before crafting the business ecosystem.

1.1.4 Energy enterprises need to design and implement inclusive business models in a business ecosystem setting

The future market success of energy enterprises will depend on their ability to include a broader set of stakeholders and create a broader set of values, whether financial (e.g., profit) or non-financial values (CO_2 reduction, creating local jobs, etc.) [3][8]. The energy business ecosystem is a mix of stakeholders. Hence, the term *value* could mean different things to different stakeholders [9]. For example, for the local community where the energy-generation facilities are set up and operated it could mean local jobs and reduced pollution; for the focal firm exploiting the energy-generation facility it could mean profit; and for the local government it could mean meeting their goals for reducing pollution. As a consequence, the business model should create value for all of the stakeholders involved in the business model, both in terms of financial and non-financial values.

Therefore, it is important to ensure that all the stakeholders are able to capture value in terms of financial and non-financial values and the business ecosystem perspective while designing and evaluating viable business models.

In addition to the above perspectives, it is also important to consider the business rules that the business models of the energy enterprises must satisfy. The energy industry is heavily regulated, resulting in myriad requirements. The internal environment also imposes stipulations on the business models of the energy enterprises (e.g., the technical architecture of the energy system may require the total amount of energy supplied to the grid and the total amount of energy consumed from the grid to be equal at any given point in time). Business rules are statements that effectively internalise the requirements that the external and the internal environments put on the business model. They can either facilitate or constrain a business model. Hence, it is very important to consider them explicitly while designing business models for energy enterprises.

In conclusion, energy enterprises need to design and evaluate new business models to cope with a rapidly changing business environment. The viability of such a model depends on the ability of the energy enterprises to create new services/products that customers want and to deliver them cost-effectively. The business models of energy enterprises should not solely address their own profitability: they should also include a broader set of stakeholders and create financial and non-financial values for them. If the stakeholders can capture the values they want, they will be motivated to participate. Additionally, the viability of the business model also depends on the ability of the underlying technology architecture to enable the logic of value creation, delivery and capture. The above context leads to the following goal of this thesis.

Goal:
To facilitate the design and evaluation of viable energy business models in a business ecosystem setting.

1.2 Business models and business model design

This section introduces business models and explains why a new business model design framework for viability is needed.

1.2.1 Introduction to business models

The term "business model" has risen to prominence over the past one and half decades [10]. The large-scale dissemination of the internet spawned the interest in business models. The term was coined to explain how firms planned to leverage the internet to create, deliver, and capture value [10], [11]. Ever since the term emerged, professionals have found it a useful concept not only for internet-related businesses but for all enterprises.

Every enterprise employs a business model, whether explicitly or implicitly formulated [12]. In essence, they tell the story of how an enterprise functions [11]. A business model defines the logic of how an enterprise creates, delivers, and captures value [12], [13]. To survive in the long term, enterprises need to design and implement viable business models.

A business model is viable when all of the stakeholders involved in it can capture value such that they are committed to it [14]. A business also has to be viable in terms of technology, and it should be able to produce or deliver the envisioned product and/or service [15].

However, designing a viable business model is challenging due to the following reasons. Cheap and affordable ICT has drastically reduced coordination costs. Firms are now able to outsource activities to other firms that can perform them efficiently effectively. Firms are increasingly working in a business ecosystem setting to gain competitive advantage. A business ecosystem can be crafted in many ways, thus increasing the complexity of designing viable business models. Accentuating the problem are rapid innovations taking place at the physical level of technology, such as the energy generation, storage, and insulating technologies mentioned above [14], [16]–[18]. Furthermore, business models have to be designed and implemented in a business ecosystem setting. Designing them in such a setting implies dealing with increased number of stakeholders and their competing interests [14].

Researchers have used two main approaches to design and evaluate business models. First is the informal approach, which involves the use of natural language [19] [20] and informal semantics to depict business models. The semi-formal approach involves the use of business model ontologies [14], [21]. In the wide sense, these are languages used to conceptualise and communicate business models [14], [21] — for example, the business model canvas [13] and e3-value [22] (see Section 1.2.2 for more details on business model ontologies). This research leans on business model ontologies because they leave little room for misrepresenting and misinterpreting business models and they provide an structured manner to approach the process of designing them [21].

1.2.2 Introduction to business model ontologies

Defining the objects and the relationships among them in the context of a domain [23], ontologies are generally built on objects and not on processes [24]. Business model ontologies are concerned with defining business models, and with explaining which objects (e.g., value proposition, cost structure, etc.) constitute a business model, as well as the relationships among these objects. In the past, business model ontologies have been used to describe business models [25]. Therefore, the business model ontologies could possibly be used to design and evaluate viable business models because of their ability to describe business models.

Business model ontologies are used as a foundation to develop tools and methods used to design and evaluate business models such as the business model canvas, e3value editor, and e3-value methodology. For example, Osterwalder proposed the business model ontology [18] and later developed the business model canvas tool [13] based on it. Gordijn proposed the e3-value model ontology and later developed the e3-value methodology, which includes a tool called the e3-value editor. As a deduction, the business model ontologies are embedded in the tools, methods and approaches.

As the tools and methods used to design and evaluate business models and business model ontology are so closely related, the term "business model ontology" is used loosely to refer also to the tools, methods, and approaches used to describe business models [14], [25]. In the strict sense, the tools and methods do not qualify as ontologies. Nevertheless, the phrase "business model ontology" sometimes also comprises the tools and methods used to design and evaluate viable business models. Therefore, it must be acknowledged of this phrase also has a meaning in the wide sense. Whenever ambiguity could arise, it will be mentioned if the term is used in the strict or the wide sense (for a detailed discussion on business model ontologies, see Section 2.3.2).

In the strict sense, business model ontologies largely ignore the process of designing and evaluating viable business models. The lack of support for the process of designing viable business models is not surprising, considering the focus of business model ontologies and the iterative, creative process of designing viable business models. Supporting the creative process of designing viable business models requires providing design elements such as design principles and configuration techniques. It is not always possible to include these design elements as objects in business model ontologies, because they often tend to be heuristic in nature. Consequently, defining the relationships among the objects is also difficult. Hence, business model ontologies largely ignore crucial elements of business model design necessary for viable business model design.

In the wide sense, several business model ontologies help to conceptualise business models such as the business model canvas and the e3-value. Each of these ontologies describes business models from a different perspective, such as the focal firm perspective or the business ecosystem perspective [14]. As will be shown in Chapters 2, 3, 4, and 5, designing and evaluating viable business models requires their designer to adopt multiple perspectives, including such as the service/product, focal actor, business ecosystem, and the technology. Integrating these perspectives together increases the risk of creating an overly complex business model ontology that is difficult to understand and use.

In the wide sense, business model ontologies are useful tools in the process of designing and evaluating viable business models. Among other advantages, they provide a standard vocabulary and are well accepted by professionals. In addition, the unique perspectives from which they conceptualise business models are of particular interest for designing and evaluating viable business models [23]. For this reason, this research builds on well-established business model ontologies and modelling techniques that are relevant for the process of designing and evaluating viable business models by integrating them into a business model design framework for viability.

1.2.3 The need for a new business model design framework for viability

Based on Chapter 2, this section briefly explains the research gap related to business model ontologies and why a new business model design framework for viability is necessary. A detailed discussion on this topic is presented in Chapter 2.

A review of well-established business model ontologies, in the wide sense, shows that they do not sufficiently facilitate the design and evaluation of viable business models [14]. They especially fall short in regard to designing and evaluating complex business models. The complexity arises due to the difficulty in formulating balanced, multi-dimensional value propositions such as financial and non-financial values; satisfying multiple stakeholders and their competing interests; formulating value creation logic that is systemic in nature; and designing a technology architecture that supports it. Also, existing business model ontologies mostly ignore important design elements such as design choices and principles, configuration techniques, assumptions, and business rules. Additionally, the design of complex business models requires approaching the design process from multiple perspectives [26] (such as service/product, focal actor, business ecosystem, and technology perspectives), because it is hard to address the complexity of designing viable business models from one perspective only. The four perspectives are derived from the literature and the author's experience in designing and evaluating viable business models. The description and the theoretical underpinnings of the four perspectives can be found in Sections 2.1.2 and 3.3.2. Ignoring the financial and non-financial values, the business model design perspectives and design elements could lead to unviable business models and eventually to the demise of the firms involved in the business model. On that account, it is necessary to consider the four perspectives, the elements of business model design, and the financial and non-financial values explicitly during the design process.

Therefore, a comprehensive business model design framework is necessary to design viable business models. The framework should explicitly consider financial and non-financial values, the elements of business model, and the design perspectives. Furthermore, the intended framework should facilitate the design process in a transparent and traceable manner.

In the information systems discipline, particularly in the enterprise architecture domain, several well-established frameworks build on existing ontologies and modelling techniques. The frameworks are used to designing enterprise architectures [27] — for example, the Zachman framework [28], and the 4+1 view model (software architecture framework) [29]. The frameworks above facilitate a holistic approach to design enterprise architectures by enabling the architect to adopt multiple perspectives while doing so, therefore increasing the chances of designing a viable enterprise architecture.

Following in the above footsteps, in the context of this research frameworks are interpreted as being less formal than the business model ontologies and the domain-specific modelling techniques. As deductions, frameworks provide the necessary flexibility for the architect to focus on the process of designing viable business models, by facilitating the integration of the much-needed business model design perspectives, business model ontologies in the wide sense, and the elements of business model design into a single business model design framework for viability. Additionally, they are also useful tools to support the process of designing and evaluating viable business models, as demonstrated in Chapters 4 and 5. Furthermore, integrating well-established business modelling ontologies and modelling techniques helps to capitalise on their strengths of formalism, rigour, and acceptance by professionals. Thus, this research builds on well-established business model ontologies to capitalise on their strengths. Figure 1.1 below further illustrates this point.

To the author's knowledge, there are no frameworks that build on top of existing business model ontologies and use the elements of business model design in a consistent and coherent manner to design and evaluate viable business models in the context of business ecosystems. Currently, business models are designed using business model ontologies. Hence, the following chapter reviews the state of the art in business model ontologies with the goal of identifying their strengths and weaknesses. Derived from literature, a list of criteria an ideal business model design tool should satisfy is necessary to identify the strengths and weaknesses of the business model ontologies. Next, these criteria are used to assess existing business model ontologies. The criteria also serve as input for developing the business model design framework for viability. Additionally, the assessment also helps to identify and choose business model ontologies on which to build the business model design framework for viability.

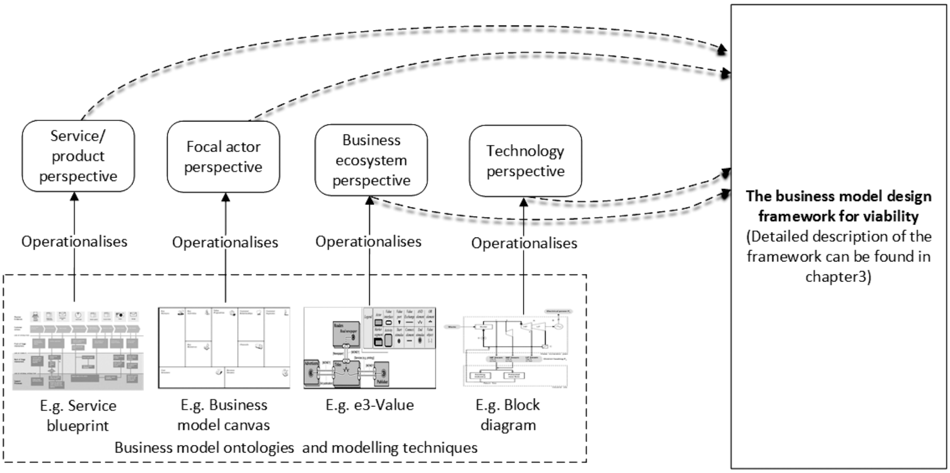


Figure 1.1 Use of business model ontologies and other modelling techniques in the business model design framework for viability – the business model ontologies and the modelling techniques are used to operationalise the four perspectives in the business model design framework for viability.

1.3 Research problem

This section presents the research questions. To mitigate the energy industry's negative impact on the planet and society and to deal with changing business conditions, the energy industry needs to transition to a sustainable energy system. Yet transitioning to such a system, as explained above, is not an easy task. Among other initiatives, the energy businesses need to design and evaluate new business models in a business ecosystem setting (that is, the business models should include a broad set of stakeholders, as well as multi-dimensional value propositions that can be classified into profit, planet, and people categories. The above context leads us to the main research question:

Main research question:
(RQ) How to *develop* a validated framework for designing and evaluating viable business models for energy enterprises in a business ecosystem?

Several existing business model ontologies and frameworks facilitate the process of conceptualising and communicating business models, such as business model canvas and e-3value. However, the literature review shows that they do not fully support the process of designing and evaluating viable business models, which leads us to the following sub-research question:

Sub-research question 1:
(SQ1) What are the *requirements* put on a framework to design and evaluate viable business models in a business ecosystem?

The identified requirements will be used to develop a framework for designing and evaluating viable business models in a business ecosystem setting, which leads us to the following sub-research question:

Sub-research question 2:
(SQ2) How to *design* a viable business model?

Sub-research question 3:
(SQ3) How to *evaluate* the designed business model for viability?

The intention is to develop a framework that facilitates the design and evaluation of viable business models in the context of business ecosystems. A framework is an artefact [30][31]. As a deduction, design science research is an appropriate method for developing such an artefact (for more details see the following section). Design science research requires rigorous validation of artefacts to develop sound, relevant methods — which leads us to the final sub-research question:

Sub-research question 4:
(SQ4) How to *validate* a framework for designing and evaluating viable business models for energy enterprises in a business ecosystem?

1.4 Methodology

Considering the context and goal of this research, the origins of the business model concept, and the researcher's background, this research is carried out within the tenets of information systems and design science research. Research in the information systems domain is prominent at the confluence of people, technology, and organisations [32]. The field of information systems "*draws research questions, methodologies, and grounding philosophies, from multiple fields that are loosely united under a common interest in understanding the way in which human-computer systems are developed, produce and process information, and influence the organisations in which they are embedded.*" [33, p.2].

Recently, design science research has gained prominence in the information systems domain, because of its ability to facilitate the design of artefacts and its ability to explore questions that have a sparse or non-existent theoretical background [33]. Hevner et al. [30], define artefacts as "*constructs (vocabulary and symbols), models (abstractions and representations), methods (algorithms and practices), and instantiations (implemented and prototype systems).*"[30, p. 77]. Similarly, Vaishnavi and Kuechler [33] have identified the following artefact archetypes: constructs, models, frameworks, architectures design principles, methods, instantiations, and design theories.

One of the core tenets of design science research is to facilitate the development of innovative artefacts that address unsolved problems, or to address them in a better way than previous attempts [30], [32]. Since the goal is to develop and validate a framework to facilitate the design and evaluation of viable business models in a business ecosystem setting, the framework is a meta artefact used to solve a class of problems. Hence, design science research is an appropriate method for achieving the above goal.

Design science research originates from engineering and sciences of the artificial [30]. It involves the application of theories from a different discipline such as information systems, computer science, and economics to develop artefacts [33], [34]. Artefacts are designed to be used in a certain environment with specific utility(ies) in mind. The environment consists of external forces that constrain the behaviour of the artefact. The artefact is made up of components and their relationships that constrain its behaviour. Thus, the body of knowledge about creating artefacts, which is creating the constituent components and their relationships that behave in a desired manner in the environment, is precisely where design science research contributes to theory [33]. Before explaining the specifics of the methodology employed in this research, it is important to understand what is a valid theoretical contribution in the context of design science research and the type of conclusions the researcher can draw within its tenets. In design science research, a valid theoretical contribution can be any validated artefact that is new and innovative. New and innovative refers to inventions that solve new problems, improvements to established solutions, adaptations of known solutions to solve new problems, and routine designs that apply known solutions to known problems, thus leading to significant contributions to the existing body of knowledge [35]. Additionally, design science research can also contribute to theory by adding explanations as to why a particular artefact should work, using well-established theories in natural, social, design, or mathematical sciences [33].

Design science research requires the researcher to draw important conclusions about the validity of the designed artefact and the contributions made to the body of knowledge. The conclusions about validity revolve around how well the designed artefact satisfy the design criteria and if it is built soundly. Next, the conclusions about the theory can be drawn that can be derived only by the act of developing and evaluating the artefacts [33].

The criticism of design science research stems from the debate on the similarities, differences, and synergies between the domains of design science research and action research. Some argue that the two are similar [36]. Others argue that design science research focuses on the design of artefacts and its proof of usefulness in a stage gate manner, while action research focuses on the active search for solutions in organisational contexts [37]. This difference in focus has led to the criticism that design science research ignores the emergent nature of artefacts (i.e., artefacts emerge in interaction with organisational elements), while action research lacks focus on developing new and innovative artefacts [37], [38]. Considering the above scope of research, several scholars call for combining the two domains while still maintaining their individual identity [34], [37]. Ivari in [39] suggests using design science research to develop the artefact and action research to test, evaluate, and improve it. Similarly, Sien et al. [37] propose action design research that combines the strengths of both design science research and action research. However, in the context of this research, where the goal is to develop an artefact that will facilitate the design of viable business models, design science research is an appropriate method. The emergent nature of the business model design framework for viability is acknowledged, but it is beyond the scope of this dissertation. It refers to exposing the framework to sustained business model design activity, and the subsequent iterations of developing the framework [34].

1.4.1 The design science research method

A well-established framework for carrying out the design science research process is the design science research approach [34].

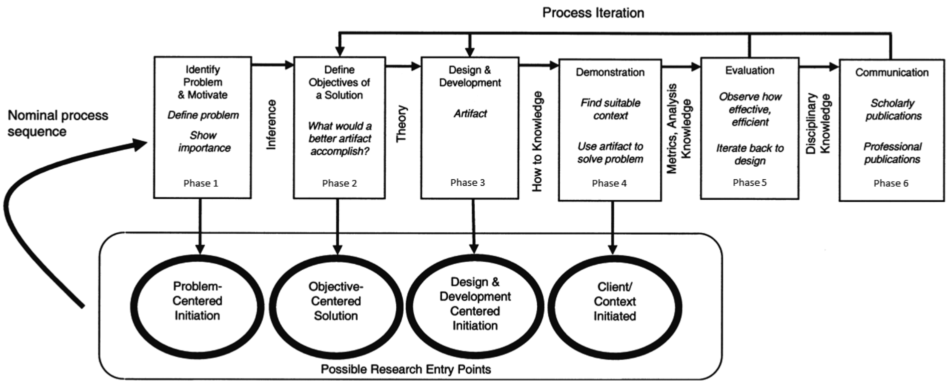


Figure 1.2 Design science research approach; modified from [23, p. 54] – the figure shows the possible research entry points into the design science research process and the six phases of the design science research approach.

As shown in Figure 1.2, the design science research approach proposed by Peffers et al. [34] has the following six distinct phases.

Phase 1 - Identify and define the problem and motivate. As the name suggests, this phase involves identifying the problem and the motivating reason for solving it. Chapter 1 identifies the problem and presents the motivation for solving it. To address the problem, the main research question and sub-research questions have been formulated. Answering the sub-research question will help to answer the main research question.

Phase 2 - Define objectives of the artefact. In this phase, researchers are expected to define the specific objectives that the artefact should achieve. The objectives can describe which utilities the intended artefact will provide and how it helps to address the problem. Additionally, if a problem has already been addressed with the aid of an artefact, one should then explicitly state how the new artefact is better than the existing one. Chapter 2 presents a list of criteria that an ideal tool should have for designing and evaluating viable business models in the context of business ecosystems. Derived from literature, these criteria are then used to assess existing business model ontologies, which are a popular way of designing business models. The assessment is performed to determine if the well-established business model ontologies fully support the process of designing and evaluating viable business models in the context of business ecosystems. Next, the deficiencies that emerge from the analysis are presented. Thereafter, the criteria also serve as requirements that the new business model design framework for viability should satisfy. Satisfying them will bridge the gap and improve the process of designing and evaluating viable business models in the context of business ecosystems.

Phase 3 - Design and development of the artefact. This phase involves determining the artefact's functionality and architecture. It also includes developing the artefact itself. The knowledge from relevant theories is drawn on and embedded in the artefact. Chapter 3 presents the artefact of the business model design framework for viability and its theoretical underpinnings.

Phase 4 - Demonstration of the artefact. Here the utility of the designed artefact is applied to solve one or more instances of the problem. Several methods are used to demonstrate the artefacts, such as simulations, case study, proof, or other appropriate activities. Chapters 4 and 5 show the application of the developed artefact using the case study method. The business model design framework for viability is used to design viable business models in two case studies. The first involves designing a mono-commodity business model for a community-owned solar farm, and the second involves designing a viable business model for a more complex, multi-commodity energy system for an industrial park.

Phase 5 - Evaluation of the artefact. The objective here is to measure and observe how the designed artefact supports the solution to the problem. Comparing the newly developed artefact's output with its objectives is a good way to measure and observe the artefact. Research methods for evaluating the results range from very qualitative to quantitative. Chapters 4 and 5 also evaluate the business model design framework after using it to design viable business models for the case studies mentioned above. Expert opinion is used to evaluate the output of the business model design framework: the mono-commodity energy model for the community-owned solar farm and the multi-commodity energy model for an industrial park. Additionally, the problem and its relevance, the theoretical underpinnings of the artefact, the artefact, and the results of applying the artefact to design viable business models have been published and presented in several peer-reviewed scientific journals and conferences. For a full list of publications see Section 1.6. Hence, the research community has accepted the developed artefact.

Phase 6 - Communication of the results. The problem and its relevance, the artefact, its utility and novelty, the rigour of its design, and its effectiveness should be communicated to relevant research communities and professionals. In addition to this thesis, as previously mentioned, this research has been shared with the research community via publications in scientific journals, and conferences. The research has also been transmitted to practising professionals via reports and publications in professional magazines. For a full list of publications see Section 1.6.

The end result of the above phases should contribute to theory in the context of design science research [33], [35]. The business model design framework for viability builds on well-established business model ontologies and modelling techniques, while proposing a new framework that addresses a well-known problem in the literature: how to design and evaluate viable business models in the context of business ecosystems. Hence, this research adopts existing business model ontologies and integrates them into the business model design framework for viability. The business model design framework for viability also adds the missing design perspectives and the elements of business model design that facilitate the design of viable business models in the context of business ecosystems in a transparent and traceable manner. Hence, the output of this research is a validated meta artefact that can be used to design viable business models for energy enterprises in the context of a business ecosystem. Thus, the contribution to theory is the validated meta artefact: the business model design framework for viability.

1.4.2 Overview of applied methods and techniques

The design science research approach is an overarching research methodology that allows for a host of methods and techniques to be used for identifying the problem, defining objectives of the solution, designing the solution, demonstrating the solution, and evaluating and communicating the artefact. Table 1.1 provides an overview of the methods and techniques used in this thesis.

Table 1.1 Overview of methods used within the overarching design science research approach

Research phase	*Method*
Identify and define the problem and motivate (Chapter 1)	Literature review on business model design and energy transition is performed to identify the problem and to present a motivation for addressing it.
Define objectives of the artefact (Chapter 2)	Existing literature is used to derive a list of criteria that the ideal tool for designing and evaluating viable business models in the context of business ecosystems (i.e., the business model design framework for viability) should satisfy. Following the activity of deriving the criteria, the current ways of designing business models (i.e., the business model ontologies) are assessed against the criteria to determine the research gap. The above activity is framed as a multi-criteria decision analysis problem. The guidelines prescribed by Belton and Stewart are followed to perform the multi-criteria decision analysis on the business model ontologies [40].
Design and development of the artefact (Chapter 3)	Based on the above analysis, a business model design framework for viability is proposed. The framework achieves the objectives set out above. The framework builds on well-established business model ontologies and modelling techniques such as business model canvas [13], e3-value [41], service blueprint [42], and block diagrams.
Demonstrate the artefact (Chapters 4 & 5)	The methods used to demonstrate the designed artefacts range from observing the use of the artefact in practice to demonstrating it in a controlled environment [30]. A case study is a common and appropriate method to demonstrate business model design meta-artefacts because it allows for a detailed demonstration of their applicability [18], [22], [43]. Hence, the case study method is used to demonstrate the business model design framework for viability.
Evaluate the artefact (Chapters 4 & 5)	Since the goal is to facilitate the design of viable business models, the application of the business model design framework should lead to a viable business model — or at least identify the conditions under which the designed business model could be viable. A well-established technique in literature to evaluate the viability of business models is to use expert opinion [44]. Hence, the latter is used to evaluate the viability of the business model designed using the business model design framework for viability.
Communication (Chapters 1-6)	The method chosen to communicate this research is via publication in scientific conference reports, journals, and professional magazines.

1.5 Contributions of this research

This research contributes a validated framework that facilitates the design of viable business models in a transparent and traceable manner in the context of business ecosystems. It has also led to the following publications:

Scientific conferences and journals:

[1] A. D'Souza, N. R. T. P. van Beest, G. B. Huitema, J. C. Wortmann, and H. Velthuijsen, "An Assessment Framework for Business Model Ontologies to Ensure the Viability of Business Models," in *16th International Conference on Enterprise Information Systems*, 2014, pp. 226–235.

[2] A. D'Souza, N. R. T. P. Van Beest, G. B. Huitema, J. C. Wortmann, and H. Velthuijsen, A Review and Evaluation of Business Model Ontologies: A Viability Perspective. Lecture Notes in Business Information Processing, Springer , 2014.

[3] A. D'Souza, J.C. Wortmann, G. Huitema, and H. Velthuijsen, "A business model design framework for viability; a business ecosystem approach," J. Business Model., vol. 3, no. 2, pp. 1–29, 2015.

[4] A. D'Souza, H. Velthuijsen, J. C. Wortmann, and G. B. Huitema, "Developing a viable business model for community-owned solar farms in the Netherlands," in USE: Understanding small enterprises, 2015.

[5] A. D'Souza, K. Bouw, H. Velthuijsen, J. C. Wortmann, and G. B. Huitema, " Designing viable multi-commodity energy business ecosystems: corroborating the business model design framework for viability", Journal of Cleaner Production (in review).

Other publications:

[6] Bouw, K., D'Souza, A., Van Someren, C., 2016. A flexible business model for the ETP Wijster. Groningen. url: https://www.researchgate.net/project/Flexiheat

[7] Flexibele Warmtenetten zijn de toekomst, Warmtenetwerk magazine, NR 25. Herfst 2016 (Dutch).

1.6 Thesis structure

This thesis is structured as depicted in Figure 1.3 below.

Chapter 1 identifies the problem, shows its importance, and makes the motivation for solving the problem explicit. The problem is further defined and broken down into a main research question and sub-research question. This chapter also provides an overview of the methods and techniques applied to carry out the research and an overview of how this thesis is structured.

Chapter 2 addresses SQ1. Hence, it presents an assessment of existing business model ontologies as to their capabilities to support the design and evaluation of viable business models. The criteria for assessing the business model ontologies are derived from literature related to business model design. To identify any gaps, these criteria are applied to assess six well-established business model ontologies. The identified gaps are then translated to a set of objectives that the intended framework should achieve.

Chapter 3 deals with SQ2 and SQ3. To addresses these sub-research questions, Chapter 3 presents the business model design framework for viability and assesses the framework theoretically against the criteria identified in Chapter 2.

Chapter 4 addresses SQ4. Therefore, it demonstrates the application of the business model design framework for viability in designing a business model for a mono-commodity energy system (a community-owned solar farm). It follows that the output of applying the business model design framework for viability is a business model for the community-owned solar farm. Experts evaluate the newly designed business model for viability. Next, a reflection on the validity of the business model design framework for viability is presented.

Chapter 5 answers SQ4. To answer SQ4, Chapter 5 demonstrates the application of the business model design framework for viability to design a business model for a more complex multi-commodity energy system. The experts evaluate the new business model for viability. Next, a reflection on the validity of the business model design framework for viability in the context of multi-commodity energy systems is presented.

Chapter 6 presents the conclusion of this research.

Figure 1.3 Thesis structure. The figure shows the structure of the thesis and how the chapters address the different phases of the design science research approach and the research questions. Also, the contribution of each chapter is made explicit.

Chapter 2

Requirements for the BMDFV: A review and assessment of business model ontologies

2.1 Introduction

Energy enterprises are increasingly operating in a complex environment. It is characterised by new technologies, intensified and fast-paced innovation, increased competition, changing customer needs, volatile government policies, climate change, economic upheavals, and more. Among other things, dealing with the resulting complexity requires energy enterprises to design, evaluate, and implement viable business models.

In the wide sense, business model ontologies are popular tools among professionals for designing and evaluating business models. For that reason, it is important to assess their capabilities to support the design and evaluation of viable business models. Business model ontologies are meta-artefacts that facilitate the process of designing and evaluating viable business models (e.g., a business model canvas) [25], [13]. As mentioned in Chapter 1, meta-artefacts are tools used to design specific solutions. In the context of this research, meta-artefacts are tools, such as business model ontologies, that are used to design specific business models. However, the current business model ontologies are conceived from different perspectives and are used for various purposes. The capabilities of existing business model ontologies to facilitate the design and evaluation of viable business models remains unclear, particularly in the context of business ecosystems [14], [21].

Hence, there is a need for a set of criteria that will help assess the capabilities of business model ontologies to facilitate the design and evaluation of viable business models. The assessment will help to identify the deficits and areas for improvement from a viability perspective. The assessment will also help to choose business model ontologies that will be used to develop the intended business model design framework for viability. Therefore, the assessment helps to specify the problem further and to define the objectives of the solution. The latter describe how the intended artefact is expected to support the solution to the problems; that is, how the intended framework should support the process of designing and evaluating viable business models in the context of business ecosystems [34]. The above context leads us to the first sub-research question, as defined in Chapter 1: (SQ1) "*What are the requirements put on a framework to design and evaluate viable business models in a business ecosystem*?" This chapter presents a list of fundamental criteria that an ideal business model design and evaluation tool (i.e., the business model design framework for viability) should satisfy to facilitate the design and evaluation of viable business models.

Derived from the literature, the criteria are subsequently used to assess the following six well-established business model ontologies: e3-value [22], business model canvas [13], value network analysis [45], e-business modelling schematics [46], value stream mapping [47], and resource event agent [48]. Four of the six ontologies were then developed for describing business models (e3-value, business model canvas, value network analysis, and e-business modelling schematics), and the remaining two (value stream mapping and resource event agent) were developed for other purposes. Value stream mapping is used to organise production systems according to lean manufacturing principles [47]. The resource event agent is a generalised accounting framework that helps to maintain information about exchanged resources, events, and agents involved in the exchange [48]. Value stream mapping and the resource event agent ontologies have overlap with business model ontologies and focus explicitly on value flows. Hence, value stream mapping and resource event agent could possibly be used to design and evaluate viable business models. Therefore, they are assessed alongside the other business model ontologies. Ontologies are usually not developed to support design and evaluation processes, but they are developed to establish a common terminology. Ontologies include a set of concepts, their definitions, and their interrelationships [23]. As mentioned in Chapter 1, some of the business model ontologies have evolved into business model design and evaluation tools such as the business model canvas and the e3-value methodology.

The research limits itself to well-established business model ontologies that are both formal and semi-formal in nature. Other informal business model ontologies are left out of the analysis for the simple reason that formal and semi-formal business model ontologies allow for the most accurate description of business models and leave little room for misinterpretation of them.

This chapter is largely based on the publications [1], [2], and [5] mentioned in Section 1.6.

In defining the conceptual focus of viable business models, Section 2.2 explains the lens through which they are viewed; that is through the viability lens. Section 2.3 discusses the related work. It reviews the position of the business model in the general management literature and in literature related to business model ontologies, as well as the previous efforts to compare business model ontologies. Section 2.4 presents the research design and explains the multi-criteria decision analysis framework used to derive a set of criteria. Section 2.4 also explains how the criteria are processed to comply with a multi-criteria decision analysis framework and how the processed criteria will be used to assess the business model ontologies. Section 2.5 presents the criteria and their theoretical underpinnings. Section 2.6 shows how the criteria are further processed to comply with the conditions of multi-criteria decision analysis and how the processed criteria are applied to assess the business model ontologies. Finally, Section 2.7 presents the conclusions.

2.2 The conceptual focus of viable business models

The conceptual focus defines the functionality the ideal tool should possess for designing and evaluating viable business models, the components that should be modelled and analysed, and the level of granularity at which the business models should be modelled. Therefore, the goal of this subsection is to synthesise a viewpoint from which business models are conceptualised and analysed. The viability viewpoint is used to conceptualise and analyse the business models. Consequently, the business model design framework for viability should focus on the design and evaluation of viable business models. The following section defines the concepts of business model and viability.

2.2.1 What is a business model?

The business model concept is relatively young, and scholars still debate its meaning and scope on several fronts, including strategy and operational detail. In the continuous debate on the scope of business models, some consensus exists on a definition [17]. A business model describes how business is carried out. It specifically defines the logic of value creation, exchange, and capture. Furthermore, business models describe the logic of each stage from different perspectives, such as the focal actor perspective, the business ecosystem perspective, the service/product perspective, and the technology perspective (for more details see Section 2.1.2). Additionally, they also define the business architecture[1] that enables the logic of the tripartite process of value creation, exchange, and capture [17], [49]–[51].

2.2.2 What is a viable business model?

A business model is viable when the service/product that customers want can be provided with reasonable resources and time. Also, for the business model to be viable, the participating stakeholders (e.g., focal actor, customers, partners) should be able to capture sufficient value such that they are motivated to be a part of the business model. Additionally, the business model should be viable in terms of technology (i.e., the envisioned technology architecture can be reasonably acquired/ developed and implemented).

Viability has multiple dimensions and this is particularly the case for business models in the context of business ecosystems. To capture the multi-dimensional nature of viability, four perspectives are derived from the literature, namely *service/product perspective* [44], [52], *focal firm perspective* [13], [26], *business ecosystem perspective* [7], [22], [26], and *technology perspective* [43], [44], [52]. For a business model to be viable, it has to be viable from these four perspectives.

The total amount of value captured by individual stakeholders largely depends on their bargaining power in the business ecosystem [53], [54].

The service/product perspective describes the benefits the service/product intends to deliver to its customers and how these benefits are delivered [6]. The business model design process usually starts with a business idea. This idea then has to be transformed into a product/service design or a concept that is valuable to the customer. Several tools and techniques help to transform the idea into a structured service design or concept that customers value [42]. A fairly structured service design or a concept is necessary for designing a business model [44], [55]. A service/product perspective is viable when the stakeholders can provide the envisioned service/products to the customers with reasonable effort, and when the customers and or other stakeholders in the business ecosystem are willing to pay for the benefits generated by the envisioned service/ product. Synthesising the service/product perspective is not an attempt to subsume

---

1 “Business architecture” refers to the key components and their organising logic, such as technology, value-creation activities, stakeholders, and value-exchange relationships.

service design under business model design, but it is an attempt to build on the strengths of the service design discipline to develop customer-centric business models.

The focal actor perspective defines how the focal actor intends to create, deliver, and capture value. It involves defining the key stakeholders (i.e., partners and customers), the value proposition for customers, channels, relationship types, key value creation activities, etc. [13], [25]. It is important to synthesise the focal actor perspective because business models that operate in a business ecosystem setting are usually anchored in a focal actor [15], [26]. The focal actor also coordinates the business ecosystem and is also involved in crafting it [15]. Therefore, designing the business model carefully from the focal actor perspective is necessary. Designing it from this perspective is usually easier before addressing the business ecosystem perspective. The focal actor perspective is viable when the focal actor captures sufficient value such that they are motivated to be a part of the business ecosystem [15], and when they have the capabilities to implement and operate the business model [56].

The business ecosystem perspective clearly defines how the different stakeholders create and exchange value. It involves assigning roles and responsibilities as well as the value creation activities, defining the value exchange relationships while ensuring the viability of the stakeholders [7], [22]. A business ecosystem is viable when all of the stakeholders participating in the business ecosystem can capture value such that they are motivated to be a part of it [15]. Furthermore, it is also essential that the stakeholders in the business ecosystem possess the capabilities to implement and operate the designed business model [56]. The business ecosystem perspective overlaps with the focal actor perspective. However, here the focus is on all of the business ecosystem stakeholders, as opposed to just one stakeholder (i.e., the focal actor).

Finally, **the technology perspective** describes the architecture of the physical technologies and the information services necessary to support the BM. This perspective is a prerequisite for synthesising the focal actor and business ecosystem perspectives; especially in the case of technology-intensive industries. Also, while synthesising the technology perspective, the capabilities of new technologies should also be considered to determine how they could lead to new and better ways of doing business [57]. According to Kraussl [43], a business model should be viable in terms of technology, so that the underlying physical technologies and the information services support the business model. As a result, it is necessary to critically assess and select the information services and physical technologies necessary to support the business model to achieve technological viability. Additionally, all of the stakeholders involved in a business ecosystem should agree on the envisioned technology architecture and should possess the appropriate technological capabilities to implement and operate the technology solution.

Synthesising all of the above perspectives is usually an iterative process, and they must align with each other. For example, the envisioned technological architecture should be able to support the provision of product/services. Similarly, the technology architecture should also support the business model from the focal firm and business ecosystem perspectives.

2.2.3 A broader approach to value

Value is the core component of a business model, and it plays a major role in making business models viable [49].

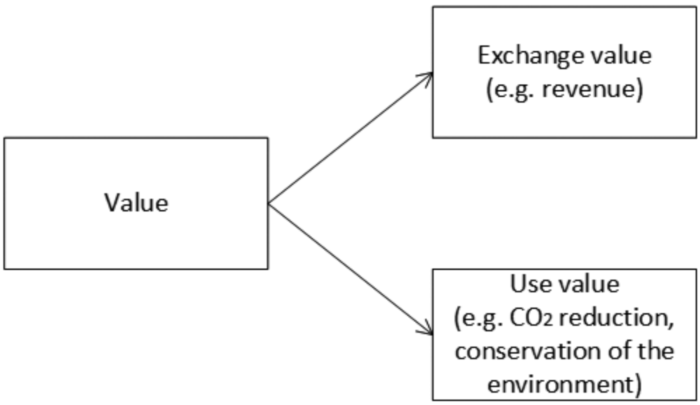


Figure 2.1 Composition of value [14], [21] – value is decomposed into exchange value and use value

As shown in Figure 2.1, value is composed of exchange value (euros, dollars, etc.) and use value (e.g., benefits of a product or service enjoyed by a customer and benefits derived by other stakeholders) [9], [58]. Use value concerns the desired benefits end users derive from a product or a service. The concept of use value was extended by Lepak et al. [9] to include benefits realised by stakeholders other than end users, such as governmental organisations and society. The above extension implies that the business model could include a broader set of stakeholders other than end users and the company selling a product or service [8]. The presence of a broader set of stakeholders is especially evident in the energy industry. For example, let us consider the business model of a community-owned, small-scale solar farm in the Netherlands [59]. This particular model involves several stakeholders, such as community members, solar farm operators, the local municipality, and the government. These stakeholders are interested in different types of value. For instance, the solar farm operator is purely interested in exchange value (profits), while the community members are interested in exchange value (return on investment) as well as use value (reduction of CO_2, jumpstarting the local economy by hiring local suppliers and installers). Similarly, the local municipality and the government are interested in use value (i.e., reducing CO_2 emissions to meet the EU's sustainability goals while boosting the local economy) [59]. The use value can be categorised further into the benefits the user derives, environmental benefits, and social benefits [3], [60].

Several frameworks can be used to systematically identify and quantify use values related to people and planet, such as the social return on investment [61] and the framework proposed by the international council for integrated reporting [62].

2.3 Related work

The following subsection provides a brief overview of research related to business models in management literature.

2.3.1 Position of business model concept in management literature

The business model concept overlaps with several management domains, such as strategy, marketing, and supply chain. It also borrows elements such as key value creation activities, value proposition, channels to create a description of how an enterprise creates, delivers, and captures value, or intends to do so [24]. The following subsections provide a brief overview of research related to business models. The goal here is not to present an exhaustive literature review, but to provide a brief account of the dominant research streams related to business models. For a comprehensive literature review on business models, see [51], [60], [63]–[65]

2.3.2 Business models in entrepreneurship, innovation, and technology management literature

Research in this area focuses on business models as a mechanism to unlock the value embedded in technologies [66]. The business model concept in this domain is perceived as the logic that defines an enterprise's value creation and value capture logic [15, pp.

1–2], [51]. Scholars here emphasise that a business model is necessary to commercialise technology successfully. Additionally, business models themselves are a unit of innovation [51]. Chesbrough et al. [15] have proposed an open innovation paradigm focusing on the business model as one of the core areas of innovation. They argue that businesses that explicitly focus on business model innovation as one of their core innovation areas have a higher success rate.

Research in this domain mainly focuses on e-business models. The focus here is on how the internet leads to new business models [50]. Researchers have also focused on identifying different e-business model typologies [46], [50]. Furthermore, much research exists on digital business models, such as freemium, software as a service, etc. [67]–[70]. Similarly, researchers in the energy sector have focused on identifying business model typologies, such as energy service companies and aggregators [71]–[74]. However, the use of business model ontologies to describe business model types and to analyse, design, and evaluate them remains limited.

2.3.3 Business models in strategy literature

In this literature stream, the debate revolves around two aspects. First, the early use of the term "business model" was criticised and dismissed by renowned strategy scholars such as Porter as "*unwise*" and "*destructive*" [75, p. 73], which may have been true fifteen years ago. Notwithstanding the criticism, the business model concept has developed further since with the help of landmark contributions from scholars such as Osterwalder et al. [13], Gordijn et al. [41], Amit et al. [16], and Chesbrough et al. Still, others criticise it as being very similar to strategy, categorising it as "strategy in new bottles" [60]. The emerging view of business models as a system of interdependent activities configured to generate efficiency or novelty [51], [76], [77] overlaps with the view in strategy, where a system of activities is configured to offer superior cost leadership and/or superior differentiation [60]. Research in the business model domain has also focused on how firms can compete in the markets using business models, which is a staple of strategy research [60].

Second, researchers argue that business model is a separate field from strategy. Literature in the business model domain challenges the assumption in strategy that if superior value is delivered to customers they will pay for it. The digitisation of industries such as media and entertainment challenges this assumption. The body of knowledge on strategy thus far has not addressed these challenges in a serious way. In contrast to strategy, how to earn revenue while exploiting a product or a service that customers want is a central question in business model research [60].

Business models adopt an integrated approach to value creation. Value creation in business model happens at the nexus of the value creation activities, key resources, transactions and the content of the transactions, business networks, and customers. In strategy, value is created mainly on the supply side, either by performing a set of value creation activities or by gaining access to difficult to imitate resources [60].

Research in business models assumes that firms and managers have limited knowledge. Consequently, designing the right business model (i.e., value creation, delivery, and capture) requires multiple iterations that change as and when information becomes available. The iterative approach to designing viable business models contrasts to a strategy approach, in which value creation, delivery, and capture processes are planned and put in place from well-understood alternatives [60].

2.3.4 Business models in information systems literature

From an information systems point of view, business models are seen as a linking pin between strategy and business processes [10], [21]. Managers have to design business processes and the supporting information technology infrastructure from generalised strategy statements [57]. Moreover, for enterprises to be successful, the business process and the information technology infrastructure have to align with strategy [78]. Yet it is extremely hard to design the right business processes and the corresponding information technology from generalised strategy statements [57]. Business models address the above problem by translating strategy into a blueprint that describes how a business works, which can then be translated into business processes and supporting information technology infrastructure [10]. Gordijn et al. [79] also argue that business models are tools for the requirements gathering process for developing information technologies. In many cases, innovative business ideas require the business model and the supporting information technologies to be developed side by side. Therefore, having a clear business model design helps in deriving the requirements necessary for developing the supporting information technologies. To help managers implement the right IT infrastructure, researchers have also identified atomic e-business models and the type of IT infrastructure needed to support them [46], [80]. Therefore, business models are seen as an alignment tool in the information systems literature.

Research on business models has also focused on developing meta-artefacts (also referred to as "business model ontologies") for business modelling purposes. A popular business model ontology is the business model canvas [13], while another example is the e3-value method [22]. Because such ontologies can be used to conceptualise business models, they have been used to conceptualise both existing business models and ones that do not yet exist.

2.3.5 What are business model ontologies?

In philosophy, ontology is the study of what exists [81]. Much of the research on this topic originates from the artificial intelligence domain. Nevertheless, ontologies are becoming popular in other domains, such as information systems and enterprise integration [18]. An ontology is defined as "*an explicit specification of a conceptualization.*" [82, p. 908]. Conceptualisation refers to objects, concepts, and other entities, and the relationships among them in an area of interest [82].

Ontologies help to address the problems of different vocabulary and conceptualization by creating commonality and shared understanding. Among their several benefits, the following are of particular interest for designing and evaluating viable business models. Ontologies help to conceptualise and communicate business models; they help to approach the business model design process in a structured manner by defining objects and the relationships among them. Business model ontologies also help to reason about the possible effects of making changes in certain building blocks of the model [18], [23].

Ontologies in the field of artificial intelligence are highly formal; predicated calculus like formalisms characterises them [81]. According to Uschold et al. [23], ontologies can take several forms, ranging from rigorously formal to highly informal.

In essence, designing and evaluating viable business models is a cross-domain exercise. As a deduction, it may require different organisations and people with diverse backgrounds, terminology, viewpoints, interests, and assumptions to collaborate to design and evaluate viable business models. Consequently, the cross-domain exercises of designing and evaluating viable business models leads to myriad problems and inefficiencies caused by varying terminologies, viewpoints, interests, etc., [18], [79].

Business model ontologies address the above problems by coming to a shared understanding of what is meant by business models. They foster shared understanding by eliminating conceptual and terminological confusion and by unifying different viewpoints, interests, assumptions, etc. Based on their level of formality, existing business model ontologies can be classified into semi-formal, semi-informal, and highly informal [23]. Semi-formal ontologies are expressed using an artificial, formally defined language, for example, unified modelling language. A semi-informal ontology is expressed in a restricted and structured form of natural language, significantly increasing clarity by reducing ambiguity. A highly informal ontology is expressed loosely using natural language [23]. Even though business model ontologies in the strict sense are useful in creating a common understanding of the business model concept, they are not specifically developed to support the process of designing and evaluating viable business models.

2.3.6 Previous work related to comparing business model ontologies

There has been some interest in the past in comparing business model ontologies for different purposes. In [25], a framework is proposed to compare two business model ontologies to find similarities and differences, with the goal of integrating them. In [83], a framework is proposed to assess business model ontologies from a taxonomical perspective. However, no attempts have been made to assess existing business model ontologies from a viability perspective.

2.4 Research design

This section describes the research design and how it is applied to distil a set of criteria that are subsequently used to assess the business model ontologies.

Figure 2.2 presents the research design visually. A literature review is performed to derive a list of criteria that an ideal tool for designing and evaluating viable business models in the context of business ecosystems should satisfy. The criteria are subsequently used to compare, assess, and select the most appropriate business model ontology for use in developing the business model design framework for viability. The criteria also function as inputs for developing the business model design framework for viability.

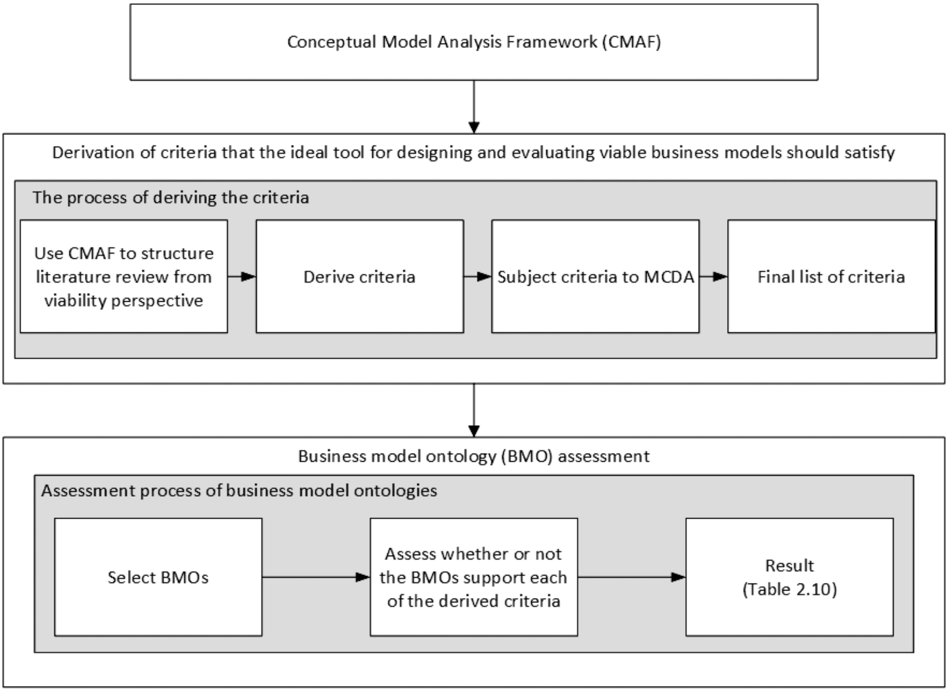


Figure 2.2 Research design for assessing business model ontologies. The figure shows how the criteria for an ideal tool for designing and evaluating viable business models are derived. Next, well-established business model ontologies are assessed against the criteria.

There is a need for a set of criteria that specifically defines the functionality of an ideal tool to design and evaluate viable business models in the context of a business ecosystem. The criteria are then used to assess business model ontologies on their capabilities to support the design and evaluation of viable business models.

Following [40], the literature from the domains mentioned above is analysed to distil a set of criteria that are relevant, understandable, complete and concise, and judgementally independent (i.e., the preference for one criterion should not be dependent on other criteria). Furthermore, the criteria are operational, which means that they are readily applicable to business model ontologies. Additionally, attention is paid to the simplicity versus complexity condition. Some of the criteria are further decomposed into a set of lower level criteria to ensure simplicity of the criteria (without sacrificing the complexity) and to ensure they are operational. Finally, in Section 2.6.3 the criteria are checked to ensure that they comply with the redundancy condition.

2.5 Derivation of criteria that the ideal tool for designing and evaluating viable business models should satisfy

This section describes the functionality of the ideal tool for designing and evaluating viable business models and the components to be modelled and analysed. The functionality and the components to be modelled are derived from literature and are directly influenced by the conceptual focus. The list of criteria includes the functionality and the components that should be modelled and analysed.

Based on the definition of the business model, the ideal tool for designing and evaluating viable business models should conceptualise, possess, and model the following concepts, functionality, and components respectively. It should be able to conceptualise the logic of value creation, exchange, and capture from different perspectives, such as focal actor perspective, business ecosystem perspective, service/product perspective, and technology perspective. The tool should also be able to model the business architecture that is the key components and their organising logic (such as the stakeholders and their roles) that enable the logic of value creation, exchange, and capture [14], [16], [24], [84]. Additionally, the tool should possess functionalities that support the process of designing and evaluating the business models. The following section presents a set of criteria that an ideal business model tool should have for designing and evaluating viable business models in a business ecosystem.

2.5.1 Service/product perspective

The process of business model design usually starts with a business idea. The initial phase involves understanding what the customers want and how the intended product or service can satisfy their needs. Next, the business idea is transformed into a product/service concept [44] that defines what is to be done for the customer and how it is to be done [6]. During this phase, it is also important to identify high-value customer needs that the service/product should satisfy and how they are to be satisfied [85]. Hence, it is crucial to design and analyse business models from the product/service perspective. Designing the service/product usually is the first action in the business model design process [24], [44].

Service/product design has a long-standing history, and the goal here is not to identify detailed criteria on how to model services/products [42], [86]. Rather, the business model design framework for viability builds on existing product/service modelling techniques that help clarify service/product ideas [42]. These techniques transform a service/product idea into descriptions that are easy to understand, communicate, and evaluate (henceforth referred to as service/product concepts). The service concept should be adequately described in a simple and easy to understand manner and in a way that facilitates the design of viable business models.

Table 2.1 Assessment criteria concerning service/product perspective

No	***Criteria***	***Sources***
1.	Service/product perspective	
1.1.	Service concept/product perspective	[42], [44]

2.5.2 Focal actor perspective and the business ecosystem perspective

The existing literature approaches the business model design from two closely related yet distinct perspectives: focal firm and business ecosystem [11], [69]. This implies that they have certain similarities and differences. They are similar because they share common building blocks of business models such as value-creation activities, stakeholders (key partners and customers), key resources, cost structure, and revenue streams. The differences arise from the perspectives they stress (focal actor and business ecosystem perspectives) and the building blocks they do not share (such as value exchange relationships, roles, customer relationships, and channels). The criteria for these two perspectives are derived together to avoid duplication. Avoiding duplicate criteria helps satisfy the non-redundancy condition of the multi-criteria decision analysis; however, these two perspectives are treated separately in the following chapters.

Also, different conceptual foci are used to study business models; that is, value creation, capture, and exchange [17], [60]. These concepts are further explored from the viewpoint of viability and of what they mean to the ideal tool for designing and evaluating viable business models. Additionally, the criteria for assessing business model ontologies are derived.

Value creation: A central concept in management literature, value creation is the increased value (exchange value and use value) that two or more parties enjoy when they engage in mutually beneficial transactions [58]. Value could also be created for other stakeholders participating in the business model, even though they do not engage directly in transactional relationships (for example, political stakeholders providing subsidies to green energy producers [26]). Business models should be able to generate enough value to keep the stakeholders committed to the business models. If the stakeholders are unable to capture enough value, they will not be committed to the business model, which consequently renders it unviable [15]. Therefore, value creation is crucial from a viability perspective. In the context of business models, value creation cannot be explained by a single theory, such as a resource-based view [16]. To truly understand value creation in the context of business models, a nexus of several theories is necessary [15]. For that reason, several theories are reviewed that utilise different units of analysis to explain value creation [16]. Further, Amit et al. [16] argue that the units these theories analyse are the sources of value creation.

Following their lead, it is posited that the ideal tool for designing and evaluating viable business models should model and analyse the different sources of value creation because, by the definition of business models, it is crucial to understand how to create value. Furthermore, business models create value for the focal actor and for the stakeholders involved in them, such as suppliers [51]. Table 2.2 highlights the theories and the sources of value creation they analyse.

Table 2.2 Sources of value creation

Theory	***Source of value creation***
Value chain framework	Value creation activities
Resource-based view	Resources
Business ecosystem	Business ecosystem
Transaction cost economics	Transactions (value exchange relationships)

Table 2.3 shows an overview of the criteria concerning value creation.

Table 2.3 Assessment criteria concerning value creation

No.	**Criteria**	**Source**
2	Focal actor / business ecosystem perspective	
2.1.	Value creation	
2.1.1.	Model value creation by each stakeholder	[15], [22]
2.1.2.	Model sources of value creation	[16]
2.1.2.1.	Value creation activities	[16]
2.1.2.2.	Resources	[16]
2.1.2.3.	Business ecosystem	[16]
2.1.2.4.	Transactions	[16]
2.1.3.	Model value creation from focal actor perspective	[9]
2.1.3.1.	Model value creation in terms of use value	[58]
2.1.3.2.	Model value creation in terms of exchange value	[58]

Table 2.3 Continued

2.1.4.	Model value creation from business ecosystem perspective	[9]
2.1.4.1.	Model value creation in terms of use value	[58]
2.1.4.2.	Model value creation in terms of exchange value	[58]

Value Capture: Value capture is the amount of value retained by each stakeholder within the business model [9]. The amount of retained value is conceptualised in terms of use value and exchange value. The value captured in terms of exchange value is the total amount of revenue a stakeholder can retain (i.e., profit) [58]. The value captured in terms of use value is the total benefits realised by a stakeholder from a product and/or a service, or by participating in a business model [9].

Successful business models ensure that the participating stakeholders can capture value, such that they are committed to the business model. If not, the business model will not be able to attract and retain competitive stakeholders. As a result, it could lead to the business model being rendered unviable. Consequently, the ideal tool for designing and evaluating viable business models should be able to model and analyse the amount of value captured by each stakeholder.

It is usually easier to measure and model the exchange value captured by a focal actor. Modelling the exchange value captured at the business ecosystem level is difficult and time-consuming, due to reasons such as stakeholders being unwilling to share information about their costs and revenues, the difficulty involved in determining the costs associated with providing services to a single customer, etc. Furthermore, determining the use value captured by the focal actor and by the stakeholders in the business ecosystem is also difficult because of the lack of information and the complexity involved in developing appropriate metrics to measure the captured use value. The capture of use value can also be assessed qualitatively. Table 2.4 shows relevant criteria.

Table 2.4 Assessment criteria concerning value capture

No.	***Criteria***	***Source***
2.2.	Value capture	
2.2.1.	*Model captured value from focal actor perspective*	[9]
2.2.1.1.	*Model captured use value*	[58]
2.2.1.2.	*Model captured exchange value*	[58]
2.2.2.	*Model captured value from business ecosystem perspective*	[9]
2.2.2.1.	*Model captured use value*	[58]
2.2.2.2.	*Model captured exchange value*	[58]

Value Exchange: Value exchanges are relationships formed among stakeholders to exchange value. From the focal actor perspective, these relationships can be analysed among the stakeholders within the focal actor's organisation, and at a dyadic level. The focal actors establish dyadic relationships with partners, such as channel partners and customers [15]. Adopting the business ecosystem perspective implies that the value exchange relationships are among the stakeholders within the business ecosystem [41]. Consequently, this perspective calls for a systemic approach, where the value exchanges are analysed not only from a focal actor perspective but also from a business ecosystem perspective. The systemic approach involves the analysis of the entire business ecosystem formed to produce, govern, and deliver the services and products to the end user [15]. Consequently, the ideal tool for designing and evaluating viable business models should be able to conceptualise and model the value exchanges from the focal actor's perspective and from the business ecosystem perspective. Table 2.5 presents an overview of the criteria concerning value exchange.

Table 2.5 Assessment criteria concerning value exchange

No.	***Criteria***	***Source***
2.3.	Value exchange	
2.3.1.	*Model value exchanged from focal actor perspective*	[15]
2.3.1.1.	*Use value from focal actor perspective*	[58]
2.3.1.2.	*Exchange value focal actor perspective*	[58]
2.3.2.	*Model value exchanged from the business ecosystem perspective*	[41]
2.3.2.1.	*Use value from the business ecosystem perspective*	[58]
2.3.2.2.	*Exchange value from the business ecosystem perspective*	[58]

2.5.3 Technology perspective

It is crucial to consider the capabilities of the underlying technologies (i.e. the ICT technologies and the physical technologies) while designing business models. For example, let us consider a business model where a prosumer produces electricity using a solar panel. The prosumers are compensated for delivering the produced electricity to the electricity grid. Two layers of technologies are necessary for this business model to work, namely the physical technology layer and the ICT layer. The physical technology layer consists of components, such as the solar panel, the cables that carry the electricity, the meters that measure how much electricity is delivered to the grid, etc. The ICT layer consists of technologies that collect data and processes it into information. The information is necessary to support the business processes and decision making such as billing and trade decisions [87].

Modelling the underlying technological infrastructure alongside business models is a good way of improving the business and technology alignment [43]. In essence, modelling the required ICT and physical technology infrastructures is a cross-domain exercise, which involves professionals from the business and technological domains. The professionals need a common language to be effective. Talking about ICT in terms of information services gives technologists and business professionals a common language. Modelling information services facilitates the discussion about business models and their need for underlying information and, therefore, ICT [80]. As a deduction, it is important to conceptualise and model the underlying information services needed to support the business model. Conceptualising these services also helps technologists to assess the feasibility of the ICT infrastructure necessary to support them, and to draft the requirements for the ICT infrastructure [80]; thus improving the alignment between business models and ICT [78]. Consequently, the ideal tool for designing and evaluating viable business models should be able to model the underlying information services of a business model.

Table 2.6 Assessment criteria concerning the technology perspective

No.	***Criteria***	***Source***
3.	Technology perspective	
3.1.	Model underlying information services	[78], [80]
3.2.	Model underlying physical technologies	[88]

2.5.4 Criteria for supporting the process of designing viable business models

For a viable business model design, the ideal tool for designing and evaluating viable business models should also support the process of designing viable business models. This section analyses the process of designing viable business models and derives a list of criteria to assess the business model ontologies.

To facilitate the design of viable business models in a business ecosystem context, the ideal tool for designing and evaluating viable business models should have the following functionality:

Ability to manipulate business model design: The process of designing viable business models is an iterative and creative process. To support the design process, the ideal tool for designing and evaluating viable business models should allow for the manipulation of the business model design to achieve viability [41]. The ability to manipulate business models supports the process of iteratively creating new business model designs.

Ability to visualise business model architecture: Business model architecture is the organising logic of how the key components that enable value creation, value capture, and value exchange relationships are organised [89]. Visualising the business model architecture helps in gaining a deeper insight into the business model. Further, it is a useful and effective technique used to brainstorm and identify alternative configurations of the business model. Hence, in the context of designing viable business models, visualising the business model architecture of the business models is an effective tool in organising the components in such a way that it enables viability [41]. In the context of this research, it is effective and efficient to visualise the business model architecture from the perspectives above; that is, the service/product, focal actor, business ecosystem, and technology. Thus, the ideal tool for designing and evaluating viable business models should be able to visualise the business model architecture.

Ability to model multiple commodities, stakeholders, and roles and responsibilities: Business models often embody multiple commodities and include multiple stakeholders [90]. Consequently, business model ontologies should also be able to model these elements. Additionally, the stakeholders can perform different roles and responsibilities within the business ecosystem. As a result, the ideal tool for designing and evaluating viable business models should support multiple commodities, multiple stakeholders, and multiple roles and responsibilities.

Elements of business model design facilitate the process of designing viable business models. They support the design process by helping business model designers make design choices. The design elements make the process of making design choices explicit and in this way make the process of designing business models transparent and traceable [24]. Business model ontologies should allow for the consistent application of the following elements of business model design to facilitate the process of designing viable business models reliably.

Design principles: Design principles are guidelines that a designer should follow. For example, the business model design should be coherent. For instance, low-budget airlines offer a no-frills service, charging extra for anything other than the trip.

Additionally, their entire business model is designed to keep costs low, such as using a single aeroplane type to keep their training and maintenance costs low [91]. And so, the ideal tool for designing and evaluating viable business models should facilitate the design process by providing a set of design principles to guide the design process.

Business rules: Business rules define conditions that govern a business model. They internalise the external requirements put on the business models, such as government regulations [89]. They also include the internal requirements put on the business model, such as the limitations of the technology architecture or resource limitations [89]. Business rules affect the value creation, value capture, value exchange, and the underlying business model architecture of a business model [89]. In the context of viability, they can hamper or facilitate the viability of a business model. For that reason, it is important that business model ontologies consider business rules.

Assumptions: Business model designers makes several assumptions during the design process. Their design choices often depend on these assumptions [24]. An assumption is a datum or a piece of information assumed to hold [92]. The viability of a business model often hinges on the assumptions made by the designer. For that reason, the assumptions should be systematically stored and updated as and when more information becomes available. The effect of the assumptions on the design choices and the business model should also be explicitly considered [24]. For this reason, the ideal tool for designing and evaluating viable business models should help to store and update assumptions systematically. The tool should also make explicit how the assumptions affect the design choices and the business model.

Configuration techniques: During the design process, business model designers may arrive at an unviable business model design. To develop viable business models, the ideal tool for designing and evaluating viable business models should provide the designer with a set of configuration techniques. The configuration techniques are a set of activities that the designer can perform to arrive at a viable business model design, such as deconstruction and reconstruction of business models [24].

Other domains such as strategy, marketing, etc., also influence design choices. Consequently, the ideal tool for designing and evaluating viable business models should be flexible enough to accommodate these influences and store the factors affecting the design choice systematically.

Table 2.7 Assessment criteria concerning the business model design process

No.	***Criteria***	***Source***
4.	Business model design process	
4.1.	Ability to manipulate business models	[41]
4.2.	Represent business model architecture	[89]
4.2.1.	*Visualise service/product concept*	[42]
4.2.2.	*Visualise business model of the focal actor perspective*	[14]
4.2.3.	*Visualise business model from the business ecosystem perspective*	[14]
4.2.4.	*Visualise the technology architecture*	[43]
4.3.	Model multiple stakeholders	[41], [90]
4.4.	Model multiple roles	[41]
4.5.	Model multiple commodities	[90]
4.6.	Store/manage design choices	[24]
4.7.	Elements of business model design	
4.7.1.	*Provide design principles*	[24]
4.7.2.	*Store/manage business rules*	[24], [89]
4.7.3.	*Store/manage assumptions*	[24]
4.7.4.	*Provide configuration techniques*	[24]
4.7.5.	*Store/manage influence of other domains on design choice*	[24]

2.5.5 Evaluation of business models for viability

The ideal tool for designing and evaluating viable business models should facilitate the evaluation of the designed business models from the perspectives above; namely, service/product, focal actor, business ecosystem, and technology [24]. A business model is viable when it is viable from all of the above perspectives. A service/product perspective is viable when the intended service/product can be provided or produced and delivered to the customers with reasonable costs and time [24]. The focal actor perspective and business ecosystems are viable when the focal actor and the other stakeholders can capture value such that they are motivated to be a part of the business model [15]. The technology perspective is viable when the stakeholders agree on a technologically acceptable solution to provide/produce and deliver the intended service/product [43]. Additionally, it is necessary to evaluate the capabilities of the stakeholders to implement the designed business model, because if they do not have the capabilities to do so, it will be rendered unviable [12]. Furthermore, visualising the aforementioned perspective facilitates the evaluation process [14].

Table 2.8 Assessment criteria concerning evaluation of viable business models

No.	*Criteria*	*Source(s)*
5.	**Evaluation of business models for viability**	[11]
5.1.	Evaluate viability of the service/product concept	[42]
5.2.	Evaluate viability from focal actor's perspective	[9], [41]
5.2.1.	*Evaluate use value capture by focal actor*	[9], [41]
5.2.2.	*Evaluate exchange value capture by focal actor*	[9], [41]
5.3.	Evaluate viability from the business ecosystem perspective	[9], [41]
5.3.1.	*Evaluate use value captured by the stakeholders*	[9], [41]
5.3.2.	*Evaluate exchange value capture by the stakeholders*	[9], [41]
5.1.	Evaluate viability of the technology architecture	[43]
5.4.1.	Evaluate information services architecture	[43]
5.4.2.	*Evaluate physical technology architecture*	[24]
5.5.	Evaluate the capabilities of the stakeholder in context of the business model	[12]
5.6.	Visualise service/product concept	[42]
5.7.	Visualise business model of the focal actor perspective	[14]
5.8.	Visualise business model from the business ecosystem perspective	[14]
5.9.	Visualise the technology architecture	[43]

The business model ontologies that conceptualise business models at a high level provide fewer details when compared to those that conceptualise business models at a lower level. It is clear from the evaluation criteria derived thus far that the design and evaluation of viable business models require large amounts of information. The ideal tool should model the business models at a relatively low level to support the design and evaluation of viable business models [84].

Table 2.9 Assessment criteria concerning level of analysis

No.	*Criteria*	*Source*
6.	**Model business model ontologies at low level of granularity**	[22]

2.6 Business model ontology assessment

The criteria presented in the previous section can be used to assess how well business model ontologies support the design and evaluation of viable business models. The criteria can be applied qualitatively to assess the characteristics of the business model ontologies. The challenge of assessing business model ontologies based on a set of criteria can also be framed as a classic multi-criteria decision analysis problem (MCDA) [40, pp. 1–2]. Therefore, the criteria are subjected to the MCDA conditions. The following section elaborates on how the conditions affect the list of criteria.

2.6.1 Restructuring the assessment criteria

As mentioned previously, for the criteria to be usable they have to meet the following conditions [36, pp. 55–58]: value relevance, understandable, measurable, non-redundant, judgementally independent, complete and concise, operational, and simple without sacrificing complexity.

Consequently, the criteria 2.1.2.3, 2.1.2.4, 5.6, 5.7, 5.8, and 5.9 are eliminated to satisfy the non-redundancy condition. The business ecosystem criteria (criteria No: 2.1.2.3) emerges under several categories where the value creation, capture, and exchange from the business ecosystem perspective are assessed. The idea of transactions (criteria No: 2.1.2.4) appears under the concept of value exchange. The visualisation of the service/ product, focal actor, business ecosystem, and technology perspectives (criteria Nos: 5.6–5.9) appears under business architecture.

2.6.2 Selected business model ontologies for assessment

Our search led to six well-established business model ontologies that focus on value. The following business model ontologies will be assessed using the criteria described above.

e3-Value: The e3-Value adopts a value constellation (business network approach), where business models span multiple organisations. e3-Value aims at conceptualising business models and evaluating them for viability [41]. Further, it aims to create a common understanding of the business models among collaborating firms (multi-stakeholder environment) by explicitly visualising the business models. It aims to improve the alignment between business and ICT. e3-Value has its roots in computer and management science [25].

Value network analysis (VNA): VNA is rooted in the principles of living systems. It views business models as a pattern of exchanges between stakeholders. It focuses on both the tangible (e.g., money and products) and intangible (e.g., knowledge) value exchanges among stakeholders [45]. VNA aims to incorporate a systemic (business network) view of business models and the intangible values into the mainstream business model analysis.

Business model canvas (BMC): The BMC views business models in terms of 9 building blocks. The BMC conceptualises business models on the level of a single organisation and not on the level of a business network. However, the BMC does identify key partners [13]. The BMC is rooted in information systems and management science. Its main goal is to help companies conceptualise how they create, deliver, and capture value [25].

Value stream mapping (VSM): VSM is based on the concept of lean manufacturing. It conceptualises the flow of value in a value stream. VSM adopts a supply chain approach to map the demand back from customers to raw materials. Their main goal is to help managers shift their attention from individual processes to a larger perspective. It is an attempt to shift the focus from individual processes to the system of interconnected processes required to deliver the product to the customer [93].

Resource event agent (REA): REA is a domain-specific (accounting) modelling ontology, which focuses on conceptualising economic resources, events, and agents, in addition to the relationships among them. The above aspects are conceptualised from the perspective of a single organisation [48]. The REA is rooted in both information and management science. It aims to design flexible accounting systems that are better integrated with other enterprise systems and decision support systems [48].

e-Business modelling schematics (EBMS): EBMS adopts a business network approach to business models, aiming at e-business initiatives. It adopts a focal organisation perspective to describe business models that span multiple organisations. It is also rooted in management and information science. EBMS was conceived with the aim of helping business executives to conceptualise and analyse new e-business initiatives [46].

2.6.3 Assessment of the business model ontologies

The criteria presented in Table 2.10 are used to assess the business model ontologies. If the business model ontology supports the criteria a ✓sign is assigned, and if it does not or does so partially an × sign is assigned. This method of evaluating the business model ontologies is adopted because partial support of the criteria will not lead to an accurate conceptualization and analysis of viability. Consequently, it may result in unreliable business model design. Table 2.10 shows how the six business model ontologies perform against the viability criteria. It is clear that not all of them conceptualise business models in the same way. It is also evident that certain essential viability criteria are ignored. None of them conceptualises the service/product concepts. Similarly, none of them conceptualises and evaluates the underlying information services and physical technologies. Hence, the business model architectures are represented to a certain extent, but not satisfactorily. Most of the business model ontologies conceptualise use and exchange value qualitatively, yet quantitative metrics are desired and useful for evaluation of viability. Nevertheless, it may not always make sense to quantify viability, especially in terms of use value. Additionally, the elements of business model design and the multi-perspective approach to business model design is missing.

Table 2.10 shows that none of the business model ontologies performs satisfactorily on all criteria. The e3-value business model ontology satisfies the highest number of criteria. The reason why some of them perform well against the criteria and some do not could be attributed to the reason that not all of them were conceived to represent business models exclusively. Furthermore, even those conceived to represent business models were not designed from the perspective of designing and evaluating viable business models, except for e3-value and the business model canvas. The assessment result shows that the viability perspective has been largely ignored in the context of business model ontologies. Additionally, in the strict sense the latter are usually developed based on objects and not on business rules, design principles, etc. Therefore, they ignore important criteria that are crucial for designing and evaluating viable business models in a reliable way.

Table 2.10 Assessment result of the business model ontologies

No.	***Criteria***	***e-3 value***	***VNA***	***BMC***	***VSM***	***REA***	***EBMS***
1.	**Service/product perspective**						
1.1.	*Service concept/product perspective*	×	×	×	×	×	×
2.	**Focal actor/ business ecosystem perspective**						
2.1.	*Value creation*						
2.1.1.	*Model sources of value creation*						
2.1.1.1.	*Value creation activities*	✓	×	✓	✓	✓	×
2.1.1.2.	*Resources*	✓	✓	✓	✓	✓	×
2.1.2	*Model value creation from focal actor perspective*	✓	×	✓	✓	✓	×
2.1.3.	*Model value creation from business ecosystem perspective*	✓	×	×	×	×	×
2.2.	Value capture						
2.2.1.	*Model captured value from focal actor perspective*						
2.2.1.1.	*Model captured value in terms of use value*	✓	✓	✓	✓	✓	✓
2.2.1.2.	*Model captured value in terms of exchange value*	✓	×	✓	×	✓	×
2.2.2.	*Model captured value from business ecosystem perspective*						
2.2.2.1.	*Model captured value in terms of use value*	✓	✓	×	✓	×	✓
2.2.2.2.	*Model captured value in terms of exchange value*	✓	×	×	×	×	×
2.3.	Value exchange						
2.3.1.	*Model value exchanged from focal actor perspective*						
2.3.1.1.	*Model use value from focal actor perspective*	✓	×	✓	✓	×	×
2.3.1.1.	*Model exchange value focal actor perspective*	✓	×	✓	×	×	×
2.3.2.	*Model value exchanged from the business ecosystem perspective*						
2.3.2.1.	*Model use value from the business ecosystem perspective*	✓	✓	×	✓	×	✓
2.3.2.2.	*Model exchange value from the business ecosystem perspective*	✓	✓	×	×	×	✓
3	**Technology perspective**						
3.1.	Model underlying information services architecture	×	×	×	×	×	×
3.2.	Model underlying physical technologies architecture	×	×	×	×	×	×
4.	**Business model design process**						
4.1.	Ability to manipulate business models	✓	✓	✓	✓	✓	✓
4.2.	Represent business model architecture						
4.2.1.	*Visualise service/product concept*	×	×	×	✓	×	×
4.2.2.	*Visualise business model from the focal actor perspective*	×	×	✓	×	×	×
4.2.3.	*Visualise business model from the business ecosystem perspective*	✓	×	×	×	×	×
4.2.4.	*Visualise the technology architecture*	×	×	×	×	×	×
4.3.	Model multiple stakeholders	✓	✓	✓	✓	×	✓
4.4.	Model multiple roles	✓	✓	×	✓	×	✓

Table 2.10 Continued

4.5.	Model multiple commodities	✓	✓	✓	✓	✗	✓
4.6.	Store/manage design choices	✗	✗	✗	✗	✗	✗
4.7.	Elements of business model design						
4.7.1.	*Provide design principles*						
4.7.2.	*Store/manage business rules*	✗	✗	✗	✗	✗	✗
4.7.3.	*Store/manage Assumptions*	✗	✗	✗	✗	✗	✗
4.7.4.	*Provide configuration techniques*	✗	✗	✗	✗	✗	✗
4.7.5.	*Store/manage influence of other domains on design choice*	✗	✗	✗	✗	✗	✗
5.	**Evaluation of business models for viability**						
5.1.	Evaluate viability of the service/product concept	✗	✗	✗	✗	✗	✗
5.2.	Evaluate viability from focal actor's perspective						
5.2.1.	*Evaluate use value captured by focal actor*	✓	✗	✗	✗	✗	✗
5.2.2.	*Evaluate exchange value captured by focal actor*	✓	✗	✗	✗	✗	✗
5.3.	Evaluate viability from the business ecosystem perspective						
5.3.1.	*Evaluate use value captured by the stakeholders*	✓	✓	✗	✓	✗	✗
5.3.2.	*Evaluate exchange value captured by the stakeholders*	✓	✗	✗	✗	✗	✗
5.4.	Evaluate viability of the technology architecture						
5.4.1.	*Evaluate viability of information services architecture*	✗	✗	✗	✗	✗	✗
5.4.2.	*Evaluate viability of physical technology architecture*	✗	✗	✗	✗	✗	✗
5.5.	Evaluate the capabilities of stakeholders in context of business model	✗	✗	✗	✗	✗	✗
6.	**Model business model ontologies at low level of granularity**	✓	✗	✓	✓	✓	✗

2.7 Conclusion

This chapter set out to answer research sub-question SQ1: "*What are the requirements put on a framework to design and evaluate viable business models in a business ecosystem*?" Our research provided an explicit answer to this question in the form of a list of assessment criteria (see Table 2.10). These criteria lay out the requirements for an ideal tool for designing and evaluating viable business models in the context of a business ecosystem.

According to Phase 2 presented in Section , the derived criteria are used to assess six well-established business model ontologies to demonstrate the gap. The analysis shows that none of them satisfies all of the criteria. Furthermore, each of them conceptualises business models differently. The e-3 value modelling ontology satisfies the highest number of criteria. From Table 2.10 it is evident that the current business model ontologies have some deficits. It is hard to design and evaluate viable business models with the current state of the business model ontologies, especially in the context of business ecosystems. The derived criteria rely on the conceptualisation of the term "viability," which is influenced by the assumption that business models rely on technology (ICT and physical technology) for execution. Furthermore, the results of the assessment are subject to the author's judgement of whether or not the business model ontologies satisfy the assessment criteria.

The assessment in Table 2.10 shows that the business model canvas is particularly adept at conceptualising business models from the focal actor perspective. The assessment also reveals that the e3-value is very useful for conceptualising business models from a business ecosystem perspective. This conclusion is also supported by other business model scholars [25]. It follows that the business model ontologies mentioned above could be very useful in operationalising the focal actor perspective and the business ecosystem perspective in the business model design framework for viability. It is also evident that none of the business model ontologies conceptualises the service and technology perspectives. Nevertheless, several domain-specific modelling techniques can be used to operationalise the service/product and technology perspectives, such as service blueprint and block diagrams. Consequently, the business model design framework for viability will lean on domain-specific modelling techniques to operationalise these perspectives.

Attempting to enhance business model ontologies to bridge the identified gaps increases the risk of making them overly complex, and thus hard to understand and use. Furthermore, business model ontologies are usually built on objects, and well-defined ontologies are highly formal. While well-defined business model ontologies are useful in the conceptualising, analysis, storing, re-use, and sharing of business models, they largely ignore the process of designing and evaluating viable business models, which remains iterative and creative. Supporting this such a process involves providing the designer with design elements, such as design principles and configuration techniques, that must be updated and reviewed regularly. Additionally, the difficulty in conceptualising relationships among objects and design elements such as design principles makes it hard to develop a business model ontology that can fully support the design and evaluation of viable business models. Keeping the goal in mind, an alternative would be to develop an umbrella framework that can build on top of well-established business model ontologies and add the design elements that are hard to incorporate into business model ontologies. Choosing to develop a framework for designing and evaluating a viable business model helps to avoid the rigid requirements of developing an ontology, while providing the flexibility to integrate already well-established business modelling ontologies and other modelling techniques into the framework.

Hence, this research will focus on developing a business model design framework for viability that bridges the gaps identified in Table 2.10. The umbrella framework will build on well-established modelling techniques such as business model canvas and e3-value to conceptualise the business model from the service/product, focal actor, business ecosystem, and technology perspectives. In addition to adopting a broader approach to value, the framework should also encompass the elements of business model design to support the design and evaluation of viable business models. Furthermore, the framework should also facilitate the evaluation of viable business models. The above assessment criteria will function as input for the development of the business model design framework for viability that is presented in the following chapter, along with its theoretical underpinnings.

Chapter 3

A business model design framework for viability

3.1. Introduction

The energy landscape is dynamic and in flux due to factors such as changing customer needs, climate, and policy. Consequently, energy enterprises need to innovate their business models. To do so, business model designers need tools that will help them to design and evaluate viable business models reliably. Business model ontologies such as business model canvas are the tools of choice that a business model designer relies on for designing and evaluating business models. However, a review of six well-established business model ontologies in the previous chapter has shown that none of them completely supports the design of viable business models. Well-established business model ontologies failed on several criteria, for example, on the ability to assist the business model designer by providing a set of configuration techniques.

The above context highlights the need for a business model design framework that fully supports the design of viable business models per the criteria identified in Chapter 2. This need for a framework that fully supports the viability criteria leads us to the following sub-research questions: "*How to design and communicate a viable business model?*" (SQ2) and "*How to evaluate the designed business model for viability?*" (SQ3). In answering these two research questions, this chapter will result in a business model design framework for viability that will facilitate the process of designing and evaluating viable business models. Figure 1.3 gives an overview of how Chapter 3 fits into the overall structure of this thesis. Largely based on publications [1], [2], [3], and [5] cited in Section of Chapter 1, this chapter is structured as follows. Section 3.2 presents an overview of the research design used to develop and evaluate the business model design framework for viability. Section 3.3 presents the framework itself, prefaced by its theoretical underpinnings. Section 3.4 evaluates the business model design framework theoretically against criteria derived in Chapter 2. Finally, Section 3.5 presents the conclusion.

3.2 Research design

According to the research phases presented in Section , phase 1 and phase 2 have already been addressed in Chapters 1 and 2, respectively. This chapter will address phase 3, which involves developing the business model design framework for viability. The conclusions of the previous chapter are used as input to develop the framework for viability. Additionally, the framework will be based on existing literature. The assessment criteria from Chapter 2 will be used to assess the new framework. The assessment is performed to verify if the newly developed framework satisfies all of the viability criteria. The development cycle ends when the newly developed business model design framework satisfies the criteria or when it cannot be further updated. Figure 3.1 provides an overview of the research.

3.3 The business model design framework for viability and the subsequent steps in applying the framework

This section presents the business model design framework for viability and its theoretical underpinnings. Figure 3.2 provides an overview of the business model design framework and the process of applying it to design a business model.

The business model design framework for viability is an umbrella framework that builds on top of well-established business model ontologies and modelling techniques to design and evaluate viable business models from the service/product perspective, focal actor perspective, business ecosystem perspective, and the technology perspective. Additionally, it adds the much-needed design elements namely design principles, business rules, assumptions, and configuration techniques that help the business model designer to make design choices in a systematic and transparent manner. The design elements and the corresponding design choices can also be systematically stored and managed.

The business model design framework for viability also adopts a broader approach to value that includes the exchange value (e.g., euros) and use value (e.g., benefits generated by the product such as ease of use or environmental/social benefits). The framework also includes a broader set of stakeholders who are directly affected by the business model.

The following section describes the subsequent steps recommended for applying the business model design framework for viability. These sequential steps are recommended but not necessary. However, they follow the most logical path, starting with a business idea and ending with either a viable business model design or the business model designer deciding to stop the design activity.

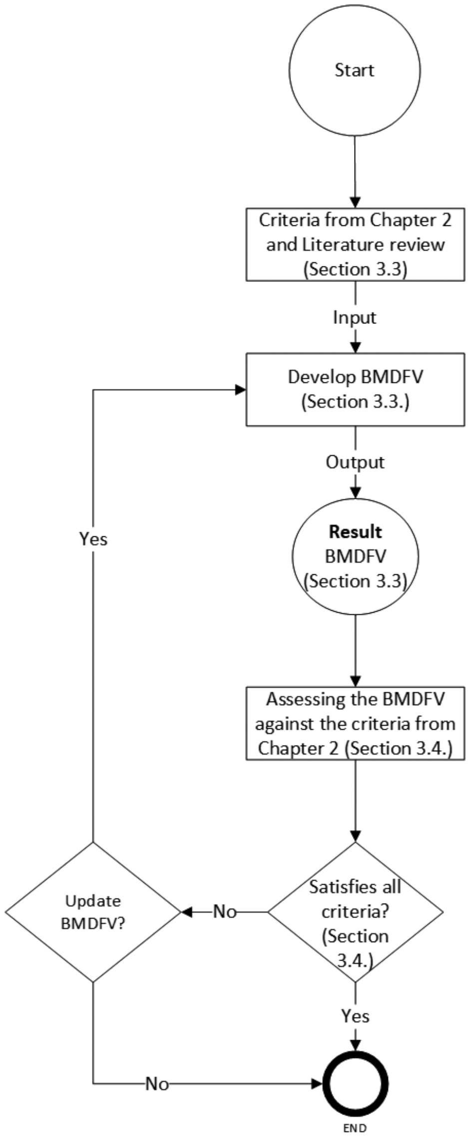


Figure 3.1 Research design of Chapter 3. The figure depicts the process of developing the business model design framework for viability. The process starts with using the criteria derived in Chapter 2 and the literature review presented in Section 3.3 as inputs to develop the framework. Next, the framework is assessed against the criteria from Chapter 2.

3.3.1 Step 1 - The business idea

As shown in Figure 3.2, the design process starts with a brief description of the business idea. Once the designer understands the business idea, one then decides which BM design perspectives to adopt to design the business model further.

3.3.2 Step 2 - The business model design perspectives

Designing a viable business model is a complex task. It requires the designer to adopt different perspectives and to align them to arrive at a viable business model design [24], [26]. The need to design and analyse business models from different perspectives probably explains why there are so many different business model ontologies that conceptualise business models from different perspectives and at different levels of granularity. From the literature review performed in Chapter 2 and from the author's experience of designing business models, four dominant perspectives emerge from which the business model design activity should be approached. As a result, the business model design framework for viability facilitates the process of designing and evaluating viable business models from the following four perspectives.

The service/product perspective: Even though the business model literature stresses the need for a tight alignment between the value proposition and customer segments [13], it treats service/product design superficially. This approach is strange, given the fact that services and products embody the value propositions that enterprises intend to offer their customers [44], [94, p. 309]. In the process of designing a viable business model, defining a clear service/product concept is often the first action [44]. In many cases, the service design activities and the business model design activities have to be carried out simultaneously so that the service/product concept aligns with the business model [44], [95]. Given the rich history of customer-dominant logic in service design history, it is also logical to integrate the service/product perspective into the process of business model design so that customer-centric business models will be created [94]. This type of model is in a better position to cater to customers' needs; consequently, they have a higher chance of achieving viability. Based on the above literature, the service/product perspective is an essential part of designing and evaluating viable business models.

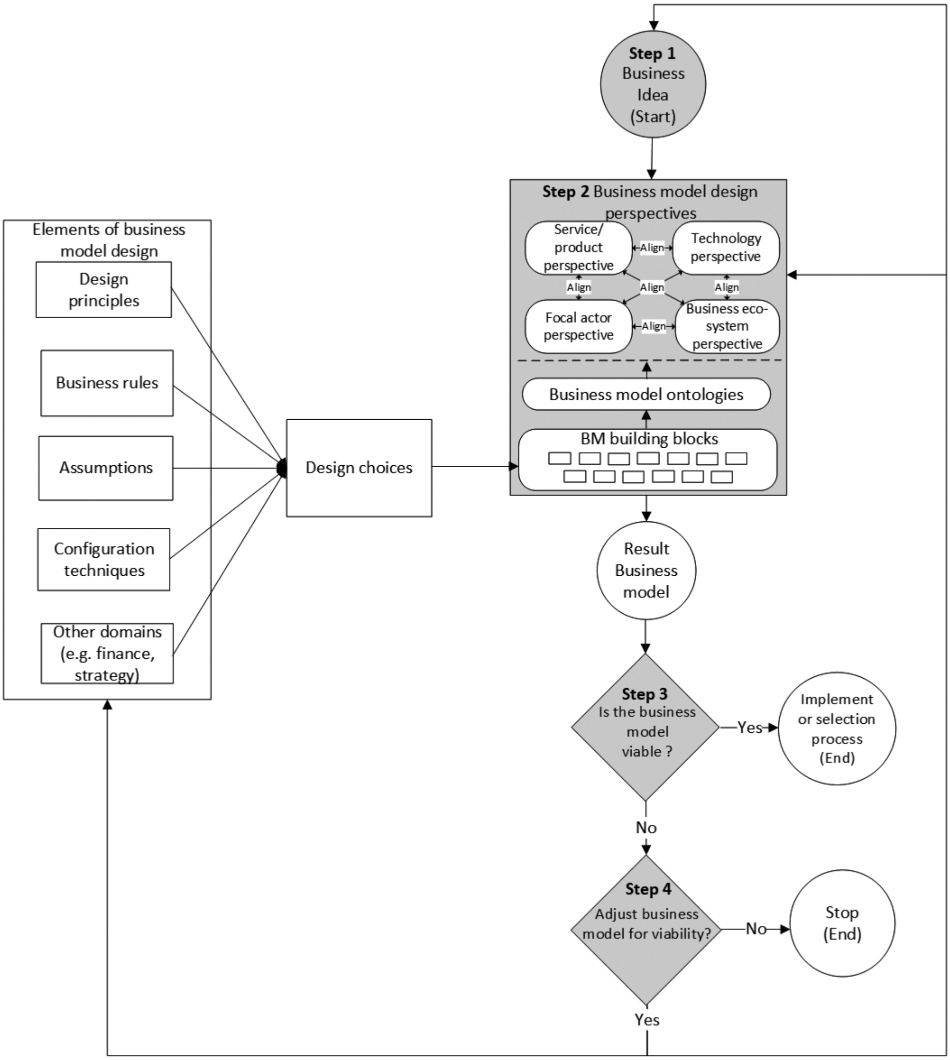


Figure 3.2 Visual representation of the business model design framework for viability. The figure depicts the sequential steps in applying the framework. On the left, the Elements of business model design that influence the design choices are depicted. The design choices are made at the level of the business model building blocks.

The service/product perspective describes what is to be done for the customer and how it is to be done [6]. This perspective provides crisp conceptualisation of the service/product concept; it involves defining the customer segment, the value proposition for the customer segment, how the customers would like to interact with service, the frequency of interaction, etc. [42]. The service concept is one of the building blocks of the business model design framework for viability. However, the framework does not define a service concept modelling technique but rather depends on other well-established service/product modelling techniques for fleshing out a clear and crisp service/product concept. In the context of applying a business model design framework for viability, it is necessary that a clear and crisp conceptualisation of the service/product concept be designed. Several techniques can be employed for this purpose, such as prototyping, service blueprinting, customer journey, etc. (see [42] for a detailed description of these methods and techniques).

The focal actor perspective and the business ecosystem perspective: The focal actor perspective defines how the focal actor creates, delivers, and captures value [13]. It is mainly concerned with how to produce and deliver the envisioned service/product to the customer profitably. This involves having a clear idea of the customer segment and which value proposition to offer it, which channels to employ, and which relationships to establish and maintain with the customers. It also involves defining which key value creation activities to perform, which key resources to acquire, and the key partners.

The business model design framework for viability defines a set of business model building blocks that can be used to conceptualise business models from the focal actor perspective. However, the framework relies on the business model canvas to operationalise the focal actor perspective. The business model canvas is a well-established ontology used to conceptualise business models from the focal actor perspective. Special care is taken to define the business model building blocks so that they align with the business model canvas.

In most cases, the focal actor designs new and innovative products/services that customers desire. They intricately design almost all aspects of the services/products [15]. To produce/provide these innovative service/products and deliver them to their customers, they often have to collaborate with several partners, such as suppliers, channel partners, etc. [15]. The presence of multiple stakeholders is particularly true for the energy industry because it is systemic in nature; that is, a host of interdependent stakeholders are involved in producing, distributing, and trading energy before the customers consume it. Additionally, other stakeholders, such as the government, regulatory bodies, etc., also have a direct interest in the energy system. Therefore, the innovative enterprises have to create value for the customer as well as for the other stakeholders involved in the business ecosystem.

The business models of such enterprises cannot be defined purely from the focal actor perspective because the focal actor depends on other stakeholders to create, deliver, and capture value [7], [15]. Therefore, the focal actor is actively involved in crafting an ecosystem that will facilitate the value creation, value delivery, and value capture process. Consequently, the business models necessary to exploit the envisioned product/service is anchored in the innovative enterprise (focal actor), but they span firm and industry boundaries [15], [16]. As a result, the business models also have to be designed from the business ecosystem perspective.

The business ecosystem perspective: The business ecosystem perspective mainly focuses on ensuring the viability of the stakeholders, because if the stakeholders are not viable, the business model will be rendered unviable [15]. Ensuring viability involves distributing the roles and responsibilities and the corresponding value creation activities to stakeholders and configuring the transactions in a way that enables them to capture sufficient value, such that they are motivated to be a part of the business model [14], [15], [79]. Additionally, this perspective also models and assesses the impact on a broader set of stakeholders than the ones who are directly involved in transactional relationships. Assessing the impact of the business model on a broader set of stakeholders involves assessing the intended and unintended effects of the business model on the stakeholders. (For example, setting up a biogas plant close to a residential area may cause problems for the residents because of the bad odour of biogas.) It also involves critically assessing the value for each stakeholder and striking a balance between value added and value captured. The business ecosystem perspective has to be modelled at a higher level of granularity to keep it meaningful. Modelling the entire business ecosystem at the granularity of the focal firm will greatly increase the complexity of the modelling process, and it will greatly increase the amount of information that has to be interpreted without adding much to the analysis [22].

The business model design framework for viability defines a set of business model building blocks that can be used to conceptualise the business models from the business ecosystem perspective. However, the framework relies on the e3-value modelling ontology to conceptualise the business model from the business ecosystem perspective. Special care is taken to define the business model building blocks so that they align with the business model ontologies described above.

The technology perspective: Technology is an indispensable part of most businesses. Often new technological innovations lead to new services/products and new business models [15], [16]. Consequently, while designing new business models, the capabilities of the underlying technology architecture should be considered. If the underlying technologies are unable to support the business model, unviable business models will result. Also, the manner in which new technologies or a different set of them can enable innovative business models should be considered [10], [15], [78]. For this reason, the technology perspective is an indispensable part of designing and evaluating viable business models.

For the purpose of designing and evaluating business models in the energy industry, the technology perspective can be further categorised into physical technologies and information services [24]. The physical technologies include solar panels, fuel cells, etc. The information services include energy management systems, energy price information services, etc.

The technology perspective in the context of the energy industry represents the technology architecture in two layers: namely, the physical technologies architecture and the information services architecture. The business model design framework for viability relies on domain-specific modelling techniques to represent technology architectures, such as block diagrams and other enterprise architecture modelling techniques

Alignment among the perspectives

For a viable business model, it is essential that the above perspectives align. Alignment is a process through which design choices made in all four perspectives complement each other, ideally creating self-reinforcing cycles [91]. The following fictive example illustrates how alignment works among the four perspectives.

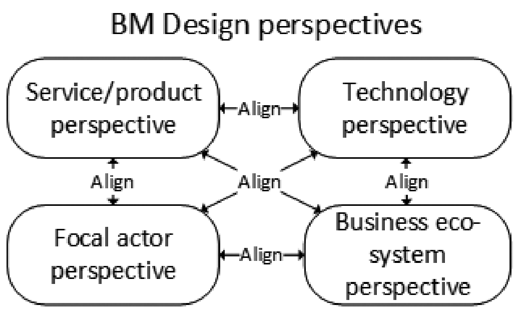


Figure 3.3 Alignment among the business model design perspectives. The figure shows the four perspectives and the alignment needed among them.

Alignment between the service/product perspective and the focal actor perspective: If the envisioned service is designed to provide energy self-sufficiency to a customer segment, the business model from the focal actor perspective has to align with the service concept. For example, the key value creation activities performed by the focal actor should help to deliver energy self-sufficiency to the customers. The service/product perspective should also align with the focal actor's perspective. For instance, just because customers want energy self-sufficiency does not mean they are willing to pay for it. Hence, the service/product designed may have to be modified so that it aligns with the focal actor perspective.

Alignment between the service/product perspective and the business ecosystem perspective: Considering the above example of energy self-sufficiency, the focal actor has to craft the business ecosystem in such a way that it aligns with the service/product perspective. Conversely, the service/product concept may have to be modified based on the requirements of one or more stakeholders in the business ecosystem, for instance, technology suppliers, regulators, etc.

Alignment between the service/product perspective and the technology perspective: The technology perspective should align with the service/product perspective and vice versa. The underlying technologies should be able to facilitate the provision of the envisioned value proposition, which is energy self-sufficiency. However, the service/product perspective may have to be modified or changed based on technological limitations.

Alignment between the focal actor perspective and the technology perspective: The focal actor perspective and the technology perspective should align. The alignment process involves making sure that the underlying technology architecture supports the business model. For instance, the technologies should enable the creation and delivery of the envisioned value proposition within a reasonable cost such that it enables the focal actor to be viable. Any changes in the technology perspective may require changes in the focal actor perspective, such as leaving out certain key partners and including new key partners who have the knowledge and capabilities to work with the new technological solution.

Alignment between the focal actor perspective and the business ecosystem perspective: The alignment process between the focal actor perspective and the business ecosystem perspective involves ensuring that the focal actor and the other stakeholders align. The focal actor plays a central role in crafting the business ecosystem around the service/product. Crafting the business ecosystem involves ensuring that every stakeholder is creating sufficient value in the business ecosystem and is capturing a proportionate amount of value in return in the process of providing/producing the envisioned service/product. Additionally, the focal actor may have to define new roles and responsibilities and recruit new stakeholders to take on new roles and responsibilities. The alignment could involve the process of eliminating certain stakeholders and redistributing their roles and responsibilities to other stakeholders in the business ecosystem.

Alignment between the business ecosystem perspective and the technology perspective: The alignment process between the business ecosystem perspective and the technology perspective involves all of the stakeholders agreeing on the technological solution and having the right capabilities to implement and operate the technological solution.

Overall alignment: The result of the alignment process should be for all of the perspectives to align with each other. Any change made in any one perspective should align with the other three.

The business model building blocks

The business model design framework for viability defines a set of thirteen business model building blocks that help to synthesise the above perspectives. Understanding the underlying business model building blocks and how they relate to each other provides insights into how they affect each other. Furthermore, it also helps to understand how design choices made in one building block affect the others. Figure 3.4 presents an overview of how the business model building blocks relate to each other (therefore facilitating the process of aligning the four business model design perspectives).

As mentioned previously, the business model design framework for viability relies on well-established modelling techniques to operationalise the building blocks into clear, crisp models that can be evaluated. The business model building blocks and the modelling techniques / business model ontologies used to design and evaluate business models should also align.

Business modelling ontologies are made up of building blocks (objects). Scholars still do not agree on a common set of business model building blocks. Considering the fact that there is no commonly accepted definition of a business model, it is not surprising that scholars disagree on a common set of business model building blocks [14], [60]. However, some common ground can be found among them, as shown in the business model building blocks presented in Table 3.1 [24].

Table 3.1 Building blocks of a BM, modified from [24]

Building blocks	***Description***	***Source***
Stakeholders	Stakeholders are entities who participate in the BM, for example, customer segment and key partners (suppliers, regulators, etc.)	[13], [41]
Roles	A role is a part that a stakeholder plays in the BM, with certain characteristics and behavioural patterns. These roles are not rigid structures, but they can be defined and redefined based on the value that has to be created, exchanged, and delivered.	[96]
Value proposition	The value proposition is a set of benefits offered to the stakeholders in the BM. A multifaceted approach to the value proposition was adopted. Adopting this approach mandates a clear value proposition for all of the stakeholders participating in the BM.	[13]
Technology architecture	The technology architecture describes how the different technological elements fit together to support the BM. It is divided into two layers: the information services and physical technologies.	[14], [44]
Service concept	A service concept describes what is to be done for the end consumer and how it is to be done.	[44]
Value creation activity	A value creation activity is performed in a system of such activities by an actor who creates value for themselves as well as for other stakeholders involved in the BM.	[13], [41]
Value exchange	Value exchange takes place between two actors participating in the BM. Objects of value are exchanged via these relationships (e.g., money and services).	[41]
Resources	Resources are all of the products and services subsumed in the value creation activities. From an ecosystem perspective, it becomes time-consuming to account for the resources subsumed by all of the stakeholders in the business ecosystem. Consequently, the focus is on resources directly subsumed by the value creation activities.	[13], [41]
Channels	Channels are the medium employed to communicate and deliver the value proposition to customers as well as the other stakeholders involved in the business model.	[13]
Revenue streams	Revenue streams describe how the business model intends to or earns cash. It also describes the revenue streams of the participating actors in the context of the business model in question.	[13], [41]

Table 3.1 Continued

Cost structure	Describes the cost structure of the business model, and how costs are distributed among various stakeholders.	[13], [41]
Relationship type	Relationship type describes the nature of the relationship among the stakeholders involved in the BM. Different types of relationships can be established and maintained, for example, personal assistance, dedicated personal assistance, automated services, communities, co-creation, and self-service.	[13]
Value captured	Value captured is the total value retained by each player or stakeholder in the BM.	[41]

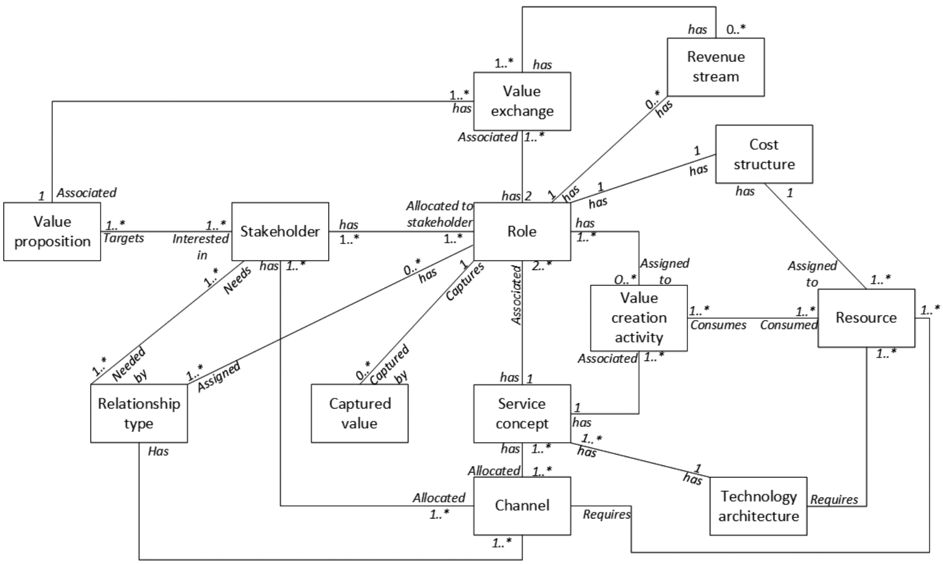


Figure 3.4 Relationships among the business model building blocks [24] The figure depicts how the business model building blocks relate to each other.

Figure 3.5 shows how the business model building blocks should align with the business modelling ontologies and other modelling techniques (i.e., techniques for service and technology modelling).

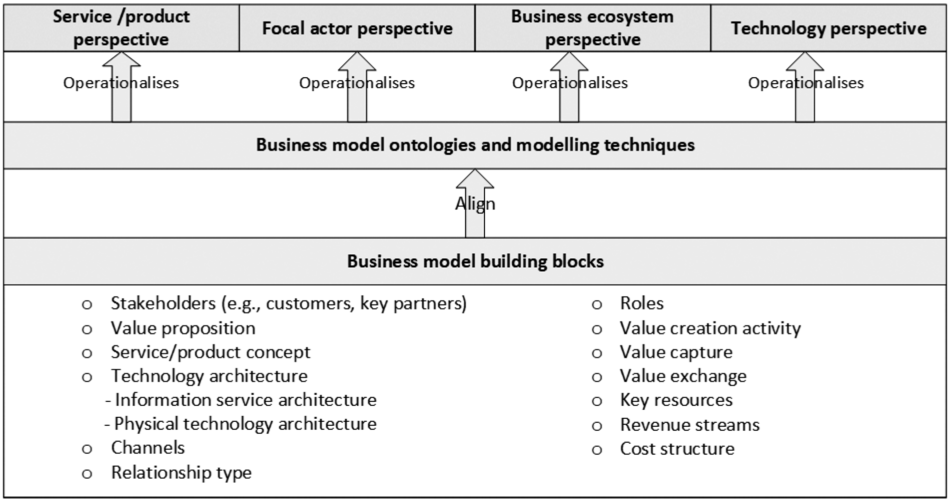


Figure 3.5 Relationship among perspectives, business model ontologies and modelling techniques, and business model building blocks. The figure depicts how business model building blocks align with business model ontologies and modelling techniques. The business model ontologies and the modelling techniques, in turn, are used to operationalise the four design perspectives.

Design choices

Scholars argue that it is not the rote application of business model ontologies that leads to a viable business model; rather, it is the choices a designer makes that lead to a viable business model [44]. Several frameworks help business model designers to make design choices and to evaluate the viability of the business models using a set of success factors [44], [97], [98]. But it is not clear how these design choices lead to a viable business model. To design viable business models in a reliable way, it is important to understand how design choices affect the business model in a transparent and traceable manner [43]. Hence, the business model design framework for viability should systematically store design choices, the motivation behind them, and how they affect the business model.

Elements of Business model design

This section describes the elements that facilitate the process of designing viable business models. Several of these design elements have been used inconsistently in some business model ontologies. Nevertheless, for a viable business model design it is necessary that the design elements be consolidated and applied in a consistent manner [24]. The business model design framework for viability consolidates these design elements and applies them in a consistent manner to design viable business models.

The elements of business model design affect the business models via *design choices.* These design choices and their interactions influence the business model at the building block level.

Business model design principles: Several scholars have proposed business model design principles [44], [49]. Such design principles are essential for a viable business model, as they guide the designer in making choices that will lead to a viable business model design. Because they are fragmented in the literature, these rules need to be consolidated to produce a reliable method of designing viable business models. Following is a list of design principles for designing a viable business model:

- Business models should enable each stakeholder to capture enough value such that they are viable [15].
- A business model design should be coherent (Al-Debei & Avison, 2010; Casadesus-Masanell & Ricart, 2011). For example, if the value proposition to the target segment is low cost, then the other building blocks such as cost structure, customer relationships, and resources should also reflect low costs.
- A business model should have a clear value proposition in terms of cost efficiency and/or superior value (Amit & Zott, 2001).
- A business model design's iterations should incorporate relevant feedback from the business model evaluation.

Business rules: Demil and Lecocq in [20] have demonstrated that the external environment imposes requirements on the business model (such as laws and regulations) that could lead to it being a viable or an unviable business. Similarly, internal requirements could also be put on the business model, such as technological limitations or safety strictures [89]. An effective way of handling these requirements is by making them explicit and internalising them in the form of business rules. A business rule is a statement that defines conditions and policies that govern a business model [21]. Therefore, the business model design framework for viability includes business rules.

Business rules directly affect the viability of the business model by either constraining or facilitating it. For example, a government policy that subsidises solar energy may facilitate new business models that exploit it, but the policy being retracted could lead to unviable business models.

Configuration techniques: Some researchers propose business model configuration techniques a designer can use to arrive at a viable business model. Enabling the designer to explore alternate configurations, these techniques are important for designing viable business models because designers often arrive at unviable ones. So far, surprisingly little attention has been paid to them. The literature review revealed two techniques, deconstruction and reconstruction, as well as the combination of atomic business models [46], [96]. As a deduction, the proposed business model design framework for viability should incorporate these configuration techniques.

Configuration techniques are actions a designer can take to make a business model viable. Following are the configuration techniques recommended:

- Deconstruction and reconstruction of business models: The value chain should be deconstructed into constituent value creation activities. The value chain should then be reconstructed in novel combinations so that it enables viability. This activity usually involves leveraging latest technologies for creating novel combinations [96].
- The combination of atomic business models: Weill and Vitale in [46] have proposed eight atomic business models, such as shared infrastructure and content provider. They argue that a designer should explore combinations of these atomic business models to arrive at a viable configuration of a business model.
- Eliminate waste: Inspired by lean manufacturing, it is suggested that the designer should eliminate waste in the business model. Elimination of waste in the context of business model design refers to eliminating stakeholders who do not add sufficient value and redistributing their roles to other stakeholders in the business ecosystem. This may also require defining new roles or redefining existing ones in a way that creates additional value and/or minimises value slippage to enable viability. While distributing roles, close attention should be paid to the stakeholder's capability to perform the assigned roles.
- Reference model: The reference model technique involves modelling relevant, innovative business models and borrowing the innovative parts from them. Rather than being blindly implemented, the borrowed parts should be critically assessed and if necessary customised to the case at hand. Additionally, it is difficult to design business models from scratch for complex business ecosystems (e.g., energy businesses), so it may be a good starting point to create reference models of successful business models that are similar to learn from them. The lessons learnt can be used as input into the design process.

Assumptions: The term "business model" is interpreted as a simplified model of the complex reality of how business is (or will be) carried out [99], [100]. Inherent to models are assumptions [101] on which the viability of a business model hinges. The literature thus far has ignored assumptions in the context of business model design. As a consequence, it is essential for the business model design framework for viability to explicitly consider assumptions.

Assumptions are data or information believed to hold [92]. While designing a business model, a designer makes assumptions that directly affect the viability of the business models. Hence, this design element makes such assumptions explicit.

Other domains: Several other domains could affect the business model design, such as key trends (e.g., technology and socio-economic trends), strategy (e.g., competitors and bargaining power), and macroeconomic forces. They affect the business models via a designer's decisions and vice versa.

3.3.3 Step 3 - Is the business model viable? Evaluation criteria

The application of the business model design framework for viability leads to a business model design, which is then evaluated for viability. The viability of the business model is evaluated from the aforementioned four perspectives. Evaluating the service/ product perspective involves assessing if the service creates value for the customer. In subsequent iterations, the capabilities of the stakeholder to provide or produce the envisioned service/product was also assessed. Evaluating the focal actor perspective includes assessing if the focal actor can capture sufficient value to be viable. Evaluating the business ecosystem perspective involves assessing if all of the stakeholders can capture sufficient value such that they are motivated to be a part of the business model. Evaluating the technology perspective includes assessing if the technology architecture is an acceptable solution that enables the provision of the service. The viability of the business model from the perspectives mentioned above also depends on the consistent application of the elements of business model design and should be assessed while evaluating the BM for viability. For example, in the business ecosystem perspective, the assignment of roles and responsibilities should comply with business rules. For example, as per requirements laid down by the Dutch law, the role of the energy retailer cannot be assigned to a transmission system operator.

If the business model is viable, it leads to an implementation or a selection process. If not, the designer proceeds to the next step.

3.3.4 Step 4 - Adjust the business model for viability?

If the business model is not viable, the designer should critically assess whether or not to proceed to the next iteration. If the business model designer decides to proceed with the next iteration, the designer can either modify the original idea or change design choices. Designing a viable business model usually requires multiple iterations.

3.4 Assessing the business model design framework for viability against the viability criteria

This section theoretically assesses if the business model design framework for viability satisfies the viability criteria identified in Chapter 2.

The business model design framework for viability adds the service/product perspective to the business model design process. The addition of the service perspective has several implications for the business model design process. First, the service/product perspective builds a synergetic relationship between the service/product process and the corresponding business models necessary to exploit the envisioned service/product. The processes mentioned above go hand in hand, thus helping to design better services/ products and corresponding business models that align with each other [15], [44], [94]. The business model design framework for viability also recommends visualising the service/product concept by using well-established techniques for designing service/ product concepts. Therefore, using such techniques help the business model design process by enabling the service/product concept to be envisioned. The latter helps the creative, communication, and evaluation process [42] of the service/product perspective. So, including the service/product perspective satisfies assessment criteria 1.1., 4.2.1, and 5.1. Additionally, these criteria also help to satisfy higher order criteria.

For the sake of this research, the focal actor and business ecosystem perspectives are operationalised using the business model canvas and the e-3value business model ontologies. These business model ontologies are used because they complement each other. The business model canvas is useful in modelling and assessing the focal actor perspective, and the e3-value is best suited for modelling and evaluating the business ecosystem perspective [25]. Moreover, the developers of these business model ontologies also recommend combining their strengths [25]. A good way of doing so is by using the focal actor and business ecosystem perspectives. Combining the strengths of the two ontologies satisfies the following criteria: 2, 4 (except for 4.1,4.2, 4.2.4., and 4.4.-4.7.), and 5 (except for 5.4, and 5.5)

Table 3.2 Assessment result of the business model design framework for viability (BMDFV)

No.	***Criteria***	***e-3 value***	***VNA***	***BMC***	***VSM***	***REA***	***EBMS***
1.	**Service/product perspective**						
1.1.	*Service concept/product perspective*	×	×	×	×	×	×
2.	**Focal actor/ business ecosystem perspective**						
2.1.	*Value creation*						
2.1.1.	*Model sources of value creation*						
2.1.1.1.	*Value creation activities*	✓	×	✓	✓	✓	×
2.1.1.2.	*Resources*	✓	✓	✓	✓	✓	×
2.1.2	*Model value creation from focal actor perspective*	✓	×	✓	✓	✓	×
2.1.3.	*Model value creation from business ecosystem perspective*	✓	×	×	×	×	×
2.2.	Value capture						
2.2.1.	*Model captured value from focal actor perspective*						
2.2.1.1.	*Model captured value in terms of use value*	✓	✓	✓	✓	✓	✓
2.2.1.2.	*Model captured value in terms of exchange value*	✓	×	✓	×	✓	×
2.2.2.	*Model captured value from business ecosystem perspective*						
2.2.2.1.	*Model captured value in terms of use value*	✓	✓	×	✓	×	✓
2.2.2.2.	*Model captured value in terms of exchange value*	✓	×	×	×	×	×
2.3.	Value exchange						
2.3.1.	*Model value exchanged from focal actor perspective*						
2.3.1.1.	*Model use value from focal actor perspective*	✓	×	✓	✓	×	×
2.3.1.1.	*Model exchange value focal actor perspective*	✓	×	✓	×	×	×
2.3.2.	*Model value exchanged from the business ecosystem perspective*						
2.3.2.1.	*Model use value from the business ecosystem perspective*	✓	✓	×	✓	×	✓
2.3.2.2.	*Model exchange value from the business ecosystem perspective*	✓	✓	×	×	×	✓
3	**Technology perspective**						
3.1.	Model underlying information services architecture	×	×	×	×	×	×
3.2.	Model underlying physical technologies architecture	×	×	×	×	×	×
4.	**Business model design process**						
4.1.	Ability to manipulate business models	✓	✓	✓	✓	✓	✓
4.2.	Represent business model architecture						
4.2.1.	*Visualise service/product concept*	×	×	×	✓	×	×
4.2.2.	*Visualise business model from the focal actor perspective*	×	×	✓	×	×	×
4.2.3.	*Visualise business model from the business ecosystem perspective*	✓	×	×	×	×	×
4.2.4.	*Visualise the technology architecture*	×	×	×	×	×	×
4.3.	Model multiple stakeholders	✓	✓	✓	✓	×	✓

Table 3.2 Continued

4.4.	Model multiple roles	✓	✓	✗	✓	✗	✓
4.5.	Model multiple commodities	✓	✓	✓	✓	✗	✓
4.6.	Store/manage design choices	✗	✗	✗	✗	✗	✗
4.7.	Elements of business model design						
4.7.1.	*Provide design principles*						
4.7.2.	*Store/manage business rules*	✗	✗	✗	✗	✗	✗
4.7.3.	*Store/manage Assumptions*	✗	✗	✗	✗	✗	✗
4.7.4.	*Provide configuration techniques*	✗	✗	✗	✗	✗	✗
4.7.5.	*Store/manage influence of other domains on design choice*	✗	✗	✗	✗	✗	✗
5.	**Evaluation of business models for viability**						
5.1.	Evaluate viability of the service/product concept	✗	✗	✗	✗	✗	✗
5.2.	Evaluate viability from focal actor's perspective						
5.2.1.	*Evaluate use value captured by focal actor*	✓	✗	✗	✗	✗	✗
5.2.2.	*Evaluate exchange value captured by focal actor*	✓	✗	✗	✗	✗	✗
5.3.	Evaluate viability from the business ecosystem perspective						
5.3.1.	*Evaluate use value captured by the stakeholders*	✓	✓	✗	✓	✗	✗
5.3.2.	*Evaluate exchange value captured by the stakeholders*	✓	✗	✗	✗	✗	✗
5.4.	Evaluate viability of the technology architecture						
5.4.1.	*Evaluate viability of information services architecture*	✗	✗	✗	✗	✗	✗
5.4.2.	*Evaluate viability of physical technology architecture*	✗	✗	✗	✗	✗	✗
5.5.	Evaluate the capabilities of stakeholders in context of business model	✗	✗	✗	✗	✗	✗
6.	**Model business model ontologies at low level of granularity**	✓	✗	✓	✓	✓	✗

Incorporating the technology perspective in the business model design framework for viability helps to satisfy criteria 3, 4.2.4, and 5.4. The process of visualising the technology perspective helps to design, communicate and evaluate the technology architecture. Furthermore, it also facilitates the overall design process of the business model by helping to foster alignment among the four perspectives.

Including the design elements and the evaluation of capabilities in the business model design framework for viability facilitates the process of designing viable business models. The framework helps to consolidate and use the elements of business model design consistently (thus increasing the chances of designing a viable business model). As a result, the business model design framework satisfies criteria 4.6–4.7.5 and 5.5.

The lower order criteria together satisfy their respective higher order criteria; for example, criteria 5.2.1 and 5.2.2 satisfy criteria 5.2. Based on the assessment above, the business model design framework for viability seems to satisfy all of the viability criteria.

3.5 Conclusion

This chapter sought to answer sub-research questions SQ2 and SQ3: "*How to design and communicate a viable business model" and* "*How to evaluate the designed business model for viability.*" We propose a business model design framework for viability as an answer to SQ2. Furthermore, SQ3 is answered by the theoretical evaluation of the business model design framework for viability against the viability criteria in Table 3.2.

The business model design framework for viability is an umbrella framework that builds on well-established business model ontologies and modelling techniques. The framework facilitates the process of designing and evaluating business models, with viability as an explicit design focus. The business model design framework approaches the design and evaluation criteria from the four perspectives of service/product, focal actor, business ecosystem, and technology. Furthermore, the framework also adds the much-needed elements of business model design namely, design principles, business rules, assumptions, and configuration techniques. Additionally, the framework adopts a broader approach to value and stakeholder.

The viability criteria identified in Chapter 2 are used as input for developing the framework. The framework is then theoretically assessed against these criteria. The assessment results show that the business model design framework, in theory, can satisfy all of the viability criteria. However, the assessment result is based on theoretical evaluation and has yet to be demonstrated in a realistic situation. Hence, the following chapters will focus on demonstrating and validating the business model design framework for viability in two real-life, energy-related business cases.

Chapter 4

Validating the BMDFV: a viable business model for community-owned solar farms

4.1 Introduction

To validate the business model design framework for viability, this chapter demonstrates the framework by applying it to design and evaluate a business model for a mono-commodity energy system. Next, the framework is evaluated by reflecting on its validity. Hence, Chapter 4 addresses the last research question, SQ4: "*How to validate a framework for designing and evaluating viable business models for energy enterprises in a business ecosystem?*". See Figure 1.3 for an overview of how Chapter 4 fits into the overall structure of this thesis.

The overall plan to validate the business model design framework for viability involves applying the framework to design business models in two case studies. The first is a mono-commodity energy business model and the second, described in the following chapter, is a multi-commodity energy system. Relatively simpler when compared to multi-commodity energy systems, mono-commodity energy systems are set up to exploit single energy commodities such as gas, electricity, or heat [90], [102]. Since this is the first attempt to apply the business model design framework for viability in a real-life setting, a mono-commodity energy system was chosen. Scholars endorse this approach of starting with a relevant but relatively simpler case to demonstrate the first iteration and eventually increasing the scope and complexity with each successive iteration [30]. In the context of this research, the mono-commodity energy system consists of a community-owned solar farm set up and operated in the Netherlands. This case study was also selected because the focal actor is looking for a viable business model. Additionally, the willingness of the stakeholders to cooperate also played a major role in choosing the community-owned solar farm as a case study.

For the framework to be valid it must satisfy the design criteria [33]. At a high level, the design criteria state that the framework should be able to facilitate the design and evaluation of viable business models. To facilitate the design of the business model, the framework should be able to help synthesise the service/product perspective, focal actor perspective, business ecosystem perspective, and the technology perspective. The framework should also be able to support the broader approach to value. Finally, it should also be able to support the process of designing the business model with the help elements of business model design.

Grunneger Power is the focal actor leading the efforts to set up and operate the community-owned solar farm. Based in the city of Groningen, The Netherlands, this energy cooperative has over one thousand members. Their long-term goal is to transition to a sustainable energy system that produces and consumes sustainable energy on a local scale and to stimulate the local economy. Grunneger Power invests their profits in local sustainable energy projects [103].

The community-owned solar farms are set up in the city of Groningen. Residents and businesses nearby own a typical community-owned solar farm in the Netherlands. A community-owned solar farm allows its members to purchase individual shares in a solar farm. Among others, community-owned solar farms provide benefits such as economies of scale and ease of use. Community-owned solar farms cater to customer segments ignored by current market offerings [104]. To successfully set up and operate ommunity-owned solar farms, Grunneger Power needs a viable business model. However, existing literature treats the business models of energy cooperatives superficially. Research has largely ignored the business models of community-owned solar farms, despite the fact that scholars have categorised it as a high-potential business model [94],[95].

Several stakeholders are involved in a community-owned solar farm business model, such as the prosumers, service providers, distribution system operators, and local municipalities. Therefore, if the business model is to be viable, the stakeholders should be able to capture sufficient value such that they are committed to the business model. However, ensuring the viability of each stakeholder is particularly hard because of his or her competing interests [15], [105]. Hence, there is a need for a viable business model design for community-owned solar farms that cooperatives such as Grunneger Power can implement directly. Such a business model will help cooperatives like Grunneger Power to avoid risk and losses, and to save time.

This chapter is largely based on the publications [3] and [4] mentioned in Section. This chapter is organised as follows: Section 4.2 presents a literature review on business models that exploit photovoltaic technology. Section 4.3 provides an overview of the methodology. Section 4.4 presents the application of the business model design framework for viability to design and to evaluate a business model for the community-owned solar farm. The business model is presented to four experts for evaluation to perform the evaluation process. Additionally, this section describes how the business model was implemented. Section 4.5 reflects on the validity of the business model design framework for viability. The final section, 4.6, presents the conclusion.

4.2 Related work

Solar photovoltaic (PV) is the fastest growing renewable technology globally in terms of install capacity; from 2008–2013, the average install capacity grew at the rate of 55% annually [106]. However, the growth of solar photovoltaics is hampered by a lack of viable business models [105], [107]. Table 4.1 presents the different types of business models for PV systems found in the literature.

Asmus in [104] makes a case for community-owned solar farms in the United States. The author provides a high-level description of how community-owned solar farms work there. This information provides valuable input for designing the community-owned solar farm business model, but it misses important elements of a business model, such as cost structure. Furthermore, the community-owned solar farms developed in the Netherlands are subject to different rules and regulations. Huijben and Verbong in [105] analyse business model experiments for PV technology in the Netherlands. They found the community-owned solar farm business model to be one of the emerging business models. They also concluded that its financial viability depends on the net metering regulation, or the ability to deduct the amount of energy supplied to the grid from the total sum of energy taken from it. According to Huijben and Verbong in [105], the community owned solar farm business model was not viable back in 2013 because the net metering regulation did not apply to community-owned solar farms. However, according to the website hier opgewekt, new regulations and subsidies were announced in 2014 that make net metering applicable for community-owned solar farms [109], which could lead to a viable business model for them. Since the community-owned solar farm business model is described at a very high level and in a general manner, the descriptions miss many important business model design details such as cost structures. Consequently, Grunneger Power or any other organisation will be unable to implement the business model directly. Furthermore, the informal descriptions of the business models leave much room for misrepresentation and misinterpretation.

Table 4.1 Business model types for photovoltaic systems

Business model type	***Description***	***Source***
Turnkey projects provider	The service provider targets commercial and residential customer segments wanting to own PV systems, but who don't care to research, install, and maintain it. Their value proposition is ease of use (i.e., a one stop shop solution for all PV system related needs, including customer support and pre and post sales.	[105], [107], [108]
Third party	Here the energy retailer installs the PV system on the customer's premise, or rents space from real-estate owners. However, the retailer owns and operates the PV system and retails the energy to the customers on whose premises the PV system is installed. The energy retail contracts usually span several years, with a fixed energy price. This business model has several variants in terms of key partners, value proposition, and cost structures, for example, the energy retailer owning the PV system may have to pay rent to the real-estate owner for using their space to set up and operate the PV system.	[105], [107], [108]
Value-added service provider	The service provider assists the customer with specific tasks in acquiring and operating the PV system, for example, administration for subsidies. These service providers are usually the consulting firms, and they target commercial as well as residential customers.	[108]
Construction and installation service provider	The service provider provides construction and installation services necessary for the PV system. They target both commercial and residential customers.	[108]
Large-scale power producers	Here the power producer owns large-scale PV systems, primarily for producing and selling energy. They mainly target energy retailers or large-scale consumers of energy.	[108]
Virtual power plant	The firm acting as a virtual power plant tries to balance the grid by controlling supply and demand. Such a player is usually a market maker, since they have insights into total demand and supply. Such players can have various revenue streams, such as transaction and membership fees.	[108]
Community owned solar farms	Here the community usually forms a cooperative, and they collectively invest in an offsite solar farm. The members of the cooperative purchase shares in the solar farm, and/or purchase power produced there. Such cooperatives usually target residential and small businesses that are unable or do not want to purchase and install PV systems on their location.	[104], [105]

4.3 Methodology

The goal of this chapter is to validate the business model design framework for viability by demonstrating its use in a case study. Within the case study, the framework is applied to design and evaluate a business model for a community-owned solar farm. The application of the framework is followed by a reflection on its validity.

The subsequent steps are followed to design the business model for the community-owned solar farm. First, a literature review was performed to set the foundation and to understand the state of the art in the domain of community-owned solar farms. Second, the business model design framework is used to design the business model. The application of the framework starts with a high-level description of the business idea. Next, the business model is designed from the service/product, focal actor, business ecosystem, and technology perspectives. Table 4.2 gives an overview of the modelling techniques and the business model ontologies used to operationalise the four perspectives.

Table 4.2 Business model ontologies and modelling techniques used to operationalise the four perspectives

Perspective	*Business modelling ontology/modelling technique*
Service/product	Service blueprint
Focal actor	Business model canvas
Business ecosystem	e3-value
Technology	Information services and block diagram

The design process also uses the elements of business model design recommended by the framework. After completion of the design process, the newly developed business model is evaluated for viability. The design and evaluation process adopts a broader approach to value by including exchange and use value and a broader set of stakeholders.

The data necessary for designing the intended business model were collected from primary and secondary sources. Ten interviews were carried out with experts and potential stakeholders in the business model. Semi-structured questionnaires were used to conduct the interviews, which lasted for about 45 min. – 1.30 hrs. The interviews were transcribed and then used as inputs for designing the business model. In addition, a workshop was organised to develop the business service concept. Seven participants attended: three academics and four experts in the domains of energy and ICT. The researchers also attended meetings organised by Grunneger Power for potential prosumers who wanted to buy shares in the proposed community-owned solar farm.

Moreover, they were also given access to four internal documents that described the business idea, cost, and revenue structures. Secondary sources of data were used to triangulate the information, such as reports on PV technologies, community-owned solar farms, and Grunneger Power's website.

Measuring viability: As previously mentioned, a business model is viable when the stakeholders can capture sufficient value such that they are motivated to be a part of the business ecosystem. This raises the question of how to measure the amount of value captured by each stakeholder. There are well-established metrics to quantify and measure exchange value (i.e., monetary value) — for example, revenue, net present value, internal rate of return, return on investment, profit, etc. Estimating exchange value is challenging because of the lack of transparency and the lack of availability of relevant data crucial for the business, such as cost structure and revenue streams. Use value is not always easy to measure, and in some cases it may not make sense to quantify it. To add to the complexity, the use values the stakeholders are interested in could vary from one business model to the other.

In the context of this case study, the intention is to design and evaluate a viable business model for a community-owned solar farm. The exchange value here is quantified in terms of operating profit, also known as earnings before interest and tax (EBIT). The earnings are best-case estimations of the potential profits. Several assumptions regarding profit margins are made based on industry reports. For example, the profit margin assumed for Grunneger Power's energy retail activity is about 4,33%. The use values quantified and measured are CO_2 avoided, jobs created, reduced energy bill, and taxes generated from the business ecosystem.

The CO_2 avoided is estimated based on the assumption that the users switch from a fossil fuel–based energy supply to the community-owned solar farm. Furthermore, only the emissions displaced as a direct result of the solar farm are considered. The emissions are calculated based on the average energy mix of the Dutch energy supply system, and the estimations include only the direct emissions. The number of jobs created is estimated based on the estimated revenue and industry averages charged per hour of work. Following Kuckshinrichs, Kronenberg, and Hansen in [110], the taxes generated in the business ecosystem are categorised as a social good. The estimates include income taxes from wages only and do not include corporate taxes (these were not calculated due to the lack of available, transparent data). Consequently, the taxes appropriated by the government would be higher than the estimations presented in this chapter.

Several techniques help to convert the above use values (such as avoided CO_2 and jobs created) into exchange value [111]. The conversion is done to allow for comparison trade-offs between use values such as CO_2 reduction and exchange values such as investments and profits. However, the conversion to exchange value is not without its disadvantages and problems. First, It is hard to determine the prices of all social values because not all use values are openly traded on the market. Even though some of the use values, such as CO_2, are traded on the markets, the prices are criticised for being too low. Figure 4.1 shows how carbon prompt-futures prices are declining; as of 09-02-2017, the price of one tonne of CO_2 on the European energy exchange was trading for €5.25 (spot prices) [112].

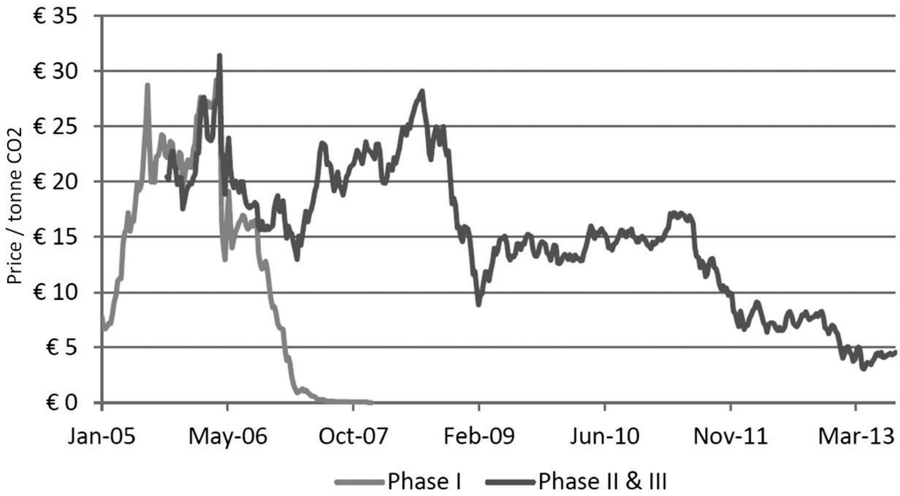


Figure 4.1 Prompt-future prices for EU in Phase I and Phase II & III [113]. From the above figure, it can be observed that the price of CO_2 is steadily decreasing.

These carbon markets are criticised for not reflecting the true price of CO_2 emissions. Critiques claim that the true cost per tonne of CO_2 should be at least €207 ($220) [114]. Similarly, the US Environmental Protection Agency and the UK Department of Energy estimate the social cost per tonne of CO_2 at approximately €36 ($38.4) and €6.9 (£5.89), respectively [115], [116]. This wide range of prices makes it difficult to estimate the value created by avoiding CO_2. Secondly, the customers are specifically interested in the value proposition of avoiding CO_2 emissions or creating local jobs, so converting these value propositions to an exchange value obscures and complicates the metrics that quantify the value propositions that customers and other stakeholders want. Therefore, to quantify and communicate the value created in this business model in a clear and straightforward manner, the use values are not converted to exchange value.

4.4 Designing and evaluating the business model using the business model design framework for viability

This section illustrates how the business model design framework for viability is applied to design and evaluate the business model for the community-owned solar farm.

4.4.1 Step 1 - Introduction to the business idea

Grunneger Power wants to provide a service that involves the setup and management of small-scale solar farms for local communities. It is estimated that a solar farm will have 150 solar panels, an operating lifespan of 20 years, and about 30 shareholders or participants. The solar farms will be set up close to the communities. They propose setting up the solar farms on unused municipal real estate. The people living around these unused parcels will be approached for investments. They can participate in the solar farm by purchasing one or more solar panels. The interested customers will then be organised into a cooperative that will invest in the solar farm collectively. Grunneger Power will manage the administration and logistics around setting up and operating the solar farm in return for a fee. The prosumers will earn revenues that include subsidies and the sale price of the electricity.

The government has introduced a subsidy programme called "postcoderoos regeling" for community-owned solar farms. Under this subsidy regime, members of the small-scale cooperatives and housing associations that invest in community-owned solar farms will receive an approximately 9-euro cent subsidy per kWh of electricity supplied to the energy retailers. This subsidy is also available to residents living in the same postcode and adjacent postcode areas. Figure 4.2 shows that regime postcode area 9733 and the postcode areas surrounding it, marked in red, qualify for the subsidy [117].

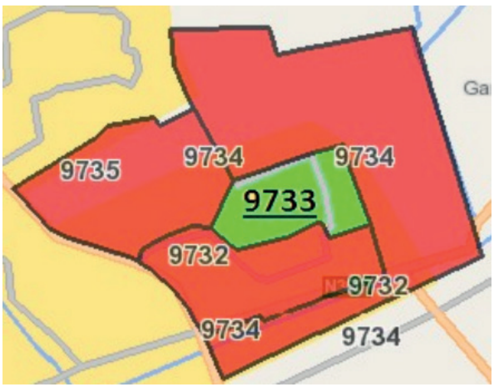


Figure 4.2 postcode subsidy example. Areas marked in green and red qualify for the subsidy.

Therefore, this subsidy is currently one of the main factors leading to a viable business model for community-owned solar farms. It is meant for small-scale users of electricity who consume 10,000 kWh or less. The prosumers will have to form a housing association or an energy cooperative to avail themselves of the subsidy [109].

Table 4.3 provides a summary of the stakeholder analysis.

Table 4.3 Summarised stakeholder analysis for the community-owned solar farm business ecosystem

Stakeholders	***Goals***	***Value proposition***	***Roles and responsibilities***
Prosumer	Sustainable lifestyle; do not want to pay more for energy than they do now; create social benefits; convenient energy services	Generate green energy; reduce CO_2 emissions; create local jobs; reasonable ROI; reports; convenience	**Prosumer:** participate in the energy cooperative that collectively invests in the community-owned solar farm. Consume energy.
Grunneger Power	Profit for purpose; profits reinvested in projects that help realise their vision of local, fair, and sustainable energy	profit	**Solar farm service providers:** provide the solar farm service to prosumers; involves activities such as setup and management of the solar farm.
Energy retailer	profit	profit	**Energy retailer:** purchases electricity produced from the solar farm. Retails energy to the prosumer. The energy retailer also collaborates with solar farm service provider and the government for allocation of subsidies.
Distribution grid operator (DSO) - Enexis	Profit	Profit	Transmission service
Municipality of Groningen	Reduce CO_2 emission as per national and regional targets, stimulate the local economy.	Reduce CO_2 emissions and stimulate the local economy by creating local jobs.	**Local governing body:** facilitate the generation and uptake of green energy. Stimulate the local economy. Provides licenses and permits to set up and operate energy generation facilities.
Government	Reduce CO_2 emission as per national and regional targets, stimulate the local economy.	Reduce CO_2 emissions and stimulate the local economy by creating local jobs.	**Subsidising agency:** provides subsidies for renewable energy.

Table 4.3 Continued

Municipality of Groningen	Reduce CO_2 emission as per national and regional targets, stimulate the local economy.	Reduce CO_2 emissions and stimulate the local economy by creating local jobs.	**Local governing body:** facilitate the generation and uptake of green energy. Stimulate the local economy. Provides licenses and permits to set up and operate energy generation facilities.
Hardware supplier	profit	profit	**Hardware supplier:** supplies the necessary hardware such as solar panels etc. Additionally, also provides necessary support and maintenance services to the solar farm service provider.
Information system supplier	Profit	Profit	**Information systems supplier:** supplies the necessary information systems and support and maintenance services.
Accounting firm	Profit	Profit	**Accounting firm:** Provides accounting services.

4.4.2 Step 2 - Business model design perspectives

In the following sections, the business model design framework for viability is applied to synthesise the four perspectives. The perspectives depicted below are obviously the ones that were found to be viable. Several iterations were made to design the viable perspectives.

Service /product perspective

The business model design framework for viability recommends designing a clear service/product concept. It is important to have a clear conceptualisation of the desired service/product concept because the other perspectives have to be designed to realise and exploit the service/product perspective. Additionally, developing the service concept helps to create a shared understanding among the stakeholders about what is to be done for the customers and how it is to be done [6]. This perspective also sets the foundation for designing the other perspectives of the business model.

The service targets a customer segment interested in generating their energy with the help of solar panels, green energy, reducing CO_2 emissions, and creating local jobs. The customers in this segment either do not have the opportunity to install solar panels on their roof, or they do not want the trouble of setting up and maintaining the solar panels, or both. The core idea here is that the customers sign up to be a part of an energy cooperative, the members of which purchase one or more solar panels for a fee. The cooperative pools the individual investments of the members and invests in a solar farm. The cooperative members also have to change their energy supplier to Grunneger Power. The value propositions offered by the latter to the cooperative members include a sustainable lifestyle with green energy locally produced by a solar farm that they jointly own, reduced CO_2 emissions, creation of local jobs, reduced energy bills, reports, energy supply, and convenience.

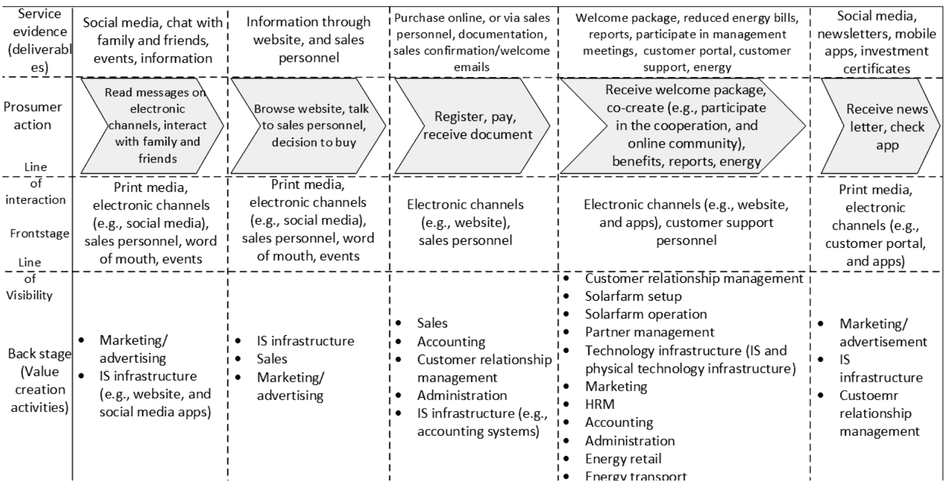


Figure 4.3 service blueprint – description of the service offered to the prosumer by Grunneger Power.

Grunneger Power is the owner of the service and of the customer relationships, which means they mostly interact with it for all issues related to the service. Grunneger Power provides convenience to the customers by functioning as a one-stop solution related to the service. Functioning as such for the client involves acquiring new clients, organising the customers into a cooperative, administration, setup of the solar farm, purchase of electricity from the solar farm, arranging for subsidies on behalf of the customer, etc.

The blueprint depicted in Figure 4.3 provides a detailed description of the service. The figure is divided into four main sections: service evidence, customer action, front stage, and backstage. The service evidence section depicts the evidence or value propositions the customer expects to experience in a consistent manner (e.g., timely revenues from subsidies and sale of electricity from the solar panels). The prosumer action section describes the actions the customer is supposed to perform during the process of service co-creation. The front stage defines the channels that Grunneger Power will use to interact with customers through the different phases of the service. The backstage section depicts the value creation activities that should be performed to create and deliver the service evidence or value propositions to the customer.

Design choices and elements of business model design: This section describes the design choices and the elements of business model design that significantly affect the service perspective. The goal here is not to be exhaustive but to illustrate the importance of design choices and the elements of business model design for a viable business model.

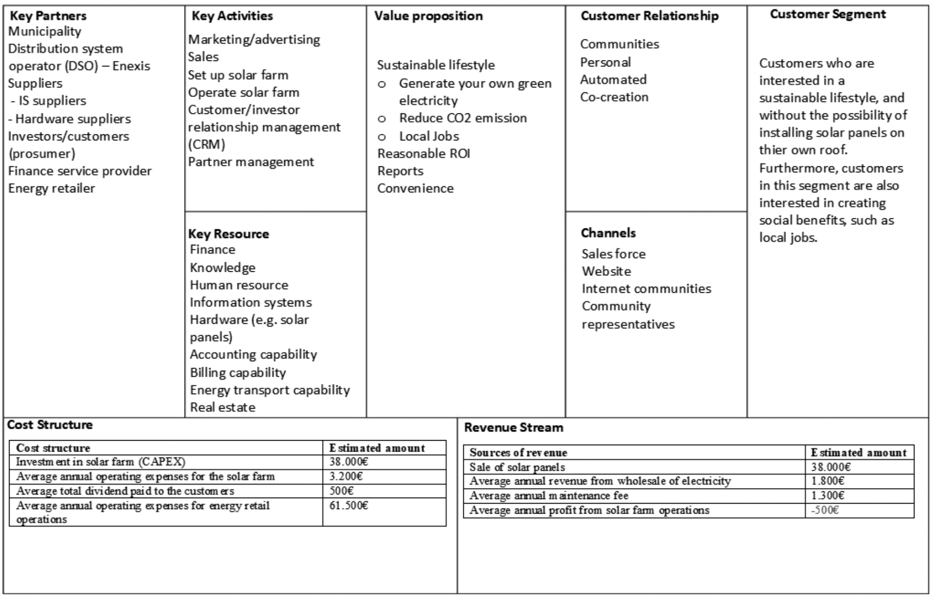
As mentioned, the subsidy announced by the government significantly influences the design of the service concept. The subsidy translates to a business rule that the customers have to form a cooperative to obtain it — which creates an additional burden for them in regard to administrative, organisational, and operational functions. Hence, the service is designed to take advantage of the subsidy as well as to create and deliver convenience and the other attendant value propositions.

Another important choice was the customer segment. Market intelligence indicated that the customers most likely to adopt the service Grunneger Power is offering are most interested in a sustainable lifestyle but are unable to install solar panels, or customers who do not want the trouble of installing and managing them. This was also evident by the type of people attending the information sessions held by Grunneger Power and the type of questions asked; for example, "How much electricity does an average household use?" and "How many solar panels do I need to buy to cover my electricity use?" Consequently, the service was designed for the customer segment above.

The focal actor perspective

Since Grunneger Power is involved in crafting the business ecosystem around the service concept, it is useful to design the business model from their perspective. Designing the business model from the focal actor's perspective is also usually easier before designing the business ecosystem perspective. Furthermore, the business model of the focal actor is usually complex and demands special attention. Therefore, this section focuses on the business model from Grunneger Power's perspective.

Figure 4.4 describes the business model from Grunneger Power's perspective, that of the focal actor. The company targets the customer segment who are interested in a sustainable lifestyle but cannot install solar panels, or do not want the trouble of setting up and maintaining them. According to the customers, a sustainable lifestyle includes producing and consuming green energy locally, creating local jobs, and reducing CO_2. An important value proposition that Grunneger Power offers this customer segment is the ability to generate green electricity using their solar panels conveniently and at the same time helping to create local jobs by hiring local suppliers. To provide the above value proposition, Grunneger Power performs or outsources the necessary value creation activities, sets up and manages channels and relationships with customers and key partners, and acquires the necessary key resources. But as shown in Figure 4.4, it is unable to provide the solar farm service profitably.



Cost structure	Estimated amount
Investment in solar farm (CAPEX)	38.000€
Average annual operating expenses for the solar farm	3.200€
Average total dividend paid to the customers	500€
Average annual operating expenses for energy retail operations	61.500€

Sources of revenue	Estimated amount
Sale of solar panels	38.000€
Average annual revenue from wholesale of electricity	1.800€
Average annual maintenance fee	1.300€
Average annual profit from solar farm operations	-500€

Figure 4.4 Business model canvas. Business model from Grunneger Power's perspective.
*Amounts in the above figure are rounded to the nearest hundred.

The traditional business model design activity would stop here, or would continue with another iteration based on the decision taken by the designer. However, in the business model design framework for viability, the design activity is approached from a different perspective to explore other configurations of viable business model designs in a systematic manner. To explore alternate configurations of the business model, the business ecosystem perspective is adopted.

The amounts presented in the Figure 4.4 should be interpreted as an indication rather than absolute values. The cost structure and revenue streams are estimations based on the information available at the time of the design activity.

Design choice and elements of business model design: The design principles, in particular the coherence principle, has significantly affected the design choice. To create and to provide the local jobs value proposition, Grunneger Power has chosen local key partners, such as hardware suppliers. The local suppliers supply the necessary key resources and perform key value creation activities like the construction of the solar farm. Hiring local key partners leads to local jobs.

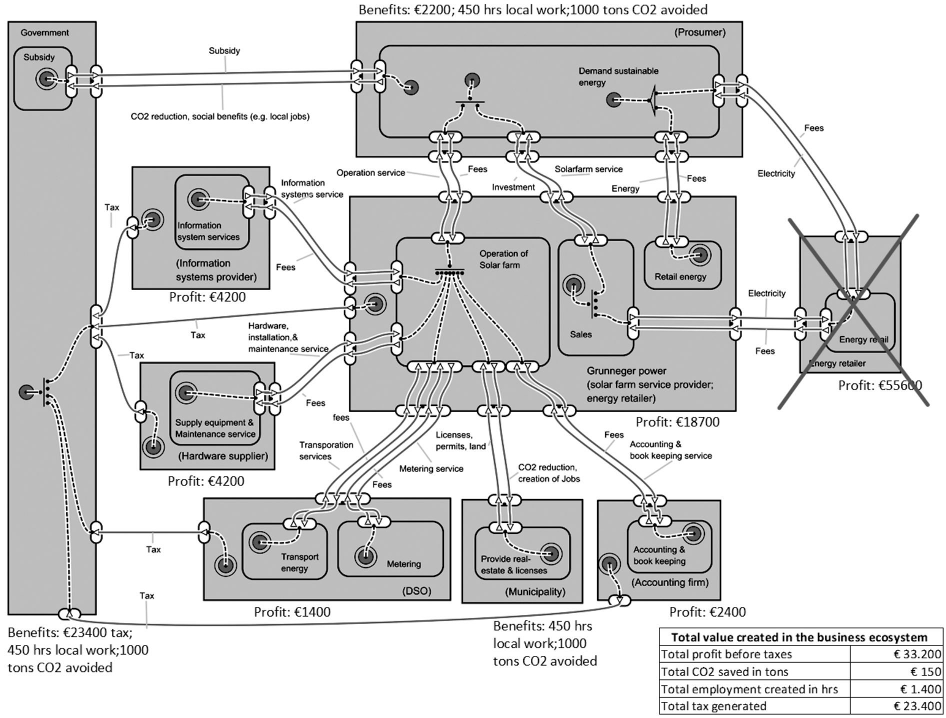
The business ecosystem perspective

The crux of the business ecosystem perspective is that the focal actor alone does not have the resources and the capacity to implement business models, especially in the context of the energy industry. Hence, Grunneger Power needs to work cooperatively with other stakeholders in a business ecosystem setting. For the ecosystem to be viable, each stakeholder should create, deliver, and capture value in such a way that the ecosystem and the business models of the individual stakeholders are viable. Therefore, it is crucial for the business model designer to synthesise the business ecosystem perspective. In the context of this case study, it is essential to synthesise this perspective because it facilitates the process of exploring alternative viable configurations of the business model.

Figure 4.5 depicts the viable business ecosystem. Grunneger Power is the focal actor that sets up and manages the solar farm on behalf of the customers (prosumers). Also in this perspective, the distribution of roles and responsibilities and how the transactions are configured becomes clear. Among other advantages of synthesising this perspective of particular interest is the ability to analyse and think about alternative configurations. Also, this perspective helps to focus on the viability of other stakeholders participating in the business ecosystem.

From Figure 4.5, it is clear that the traditional energy retailers are eliminated from the business ecosystem, and their roles and responsibilities are now allocated to Grunneger Power. The allocation of the role implies that Grunneger Power will now be performing energy retail activities, in addition to setting up and operating the solar farm. The reasoning behind how and why this was done is explained in the following subsection. The figure also shows that all of the stakeholders can capture additional value. From the figure, it is also evident that not all stakeholders are interested in exchange value (financial value); some of them are also interested in use values, such as the creation of local jobs (local work) and the reduction of CO_2. The stakeholder participating in this business model for profit, namely the information system suppliers, hardware suppliers, distribution system operator (DSO), accounting firm, and Grunneger Power, can earn a profit. Not all the value propositions for the customer (prosumer) can be quantified, and in the context of this research, it does not make sense to quantify all of the value propositions, for example, energy supply. The value proposition sustainable lifestyle is quantified in terms of CO_2 avoided, and the number of hours of local work created. Furthermore, the reduced energy bill is estimated in terms of euros. The quantified value propositions are clearly indicated above the prosumer in Figure 4.5. Similarly, the other actors who are interested in use value — the government and the municipality — also capture the use value created in the business ecosystem. However, it is hard to determine which of the stakeholders captures use values and how much, especially values such as local jobs and reduced CO_2. Hence, the total amount of use value created is distributed equally among the parties interested in these values. Following Kuckshinrichs, Kronenberg, and Hansen in [110] generating taxes is also seen as a social benefit. Therefore, the amount of tax generated from this business ecosystem is also considered. Tax is categorised as a social benefit because the government can further use the tax for the benefit of the society.

Obviously, all of the values are estimates based on a set of assumptions (such as the assumed profit margins of these stakeholders) and on data available at the time of research, which could change in practice. Furthermore, the availability of data and lack of transparency into the financials of certain stakeholders has limited the estimation process. This has also had an effect on estimating the use values, such as taxes appropriated by the government. Also, since this project is fairly small, the benefits of creating local jobs is relatively limited. In larger projects, such as the one studied by Kuckshinrichs, Kronenberg, and Hansen in [110], business models create much more social value, and the government could earn more in terms of tax and cost savings when compared to the amount of subsidies disbursed. The cost savings are a direct result of the reduced social benefits payments, because the people living on them were trained to perform certain tasks in the business model.



Total value created in the business ecosystem	
Total profit before taxes	€ 33.200
Total CO2 saved in tons	€ 150
Total employment created in hrs	€ 1.400
Total tax generated	€ 23.400

Figure 4.5 e-3 value. Viable configuration of the solar farm business ecosystem (the business ecosystem perspective). The figure depicts that after the traditional energy retailers were eliminated and their value creation activities and cost and profits reallocated to Grunneger Power, the business ecosystem becomes viable; that is, all of the stakeholders are able to capture sufficient value such that they are motivated to be a part of the business ecosystem.

*The figures above are cumulative estimates over 20 years.

The amounts presented in Figure 4.5 are estimations of the potential exchange value (profit, revenue) and use value (utility, reduction of CO_2, jobs created, and tax) and are based on data available at the time of the research and several assumptions such as potential profit margins.

Design choices and elements of business model desing: This section describes the elements of business model design that have had a prominent effect on the design choices (this does not mean that other design elements are less important).

The business configuration techniques, in particular, the technique to eliminate waste, significantly affected the design choice. One of the ways of eliminating waste is to remove stakeholders who do not add sufficient value to the business ecosystem and redistributing their roles and responsibilities over other stakeholders. From Figure 4.4, it is clear that the focal actor is not viable. Consequently, the entire business ecosystem will be unviable. Figure 4.5 shows that the traditional energy retailers were capturing a disproportionate amount of value from the business ecosystem, rendering the business ecosystem unviable. Therefore, the traditional energy retailers were eliminated from it, and their roles and responsibilities, along with the corresponding cost and revenue streams, were allocated to Grunneger Power, which is now able to earn a profit. The design choice was based on the assumption that Grunneger Power could easily acquire the necessary energy retail capabilities and could perform the energy retail activities at prevailing industry profit margins of 4.33% [118]–[121]. As a result, Grunneger Power is now profitable. These assumptions were made after consulting Grunneger Power and experts in the energy domain. It can also be observed that all of the other actors are also viable. The viability of the above business model hinges on the assumed cost and revenue structure and the capabilities of Grunneger Power to implement and operate the business model, including the ability to acquire and retail energy profitably. The cost structure and revenue streams assumed above should be updated as and when more information becomes available.

The technology perspective

The technology perspective is operationalised by the technology architecture that supports the business model. A technology architecture is a collection of fundamental concepts or properties of a technical system in its environment that are embodied in its components, in its relationships, and in the principles of its design and evolution [122]. The technology perspective is an indispensable part of a business model, especially for business models that rely on technologies for creating, capturing, and exchanging value [44]. In the context of this case, there are two layers of technology architectures: physical technology and the information services.

Figure 4.6 shows the technical architecture of the business model. The physical technology architecture shows the necessary physical technologies needed and their organising logic, for example, PV panels, inverter, etc. The solar farm will be using the grid of the DSO to transport electricity. Furthermore, it can also be observed that the metering and operation-related data (e.g., are the PV panels functioning properly?) are transmitted to the appropriate information services. The information service will then process the data into necessary information needed to support the three perspectives of focal firm, business ecosystem, and the service/product. The information services architecture part of the figure shows the different services necessary to support the business service. The boxes with sharp edges represent the stakeholder; the box with rounded edges contained within the stakeholder box represents the information service; and the dotted lines connecting the boxes represent the flow of information and data.

The information services are assigned to stakeholders who are responsible for providing them. The figure also shows the distributed nature of the information services.

High-level business processes were designed to derive the depicted information services. Designing such processes is an important logical action to perform in arriving at the depicted information services architecture [122]. However, discussing the designed business processes is beyond the scope of this thesis. Following is a brief description of the information services.

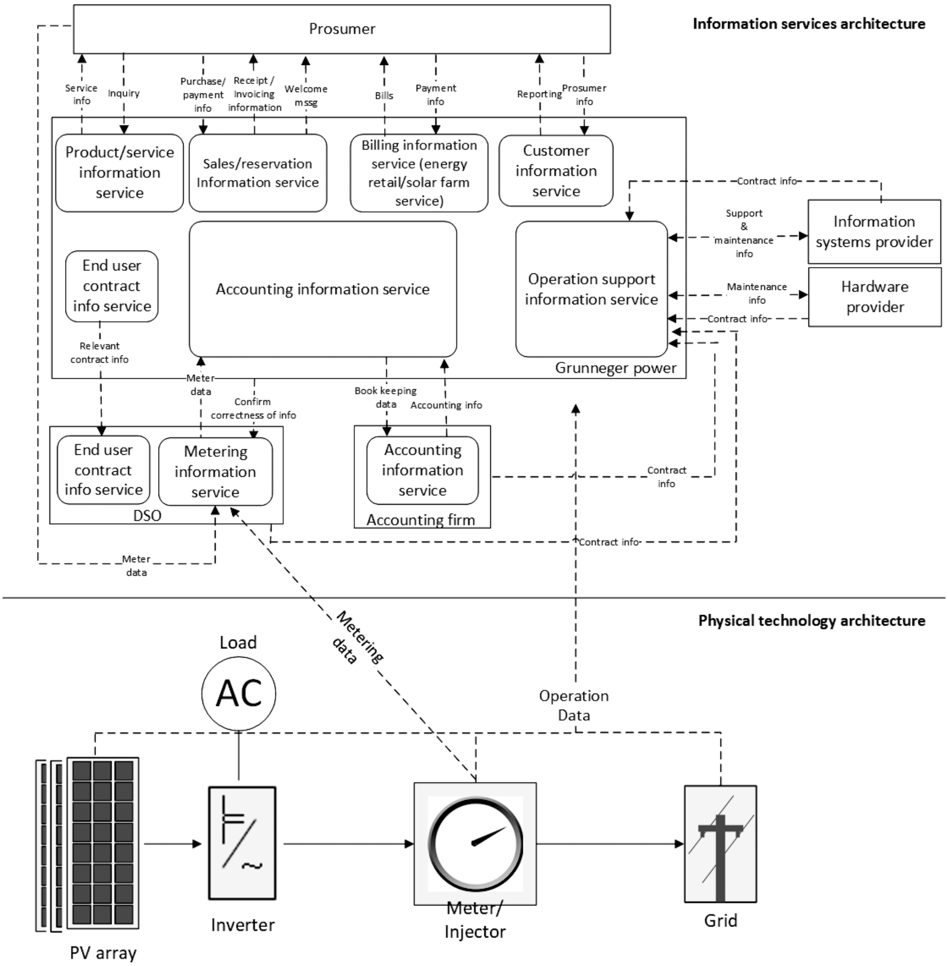


Figure 4.6 Block diagram and the information services modelling technique – information service and physical technology architecture. The figure depicts the envisioned information services and physical technology architecture and how they align with each other. The architectures depict how the individual components fit together.

Table 4.4 Stakeholders and corresponding information services

Stakeholder	***Description***	***Assigned to***
Solar farm service provider	The solar farm service provider owns and operates the following main information services: Service/product information service – provides relevant information related to the service, such as value proposition. Sales/reservation system – facilitates sales and reservation transactions. Billing information services – generates appropriate and timely bills. Accounting information service – collects and relays relevant accounting data such as bookkeeping data, and allocates subsidies to the accounting information services operated by the accountant. Its main purpose is to help manage the income and expenses of Grunneger Power and the energy cooperative formed by the prosumers. Operations support information service – collects and manages data around the operations of the solar farm, such as work order tracking, maintenance contracts, etc. End user contract information service – maintains information about energy supply contracts and relays relevant data to the DSO. Customer information service – collects and maintains prosumer information and conveys relevant information to prosumers (e.g., reports).	Grunneger Power
Distribution system operator	The distribution system operator owns and operates the following information services: Metering – Collects energy use data from the prosumers' homes and energy supply data from the solar farms. Relays the information to the relevant parties, such as Grunneger Power. End user contract information service – maintains information about energy supply contracts for billing purposes.	Enexis
Accounting firm	Accounting information service receives bookkeeping data and transforms it into information that Grunneger Power can use (e.g., accounts receivables).	Accounting firm

Design choices and elements of business model design: Business rules (the subsidy in particular) have had a significant impact on the choice of technology and the manner in which the information systems are organised. The subsidy clearly targets solar farms; consequently, they are chosen as a way of offering the value proposition of a sustainable lifestyle to customers. Furthermore, to align with the viable business ecosystem perspective, Grunneger Power has to set up and operate information services related to energy retail activities, such as the end user contract information services.

4.4.3 Step 3 - Is the business model viable?

This section describes how the business model was evaluated before being implemented by Grunneger Power. A follow-up interview occurred at a later stage to find out how it was actually implemented; therefore, this section also describes that aspect of the business model.

Expert opinion on the viability of the business model for community-owned solar farms: Expert evaluation of business models is a well-established method to evaluate newly designed business models that are yet to be implemented [44]. The designed business model was presented to four experts active in the field of energy. Two of them were academics with previous experience in the industry, and the other two are still active in management positions in the field. The experts were asked to rate the designed business model on the following scale ++ (very positive), + (positive), +/- (neutral), - (negative), -- (very negative). Table 4.5 presents the evaluation results.

Table 4.5 Expert evaluation of the viability of the business model from the four perspectives

Business model design perspective	*Expert 1*	*Expert 2*	*Expert 3*	*Expert 4*
Viability of the Service concept	++	++	++	++
Viability of the focal firm	+	++	+/-	+
Viability of the business ecosystem	+	+	+/-	+
Viability of the technology architecture	++	++	++	++
Overall viability of the business model	++	++	+	++

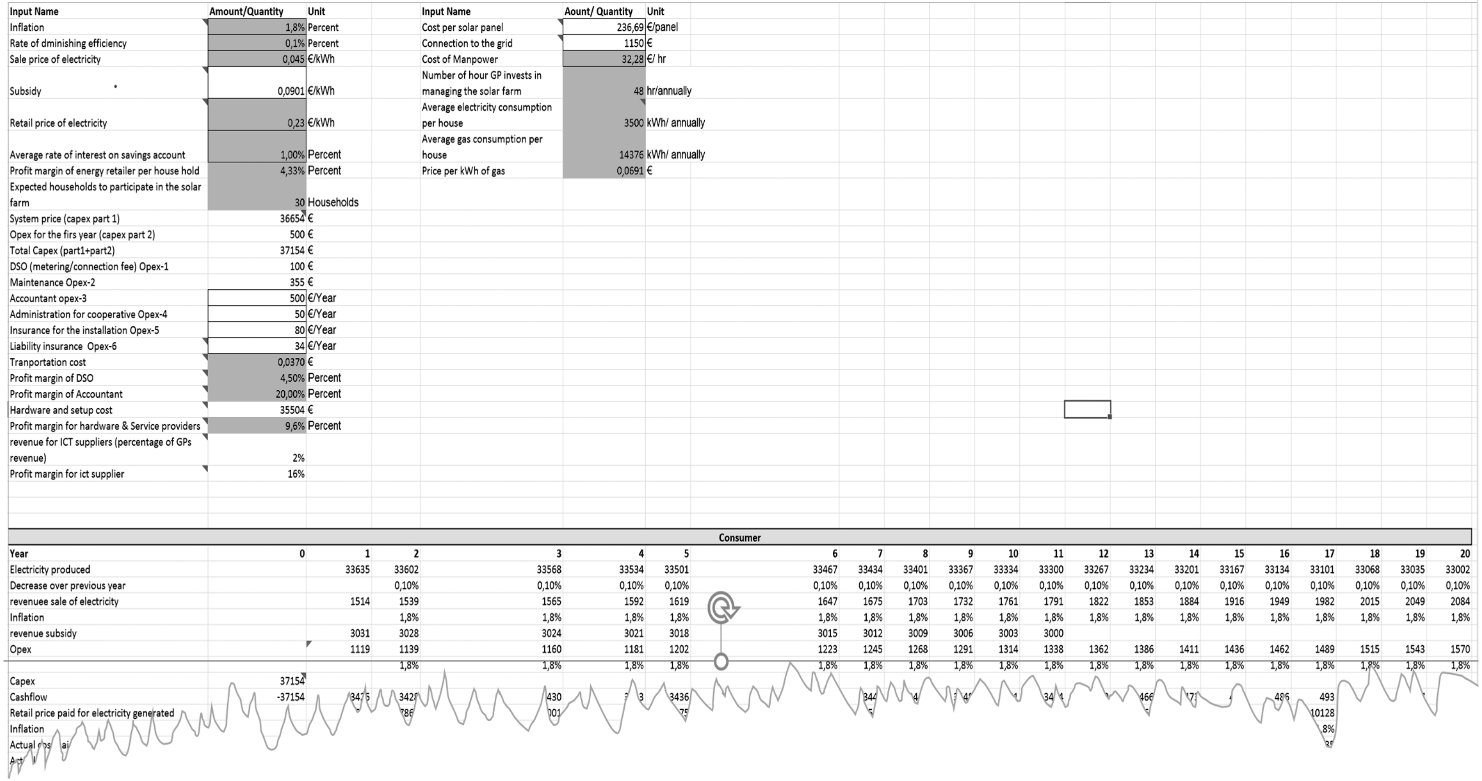
From Table 4.5 it is clear that all of the experts are very positive about the service and technology perspectives. The experts believed that the service concept and technology architecture were achievable and that they align with each other. They were also positive about the focal actor and business ecosystem perspectives. However, they were a little less positive when compared to the service perspective and the technology perspective.

Expert 3, in particular, was neutral about the viability of the focal actor and business ecosystem perspectives. The expert had doubts about the assumption that Grunneger Power would be able to perform energy retail activities at the same profit margin as the larger energy retailers. The expert mentioned that Grunneger Power is a small start-up without the overhead of a large energy firm but, on the other hand, they had a small customer base and did not have the economies of scale of a large energy retailer. Similarly, others also expressed a certain degree of doubt about the amount of exchange value that the different stakeholders would capture from this business ecosystem, due to uncertainties such as electricity prices and the number of customers signing up for the service.

To evaluate the business model, the experts were provided with a description of the above perspectives. They were also given access to the models used to calculate the exchange and use values. Figure 4.7 is a screenshot of the model made available to the experts for evaluating the business model. Additional questions were also answered during the evaluation sessions.

The viability of the business model is obviously sensitive to the capital and operations expenses. The revenue streams and the assumed profit margins also have an impact on the business model. The variables that had the largest impact on the revenue stream of the business model from the focal actor's perspective (Grunneger Power) is the number of customers signing up for the solar farm and energy retail services. The amount of exchange value that the prosumer captures is highly sensitive to the subsidies provided, the purchase price of energy, and the sale price of electricity (from the solar farm to the energy retailers).

The use value captured by the different stakeholders, in particular the CO_2 avoided, depends on the estimated amount of electricity produced. The local jobs created depends on the total sum of CAPEX and OPEX. In the context of this case, the taxes captured by government depend on the salaries paid and the assumed tax rates. The amount of taxes captured by the government also depends on the profits of each stakeholder however due to lack of data these figures were not estimated. Hence, in the designed business model the tax captured by the government is only sensitive to the salaries paid.



Input Name	Amount/Quantity	Unit
Inflation	1,8%	Percent
Rate of dminishing efficiency	0,1%	Percent
Sale price of electricity	0,045	€/kWh
Subsidy	0,0901	€/kWh
Retail price of electricity	0,23	€/kWh
Average rate of interest on savings account	1,00%	Percent
Profit margin of energy retailer per house hold	4,33%	Percent
Expected households to participate in the solar farm	30	Households
System price (capex part 1)	36654	€
Opex for the firs year (capex part 2)	500	€
Total Capex (part1+part2)	37154	€
DSO (metering/connection fee) Opex-1	100	€
Maintenance Opex-2	355	€
Accountant opex-3	500	€/Year
Administration for cooperative Opex-4	50	€/Year
Insurance for the installation Opex-5	80	€/Year
Liability insurance Opex-6	34	€/Year
Tranportation cost	0,0370	€
Profit margin of DSO	4,50%	Percent
Profit margin of Accountant	20,00%	Percent
Hardware and setup cost	35504	€
Profit margin for hardware & Service providers	9,6%	Percent
revenue for ICT suppliers (percentage of GPs revenue)	2%	
Profit margin for ict supplier	16%	

Input Name	Aount/ Quantity	Unit
Cost per solar panel	236,69	€/panel
Connection to the grid	1150	€
Cost of Manpower	32,28	€/ hr
Number of hour GP invests in managing the solar farm	48	hr/annually
Average electricity consumption per house	3500	KWh/ annually
Average gas consumption per house	14376	KWh/ annually
Price per kWh of gas	0,0691	€

Consumer

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Electricity produced		33635	33602	33568	33534	33501	33467	33434	33401	33367	33334	33300	33267	33234	33201	33167	33134	33101	33068	33035	33002
Decrease over previous year			0,10%	0,10%	0,10%	0,10%	0,10%	0,10%	0,10%	0,10%	0,10%	0,10%	0,10%	0,10%	0,10%	0,10%	0,10%	0,10%	0,10%	0,10%	0,10%
revenuee sale of electricity		1514	1539	1565	1592	1619	1647	1675	1703	1732	1761	1791	1822	1853	1884	1916	1949	1982	2015	2049	2084
Inflation			1,8%	1,8%	1,8%	1,8%	1,8%	1,8%	1,8%	1,8%	1,8%	1,8%	1,8%	1,8%	1,8%	1,8%	1,8%	1,8%	1,8%	1,8%	1,8%
revenue subsidy		3031	3028	3024	3021	3018	3015	3012	3009	3006	3003	3000									
Opex		1119	1139	1160	1181	1202	1223	1245	1268	1291	1314	1338	1362	1386	1411	1436	1462	1489	1515	1543	1570
			1,8%	1,8%	1,8%	1,8%	1,8%	1,8%	1,8%	1,8%	1,8%	1,8%	1,8%	1,8%	1,8%	1,8%	1,8%	1,8%	1,8%	1,8%	1,8%
Capex	37154																				
Cashflow	-37154																	493			
Retail price paid for electricity generated																		10128			
Inflation																					

Figure 4.7 Screen shot of the Excel model used to calculate use value and exchange value. It illustrates the type of information made available to the experts for evaluation.

How the business model was implemented

A follow-up interview with Grunneger Power was performed to find out how the designed business model was implemented. The business model was initially implemented as designed above. However, Grunneger Power soon made another iteration to their business model. The motivation for the iteration and the changes made are explained below.

Energy cooperatives similar to Grunneger Power in the three provinces of the north of the Netherlands — Groningen, Friesland, and Drenthe — realised the advantages of taking on energy retail activities. The cooperatives started to perform energy retail activities and soon realised that they could create economies of scale by joining forces. Hence, these energy cooperatives formed an energy retail company called the "Noordelijk Lokaal Duurzaam" (NLD). NLD performs energy retail activities on behalf of the member energy cooperatives, and the profits earned from these activities are paid back to the energy cooperatives. The profits paid to the cooperatives depend on the number of customers they refer to NLD. Hence, energy retail activity has become an important source of revenue for Grunneger Power, which has also developed other community-owned solar farms in Groningen.

Given the above context, this section describes how the business model was actually implemented. From the service perspective, no changes were made to the service concept. From the focal actor perspective, nothing much changes except the new revenue stream from NLD to Grunneger Power from their energy retail activities. From the business ecosystem perspective depicted in Figure 4.8, it is clear that the energy retail activities are again outsourced to an external energy retailer called NLD. As explained previously, NLD was formed to create economies of scale. In this case, the changes in the focal actor and business ecosystem perspectives lead to the following changes in the technical architecture. All the changes occur in the information systems architecture. The changed elements are shown in the form of solid lines and shaded boxes in Figure 4.9. Since NLD is retailing the energy to the prosumer, all of the necessary data, such as the household metering and production allocation data, is now collected by NLD to generate accurate and timely bills. The home metering data and the production allocation data refer to the amount of energy consumed by the prosumer and the amount of electricity produced by the solar panels purchased by the individual prosumer in the community-owned solar farm. Also, Grunneger Power has to register its members with NLD so that the profits earned from Grunneger Power's members is allocated to Grunneger Power.

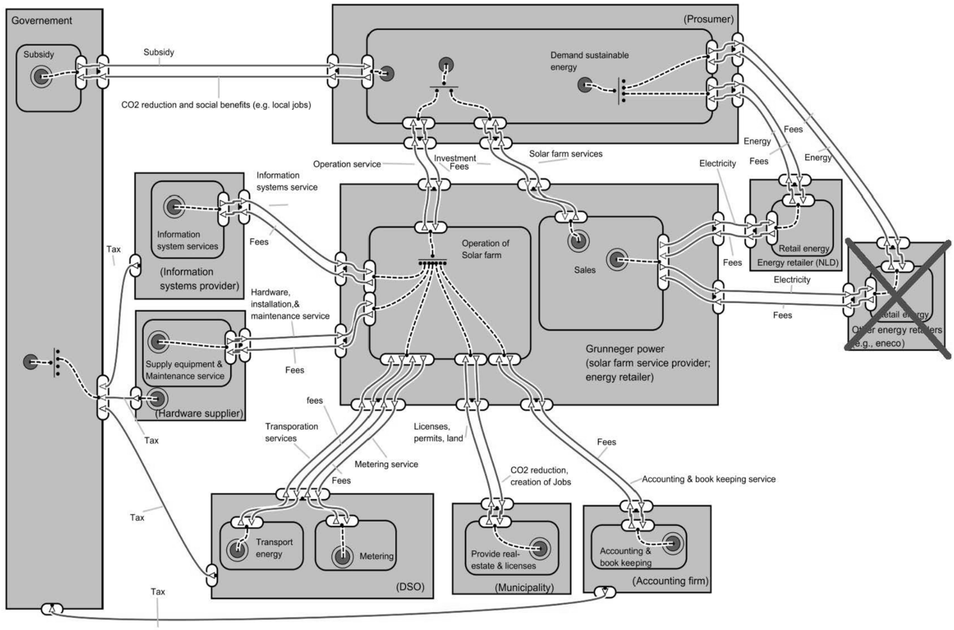


Figure 4.8. Business ecosystem perspective of the implemented business model. The figure shows that the traditional energy retailer was replaced with another energy retailer called NLD. NLD was formed by Grunneger Power and other energy cooperatives to create economies of scale and reduce costs.

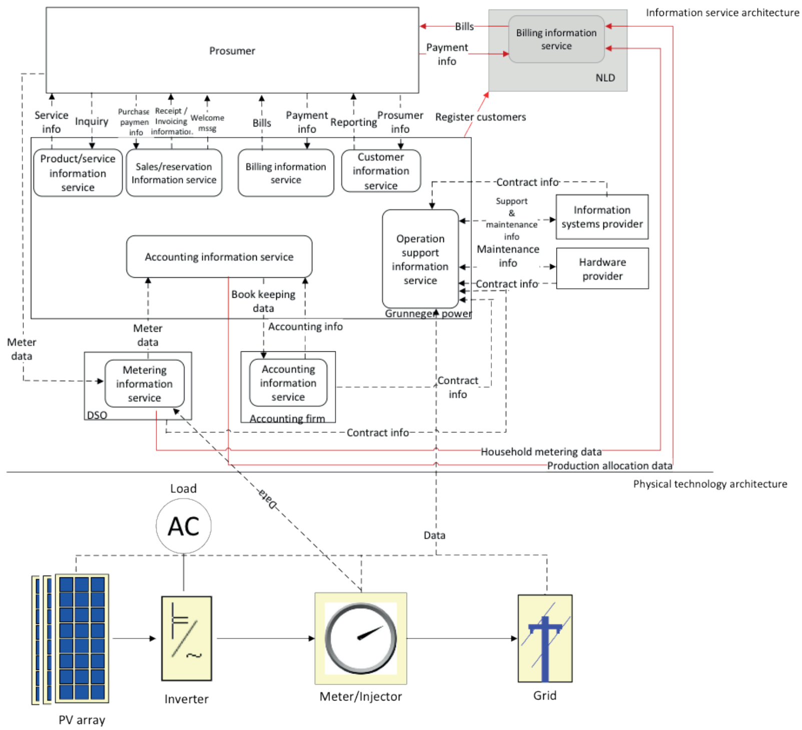


Figure 4.9 Implemented technology architecture. The figure depicts the changes made to information architecture as a result of the changes in the business model (the solid lines and grey box depicts the changes). A new stakeholder(NLD) is introduced, and the billing information service is allocated to NLD. This implies that the household metering data and production allocation data have to be sent to NLD, and NLD also manages the communications related to bills and payment information with the prosumer.

4.5 Reflection on the validity of the business model design framework for viability

Designing and evaluating a viable business model for the community-owned solar farm using the business model design framework for viability was successful. The framework facilitated a broader approach to value; it also allowed for the creation and capture of both use value and exchange value. The four perspectives helped to develop a viable business model in a systematic manner. As demonstrated, the business ecosystem perspective and the eliminate waste configuration technique were useful in exploring an alternative configuration of the business model that was viable. The business ecosystem perspective facilitated the process of analysing which actors were performing which roles and the corresponding value creation activities, and how much value the stakeholders were capturing in return. The eliminate waste configuration technique guided the process of eliminating the stakeholders who were capturing disproportionate value when compared to the value they were adding to the business ecosystem. Hence, the traditional energy retailers were removed from the business ecosystem, and their roles, corresponding value creation activities, transactions, cost structures, and revenue streams were allocated to Grunneger Power. Consequently, the focal actor was able to capture sufficient value such that it and all stakeholders in the business ecosystem were rendered viable. As a deduction, the business model design framework for viability was able to guide the design process in a way that led to a viable business model design.

The four perspectives, the elements of business model design, and the design choices helped to make the motivation and assumptions behind the design choices explicit. This enabled the experts to assess the business model critically. Expert 3 was able to critically assess risks involved in assuming that Grunneger Power would be able to perform energy retail activities at the same profit margin as the large energy retailers due to lack of economies of scale. Hence, the business model design framework for viability can facilitate the evaluation of the designed business model.

The designed business model was implemented in real life. However, Grunneger Power made a quick iteration and outsourced the energy retail activity to NLD. This was done to create economies of scale and lower costs. Grunneger Power collaborated with other energy cooperatives in the north of the Netherlands to form an energy retail company, thus lowering costs and reducing the risk of lower profit margins.

The process of designing business models using the business model design framework for viability is both iterative and creative. The four perspectives — in particular, the business ecosystem perspective — were crucial in designing the viable business model.

The elements of business model design made the business model transparent and traceable, easy to tweak with each iteration, and easy to evaluate for viability. Also, the configuration techniques played a major role in the design of the viable business model by eliminating the traditional energy retailers who were not creating sufficient value in the business ecosystem. Grunneger Power also implemented the design business model. Based on the above analysis, the business model design framework for viability has successfully facilitated the design of a viable business model for a mono-commodity energy system and therefore is validated.

4.6 Conclusion

Chapter 4 addresses SQ4, *"How to validate a framework for designing and evaluating a viable business model for energy enterprises in a business ecosystem"*. The business model design framework for viability is used to design a viable business model for a mono-commodity energy system. The model was designed for Grunneger Power, an energy cooperative in the north of the Netherlands. Grunneger Power wants to set up and operate community-owned solar farms and hence was looking for a viable business model to exploit community-owned solar farms. The application of the framework to design the viable business model was successful. The four business model design perspectives were useful in approaching the business model design process systematically. The business ecosystem perspective was crucial in facilitating the viability of the business model because it allowed for an analysis of which roles were being performed by which stakeholder and how much value they were capturing in return. The above analysis combined with the eliminate waste configuration technique led to the elimination of the traditional energy retailers from the business ecosystem. Their energy retail activity was then reassigned to Grunneger Power, which resulted in the focal actor being viable. The framework was also able to account for use values such as reduction of CO_2 and creation of local jobs.

Four experts evaluated the resulting business model for viability positively. The application of the framework provided deeper insights to the experts that allowed for more critical assessment of the designed business model. Expert 3 found the assumption made about the capability of Grunneger Power to perform energy retail activities at the same profit margins as the large energy retailers questionable. The expert found the assumption to be reasonable, considering that Grunneger Power was a start-up without the overhead of a large energy retailer. On the other hand, the expert questioned the assumption, because the company did not have the requisite economies of scale.

However, this element of risk was addressed in a business model design iteration Grunneger Power made after implementing the business model presented in this chapter.

Grunneger Power implemented the designed business model but soon made another design iteration. During the latter, energy retail activities were outsourced again, to an energy retail company called NLD, which was formed by energy cooperatives such as Grunneger Power to reduce costs and create economies of scale.

The business model design framework for viability successfully facilitated the design of a viable business model for the community-owned solar farm. Therefore, the business model design framework for viability is validated, and hence SQ4 has been answered.

Chapter 5

Validating the BMDFV: a viable business model for multi-commodity energy systems

5.1 Introduction

To strengthen the validation of the business model design framework for viability, this chapter demonstrates the framework by applying it to design and evaluate a business model for a multi-commodity energy system. Next, the framework is evaluated by reflecting on its validity. This chapter addresses the last research question, SQ4: *"How to validate a framework for designing and evaluating viable business models for energy enterprises in a business ecosystem?"* See Figure 1.3 for an overview of how Chapter 5 fits into the overall structure of this thesis.

To develop a robust business model design framework for viability requires rigorous validation. One way to ensure that is to increase the scope and/or complexity of the problem with each successive iteration [30]. In the previous chapter, the business model design framework for viability was validated for a mono-commodity energy system. Here, the framework is applied to design and evaluate a business model for a multi-commodity energy system, which are relatively complex when compared to mono-commodity ones [102].

Multi-commodity energy systems include several commodities (e.g., heat and electricity), and the corresponding production, conversion, transport, and storage technologies are integrated in an intelligent manner. Depending on the supply and demand dynamics, this approach allows energy to flow from one form to another, thus providing flexibility [90], [102].

Flexibility is defined as "*the modification of generation injection and/or consumption patterns in reaction to an external signal (price signal or activation) in order to provide a* *service within the energy system*" [114, Pg 5]. In the context of this research, flexibility refers the increase or decrease in the production of heat and electricity by the MSW-incinerator based on the price signal and the extent to which their heat consumers are willing to increase or decrease their consumption of heat.

Obviously, the complexity of multi-commodity energy systems is greater than that of mono-commodity energy systems, and the corresponding BMs are also more complex. This complexity stems from the competing interests of an increased number of stakeholders, dynamic interaction among the commodities and the underlying infrastructure, multiple markets, and multiple regulatory regimes and policies. Correspondingly, the process of designing viable business models that can exploit multi-commodity energy systems successfully are even more complex.

In this chapter, the business model design framework for viability is applied to design and evaluate a business model for an industrial park with a multi-commodity energy system in the north of The Netherlands. The industrial park has one heat consumer, one potential new firm which is exploring the option to relocate to the industrial park, and a municipal solid waste incinerator. The industrial park wants to transition to a multi-commodity energy system where flexibility is the key value driver. By doing so, they hope to create value for all the stakeholders involved in the business model, consequently attracting many more energy-intensive industries.

This chapter is largely based on publication [5] referenced in Section ., and is organised as follows: Section 5.2 presents a literature review on research related to business models of multi-commodity energy systems. Section 5.3 provides an overview of the methodology. Section 5.4 presents the application of the business model design framework for viability to design and to evaluate a business model for the industrial park. The business model is presented to two experts for evaluation. Section 5.5 reflects on the validity of the business model design framework for viability. The final section presents the conclusion.

5.2 Related work

This section reviews literature related to the design of business models for multi-commodity energy systems. Extant literature mainly focuses on designing and validating multi-commodity energy systems using techno-economic models. Bachmaier et al., in [124], focus on choosing optimal locations for realising thermal storage capacity in district heating networks that utilise excess heat produced by combined heat and power units (CHPs). The CHPs, in turn, will focus on providing balancing services. They have developed a techno-economic model that optimises the location, size, and operation of the thermal storage by minimising CAPEX and OPEX and maximising revenue on the electricity markets.

Fabrizio, Corrado, and Filippi in [125] have developed a techno-economic modelling approach for multi-commodity energy systems for buildings. It is intended to be used at the conceptual phase of designing multi-commodity energy systems. The modelling approach can be used to determine the optimal configuration of the multi-commodity energy system. The approach focuses on minimising initial investment costs, use of non-renewable energy sources, and life-cycle costs.

In [126], Dall Ánese, Mancarella, and Monti make a case for techno-economic models that facilitate the process of optimising multi-commodity energy systems across multiple spatiotemporal scales to maximise socioeconomic, operational efficiency, and environmental benefits by leveraging the flexibility of the various controllable assets.

In summary, the focus is on designing multi-commodity energy systems using techno-economic models, with some attention to the business cases. A techno-economic model is an important part of a viable business model, but it does not necessarily lead to one. The techno-economic models ignore important aspects, such as the viability of the stakeholders in the business model, service concept, business rules, etc. Hence, the business model design approach has largely been ignored in the context of multi-commodity energy systems.

5.3 Methodology

Given the objective of this chapter, an industrial park located in the north of the Netherlands was chosen as a case study. The chosen case is a complex multi-commodity energy system with an increased number of stakeholders with competing interests, dynamic interactions between the commodities and the underlying infrastructure, and multiple regulatory regimes (i.e., heat and electricity regimes). To add to the complexity, the stakeholders want to specifically shift their business where flexibility is the key value driver. The willingness of the industrial park to participate in the research also played an important role in selecting the case study.

The following steps were followed to design the business model for the industrial park. First, a literature review was performed to set the foundation and to understand the state of the art in the domain of multi-commodity energy stems. Second, interviews and existing multi-commodity business models (greenhouse clusters) that also exploit flexibility were used as an input to design the business model. Descriptions of the BMs of the relevant greenhouse clusters in the Netherlands were created because they are frontrunners in the area of multi-commodity energy systems (for more information see [127]). Third, the existing business model of the industrial park was benchmarked with the reference business models of the multi-commodity business models of the greenhouses, and a set of lessons learned were distilled and used to create the first iteration. Fourth, the business model design framework for viability was used to design the business model. The application of the framework starts with a high-level description of the business idea. Next, the business model was designed from the following four perspectives: service/product, focal actor, business ecosystem, and technology.

Table 5.1 gives an overview of the modelling techniques and the business model ontologies used to operationalise the four perspectives:

Table 5.1 Business model ontologies and the modelling techniques used to operationalise the four perspectives

Perspective	***Business modelling ontology/modelling technique***
Service/product	System platform
Focal actor	Business model canvas
Business ecosystem	e3-value
Technology	Information services modelling technique and block diagram

Following the design activity, the resulting business model was evaluated by experts. Finally, a reflection on the validity of the business model design framework for viability is presented.

In order to evaluate the output of the business model design framework for viability (i.e., the business model for the industrial park), this research makes use of expert opinion, which is a well-established method for evaluating business models [44]. Two experts evaluate the BM. One is an academic whose research focuses on developing techno-economic models in the energy industry. The other expert works as an enterprise architect in the domain of smart grids and telecommunications.

For data collection purposes, two researchers conducted semi-structured interviews with four experts. From the interviews, it was obvious that flexibility is a key value driver in multi-commodity energy BMs. The experts were selected based on their ability to provide insights into current practices and into ongoing trends and developments. One of them, an expert in the energy markets, provided us insight into how flexibility could be exploited in markets and the necessary trading strategies. Two experts work for a distribution system operator, and they supplied information on the general trends in the energy transport infrastructure and the innovative services they are developing that exploits flexibility. One of them is a product development manager for an energy services company that provides aggregator services to the agriculture sector. The expert gave us insights into their BMs, existing services, services under development, and the technical architecture needed to support these services. Additionally, the researchers also met relevant stakeholders at the industrial park five times for setting up scope, requirements gathering, data collection, and business model evaluation. The interviews and meetings lasted from about 45 mins–1:30 hrs. Additionally, several emails were exchanged on an ad hoc basis for information gathering and necessary clarification. Secondary sources of data were also used, such as the academic literature, websites, reports, and online documents.

5.4 Designing and evaluating the business model using the business model design framework for viability

This section illustrates how the business model design framework for viability is applied to design and evaluate the business model for the industrial park.

5.4.1 Step 1 - Introduction to the business idea

The case study involves an industrial park that includes a municipal solid waste incineration plant producing energy and two heat consumers. One heat consumer is already located at the industrial park and consumes high-quality steam (175^{o}C), and the other one is a potential new firm that is similar to the existing consumer. Table 5.2 provides a summarised stakeholder analysis. Processing solid waste is the core business of the municipal solid waste incineration plant. The resulting energy products include electricity, biogas, and heat (steam) of different qualities. It currently sells the electricity on the forward and day-ahead markets and retails the steam to nearby industries. The incinerator is confronted with changes in the municipal solid waste sector and the energy market that has triggered an investigation of alternative business models. The amount of waste to be incinerated is decreasing due to improving recycling technologies, while the average price on the Dutch electricity markets is decreasing as well. Additionally, the increasing amount of renewables in the electricity system only increases the demand for flexibility to balance supply and demand, which is reflected in the volatile prices for electricity. This creates new business opportunities for market parties such as the municipal solid waste incinerators — if these parties can react flexibly to prices in the electricity market.

Hence, the incineration plant wants to change their business model so that flexibility becomes the key value driver. The municipality solid waste incinerator wants to explore flexible operation by interlinking heat and electricity commodities. The flexibility stems from the heat consumer's ability to increase or decrease steam consumption and the municipality solid waste incinerator's ability to change the ratio of steam that is converted to electricity and the steam that is supplied to the heat consumers. The *business idea* is that the ratio between electricity and steam supplied is determined by the electricity market prices on the day-ahead, intraday, and balancing markets and the availability of flexibility. When electricity prices increase beyond the threshold price, more electricity will be produced and less steam will be supplied to heat consumers (and vice versa).

Table 5.2 Summarised stakeholder analysis for the industrial park business ecosystem

Stakeholder	Goals	Value proposition	Roles and responsibilities
Municipality solid waste incineration plant	Attract new heat customers; increase energy efficiency; maximise profit by providing flexibility	Maximise revenue by exploiting flexibility	**Energy producer -** optimise production and supply of steam and electricity; sale of energy **Internal aggregator –** set up and operate the necessary information services; accounting for energy supplied/consumed and flexibility traded (clearinghouse services)
Industrial customers	Minimise energy costs	Obtain additional revenue by trading flexibility	**Flexible consumers** - actively manage heat consumption Trade flexibility on the internal trade platform

Table 5.2 Continued

Programme responsible party (PRP)	Maximise profit; Balance portfolio; Collect flexibility to trade on the imbalance	Flexible controllable load (<= 4 sec response time)	**PRP**- balance portfolio Report E-programmes to the TSO Trade on imbalance market Internal balancing activities / acquire flexible assets that can be controlled via an external aggregator. **External aggregator** - collect flexibility on an electronic platform Trade available electricity optimally Send control signals based on trades executed
Transmission grid operator (TSO)	Maintain grid balance (transmission grid)	Help maintain grid balance	Transmission service System service Operate balance market mechanism
Distribution grid operator (DSO)	Maintain grid balance (distribution grid)	Help maintain grid balance	Transmission service

5.4.2 Step 2 - Business model perspectives

Following the business model design framework for viability, the four perspectives are synthesised.

Service/product perspective

The business model design framework for viability requires a clear conceptualization of the service concept, as it provides a description of what value is created for the consumer and how it is to be done. It also helps to create a common understanding of the service among the stakeholders who are going to be involved in providing this service. Designing a crisp service concept also sets the stage for further designing the business model. The service concept as described below was developed in collaboration with the stakeholders who are involved in this business model.

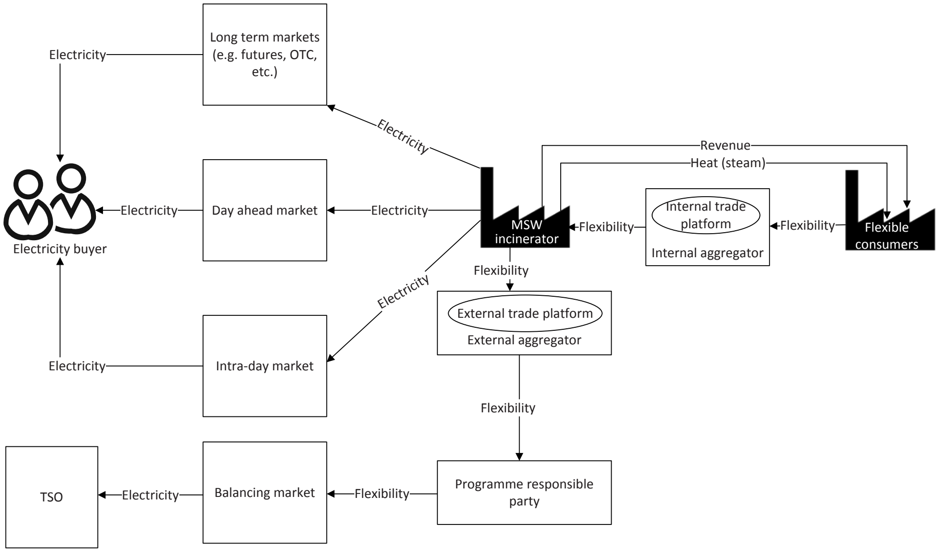


Figure 5.1 System platform - service concept for the industrial park. The figure depicts the different stakeholders, entities, and transactions among them. On the right are the flexible consumers who trade their flexibility on an internal trade platform owned and operated by the internal aggregator. The municipal solid waste incinerator then leverages the flexibility offered to take advantage of the trading opportunities in the long-term, day-ahead, and intra-day markets. Additionally, the municipal solid waste incinerator also trades flexibility on the balancing market via the external aggregator and the programme responsible party.

The service targets three customer segments, namely the electricity buyer, the programme responsible parties[2] (PRPs), and the flexible heat consumers. The electricity buyers are traders who want to buy and sell electricity via the energy markets. The PRPs require flexible loads that they can control within 30 seconds. They use this flexibility to balance their portfolio of producers and consumers and to trade in the balancing market. The flexible heat consumers can earn additional revenue by trading their flexibility. The heat consumers located at the industrial park sign long-term contracts with the municipality solid waste incineration plant for supply of steam at a fixed price. Additionally, the consumers are flexible in their heat consumption and offer their flexibility (in terms of increase or decrease in consumption quantity, and price per 15 mins) to the municipality solid waste incineration plant via an internal electronic trade platform. This platform

2 A programme responsible party is responsible for the e-programmes that specify how much electricity their customers expect to put in or take out of the grid every day. At the end of the day, the PRPs measure their customers' actual consumption and submit it to the TenneT [130].

allows for scalability and efficiency by introducing a market mechanism. The plant then sells the flexibility in terms of electricity on the different commodity markets directly and to the balancing market via the external aggregator's trade platform. The external aggregator is an emerging role, and it is usually performed by the PRP. However, for conceptual clarity, the external aggregator is modelled as a separate entity. The external aggregator aggregates flexibility from several energy producers and consumers and offers it to the PRP [128]. The PRP, in turn, uses this flexibility to trade on the balancing market.

Table 5.3 presents an overview of the trading strategy that will be adopted by the municipality solid waste incinerator.

Table 5.3 Trading strategy of the municipal waste incinerator for electricity on the energy markets

Order →	**APX day-ahead**	**APX Intra-day**	**Balancing (via PRP)**
Method	Optimise energy production and consumption to day-ahead market	Upregulate (extra trade compared to APX position)	Up- or downregulate (extra trade compared to APX position)
Closing time	24 hrs	5 mins	15 min
Platform	APX trading	APX trading	External

Design choices and elements of business model design: This section describes the design choices and the elements of business model design that significantly affect the service perspective. The goal here is not to be exhaustive but to illustrate the importance of design choices and the elements of business model design for a viable business model. For more details see [127].

The configuration techniques are used to synthesise the above service perspective; in particular, the deconstruction and reconstruction technique is used. This technique involves deconstructing the existing value chain into its key value creation activities by introducing new innovations and reconstructing the value chain in a novel combination such that it offers superior value and/or superior cost advantage [24], [96]. The value chain at the industrial park is deconstructed into key value creation activities, such as the production of steam and electricity. Next, the innovations are introduced, for example, the electronic trade platform and transactions that trade flexibility and reconstruct the value chain in a way that it provides flexibility and additional revenue. Reference business models, i.e., the energy business models of the Dutch greenhouses, were created to perform the deconstruction/reconstruction activity. Understanding similarities and differences between the industrial park and the greenhouse clusters, and distilling a set of lessons learnt, provides invaluable input for the design activity. For the aim of this thesis, it suffices to mention that the greenhouses actively manage their energy consumption. The greenhouses also extensively use the internal and external aggregators' trade platforms to trade flexibility among themselves, as well as with the PRP. Additionally, they also trade electricity on several markets, for instance, the forward, day ahead, and intra-day markets.

Another design choice that affects the service perspective is how the balancing market is approached. The two main ways to access it are the active and passive balancing approaches. The analysis of the business rules showed that adopting the active balancing approach would render the service concept unviable for reasons such as minimum install capacity needed (60 MW or higher) and the standby capacity they have to make available at all times to provide flexibility. Hence, the passive balancing approach was chosen. Consequently, the choice to access the balancing market via the PRP and the external aggregator's trade platform was made.

Focal actor perspective

It is important to design the business model from the focal actor's perspective because the focal actor plays a pivotal role in crafting the business ecosystem, and the business model is anchored on the focal actor. Designing the business model from this perspective is usually also easier to perform before designing the business ecosystem. It also provides inputs for designing the business ecosystem by identifying the key partners, key value creation activities, and the value proposition. The rest of this section will focus on the key elements of the municipality solid waste incinerator's business model, because this is the focal actor.

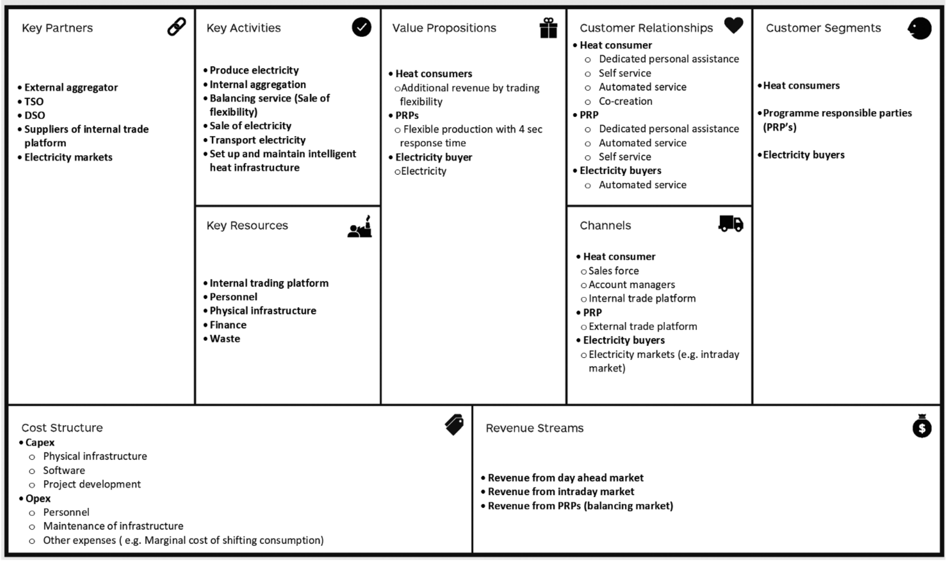


Figure 5.2 Business model canvas - business model from the municipality solid waste incineration plant's perspective

Figure 5.2 presents the business model from the focal actor's perspective. The municipality solid waste Incinerator targets three customer segments, namely the heat consumers, the PRPs, and the electricity buyers. On the one hand, the heat consumers have valuable flexibility embedded in their industrial processes, but currently they have no feasible way of trading flexibility to earn additional revenue. On the other hand, the PRPs want affordable, on-demand flexibility. The municipality solid waste incinerator is in a unique position to harvest the flexibility embedded in the industrial process of the heat consumers and supply it to the PRPs in a way that creates value for all of the stakeholders. Additionally, it can also exploit this flexibility by selling more electricity to the electricity buyer on the day ahead and on the intraday markets, when the prices are high and less steam is supplied to the heat consumers and vice versa. To deliver the above value propositions, the municipality solid waste incinerator needs to perform value creation activities, attract partners and resources, establish and maintain relationships and channels, and define cost structure and revenue streams, as described in Figure 5.2.

Design choices and elements of business model design: The design principles influence the focal actor's perspective. In particular, the coherence design principle has led to design choices that have defined the building blocks that synthesise the focal actor perspective. The coherence principle states that all of the perspectives and the underlying business model ontologies and building blocks should align [24]. For example, to offer the PRPs flexible production and to offer the heat customers additional revenue, the municipality solid waste incinerator should perform corresponding value creation activities that will facilitate the process of harvesting and exploiting flexibility (for instance, internal aggregation, the sale of flexibility to the PRPs, etc.).

Business ecosystem perspective

The crux of the business ecosystem perspective is that the focal actor alone lacks the resources or the capacity to implement complex business models such as that of multi-commodity energy systems. Hence, those in charge of the municipality solid waste incinerator need to work cooperatively with other stakeholders in a business ecosystem setting. For the ecosystem to be viable, each stakeholder should create, deliver, and capture value to render the ecosystem viable as a whole, as well as the business models of the individual stakeholders. Therefore, it is crucial for the business model designer to synthesise the business ecosystem perspective.

The industrial park as a whole should be able to convert steam to electricity and adapt the steam consumption to exploit flexibility on the energy markets successfully. It can achieve this in a business ecosystem setting where flexible heat consumers are connected to the energy markets via a complex interplay of stakeholders and value exchange relationships. In this business ecosystem, each stakeholder performs certain roles and assumes certain responsibilities, as well as the corresponding set of value creation activities. Furthermore, each of these stakeholders must be viable. Representing the business model found to be viable, Figure 5.3 depicts the business ecosystem perspective. It also provides an overview of the value creation activities performed by the actors and the value exchange relationships among them.

Table 5.2 presents a list of stakeholders, their goals, value propositions, and roles and responsibilities. The stakeholders were identified based on the service and the focal actor's perspective. Understanding the stakeholders' goals helps design value propositions for each of them. Additionally, it helps design the business ecosystem with appropriate value exchange relationships and assigned roles and responsibilities.

Design choice and elements of business model design: The role of the internal aggregator was assigned to the municipality solid waste incineration plant (design choice), because of two strategic reasons. The first is their unique set of capabilities. Two, the presence of only two customers at the industrial park does not justify costs related to creating a separate entity that performs the role of the internal aggregator. In addition to its existing relationships with PRPs, the unique capabilities of the municipality solid waste incinerator are the ability to regulate steam supply and electricity production, manage heat networks, and trade energy.

Another crucial design choice for the viability of this business model ecosystem is that the heat consumers have the autonomy to plan their heat consumption and trade their flexibility on the internal trading platform. To make this design choice, it was assumed that the heat consumers had the capability to manage their heat consumption and trade flexibility actively.

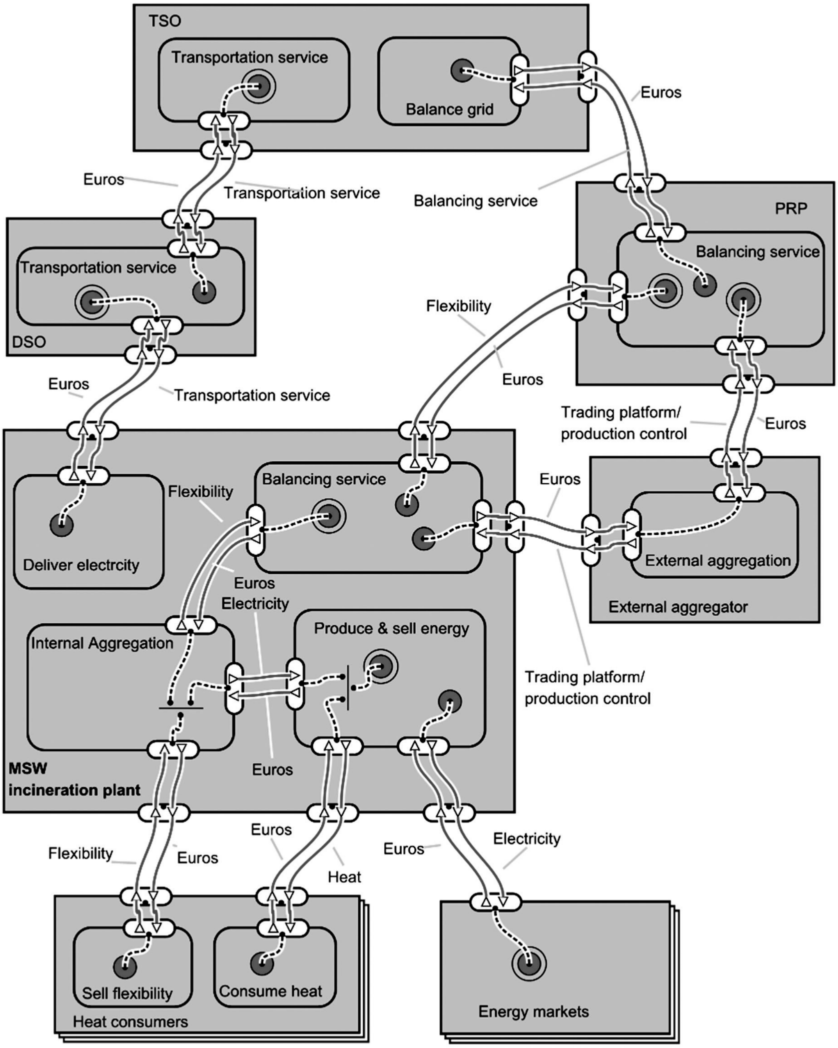


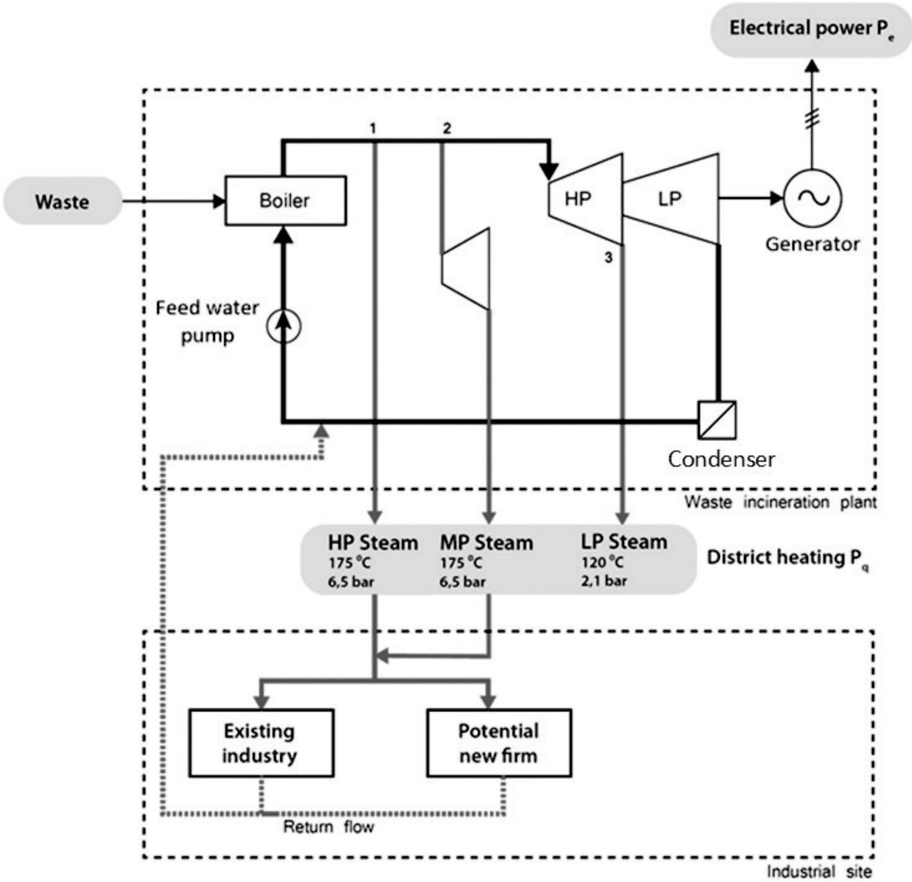
Figure 5.3 e-3 value business ecosystem perspective of the industrial park. The figure depicts the different stakeholders involved in the business ecosystem and the transactions among them. The municipal solid waste incinerator plays a central role here. It harvests the flexibility embedded in the heat consumer's industrial processes, converts it to electricity, and exploits it on energy markets and sells it to the programme responsible parties.

Technology perspective

The technology perspective describes the underlying technology architecture that supports the business model and how the technological components fit together in a multi-stakeholder environment. This perspective helps to assess if the envisioned technological solution is acceptable to the stakeholders and if it enables the provision of the service. In the context of the energy business models, the business model design framework for viability recommends describing technology architectures in terms of a *physical technologies architecture* and an i*nformation services architecture.*

Physical technology architecture: Figure 5.4 presents a high-level description of the physical technologies architecture. The process of producing steam and electricity starts by feeding waste into a boiler that produces steam. The steam is led through the high pressure (HP) and low pressure (LP) turbines. It is then converted to electricity at the generator.

The remaining steam is condensed using a condenser and pumped back into the boiler using a feed water pump. The steam is extracted at different points in the steam cycle (1, 2, and 3 in Figure 5.4), which allows the municipality solid waste incinerator to supply steam at different temperatures and pressures. The industries require steam at 175^{o}C /6-7 bar. Steam is therefore extracted at point 2 and led through a backpressure turbine that reduces the temperature and the pressure to required levels. When the demand exceeds supply, additional steam is extracted from the high-pressure point (point 1). Here, temperature and pressure are brought down from 400^{o}C/40 bar to 175^{o}C/6-7 bar by leading it through a pressure reducer. The steam is transported through a pipeline to the industries. The steam controller that controls the flow of steam at points 1 and 2 receives control signals to regulate the flow of steam from the information services architecture. For more details on the physical technology architecture, see [127].



HP- High pressure; LP- Low pressure

Figure 5.4 Block diagram: physical technology architecture of the industrial park. On the left waste is burned by feeding it into the boiler. High-quality steam is produced, which is then led into the turbines to produce electricity. At points 1 & 2, steam is extracted to supply to heat consumers, that is, the potential new firm and the existing industry.

Information services architecture: The information services architecture describes the information services necessary to support the business model, how the different components are configured, and the information flows among the stakeholders. The objective here is not to be exhaustive but to highlight the most important aspects.

The information services conceptualised below were based on the business processes specified by several actors. A discussion on these business processes is beyond the scope of this thesis. A detailed description of the processes above can be found in [128]–[133].

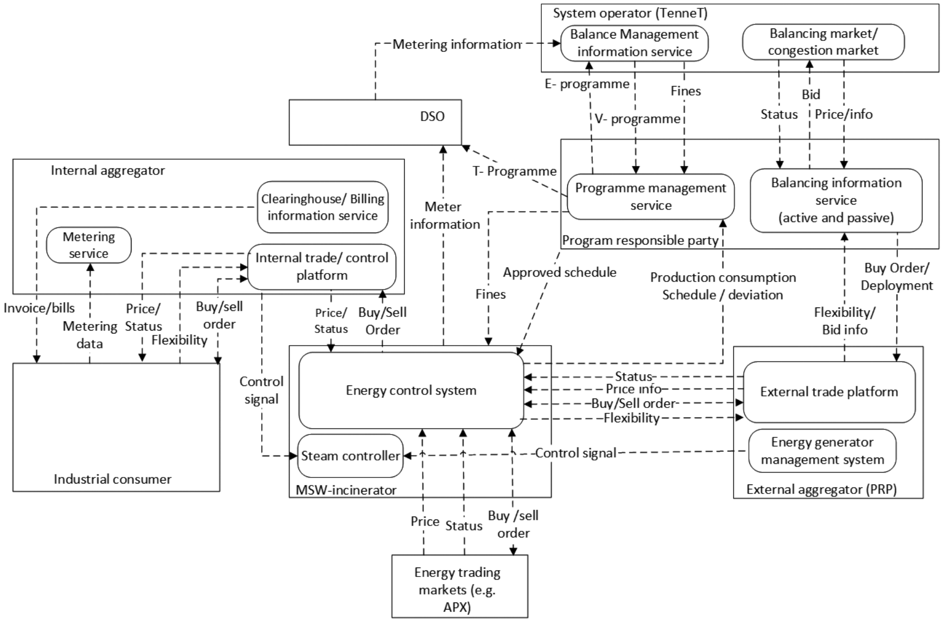


Figure 5.5 Information services modelling technique / information services architecture. The figure above depicts the distribution of information services and information flow among the stakeholders necessary for a viable business model. The key to this business model is that the industrial consumers (heat consumers) can communicate the amount of flexibility they have and at which price they are willing to trade their flexibility. The municipal waste incinerator uses this information to convert the flexibility to electricity and trade it on the different energy markets and with the programme responsible party via the external aggregator's trade platform.

Figure 5.5 depicts the information services operated by different stakeholders. The key components of the service are the internal and external trade platforms. The internal trading platform aggregates the flexibility available at the industrial park and offers it to the municipality solid waste incinerator, which in turn trades it on the energy markets and offers the flexibility to the PRP. The internal trade platform is operated by the internal aggregator (i.e., the municipality solid waste incinerator). The internal aggregator controls the flow of energy based on the trades executed and also provides clearing, billing, and metering services. The flexible consumers submit bids to the internal trade platform. The municipality solid waste incinerator then chooses offers on a cost-based merit order up to the point that its plant has reached its maximum capacity. Additionally, it sends control signals to the steam controller that regulate the amount of steam based on the trades executed on the internal trade platform. The trading platform also sends necessary information internally to the clearinghouse/billing information service. Nevertheless, for the sake of simplicity, the internal information flows are not modelled. On the external trading platform, the flexibility of several producers and consumers is aggregated and offered to the PRP. The producers offer their flexibility via the external aggregator's trade platform. The PRPs purchase the required flexibility at suitable price points on the trading platform. Table 5.4 presents a detailed overview of the different elements of the information services architecture and how they are configured.

Table 5.4 Stakeholders and corresponding information services

Stakeholder	***Description***	***Assigned to***
Internal aggregator	The internal aggregator owns and operates three main information services: Internal trade platform (E-web) – aggregates bids, executes trades, relays relevant information to relevant services; Metering services – collects consumption data and relays information to clearinghouse/billing information service; Clearinghouse/billing information services – generates appropriate bills and reconciles production, the flexibility offered/purchased, and consumption/supply.	Municipality solid waste incineration plant
Energy producer	The flexible producer owns and operates the following information services: Energy control system – continuously monitors the prices on the trading platforms (such as the external aggregators platform) and executes profitable trades. Steam controller – regulates the flow of the steam to the turbine and heat extraction points.	Municipality solid waste incineration plant
Flexible heat consumers	Register flexibility on the internal trade platform. The meters installed on the prosumers' premises transmit metering data to the internal aggregator.	Industries

Table 5.4 Continued

External Aggregator	The external aggregator owns and operates two information services External trading platform – collects flexibility from several actors and offers it to the PRP Energy generator management system – sends control signals to the steam controller based on the trades executed on the trading platform.	PRP
Programme responsible party (PRP)	The programme responsible party owns and operates two information services Balancing information service – constantly monitors the imbalance market prices and the prices on external aggregator's trade platform Programme management service – collects production and consumption schedules from producers and consumers	Can be taken on by any licensed PRP
Transmission system operator (TSO)	The system operator owns and operates two relevant information services Balancing market Balance management system collects and manages e-programmes. In addition, the system also cross verifies the actual production and consumption against the submitted programmes. It calculates fines accordingly and communicates them back to the PRPs. For more information see Wismans et al. (2010).	TenneT
Distribution system operator (DSO)	The DSO receives the meter data from the flexible producer. This is mainly read from a meter installed on energy producer's premises. The DSO stores this information in a CAR database, which is then made available to the TSO and the energy supplier.	Enexis

Design choices and elements of business model design: The technological architecture should be able to regulate the electricity production as per the *business rules* specified by TenneT and the PRP. The capability to regulate electricity production requires changes to the technological architecture of the industrial park (such as the intelligent steam controllers that can control the flow of steam based on control signals received from relevant stakeholders). Hence, in consultation with the stakeholder, the *assumption* was made that the technological architecture can regulate the electricity production as necessary.

5.4.3 Step 3 - Is the business model viable?

This section evaluates the viability of the designed business model from the four perspectives, because if any one of them is not viable, the business model will not be viable. The designed business model was presented to two experts for evaluation. During the evaluation process, the experts considered aspects such as the following: How realistic are the perspectives? Are the design choices valid and logical? Are the elements of business model design valid? Can the business model be viable?

The experts were also given additional information related to the financial value that each stakeholder would potentially capture from this business ecosystem. A techno-economic model was developed that simulates the trading strategies presented in Table 5.3**.** Such a model helps to estimate the potential financial value that can be captured from the business ecosystem. The prices of the day ahead, intra-day, and balancing market for the year 2015 were used to estimate the earnings. The earnings were then extrapolated over the next ten years. Furthermore, a scenario analysis was performed by developing a best case, most likely case, and worst case scenario to account for uncertainties and risk, as depicted in Table 5.5 and Table 5.6. The scenario analysis was performed both on exchange value and use value. For more details on the simulation and scenarios, see [127].

Table 5.5 Best case, most likely case, and worst case scenarios of exchange value for the municipal solid waste incinerator

Variables	*Best case*	*Most likely case*	*Worst case*
Net present value for the industrial park	*€ 471.759*	*€ 20.456*	*€ -467.134*
Lifetime (years)	*10*	*10*	*10*
Cost of capital/ year	*6.72%*	*8%*	*10%*
Capex/ year	*€ 600.000*	*€600.000*	*€650.00*
Opex/ year	*€ 139.749*	*€ 157.776*	
Total revenue/ year	*€320.583*		
Tax rate	*25*		
Depreciation			

Table 5.6 Best case, most likely case, and worst case scenarios of use value for the municipal solid waste incinerator

Use value	*Worst case*	*Most likely case*	*Best case*	*Units*
CO_2 avoided	152.887.188	154.448.363	156.009.538	Kg CO_2 /Year
Job created	1	1	1	Fte

Table 5.7 Exchange value captured by the stakeholders in the industrial park business ecosystem

Actor	*NPV*	*Revenue*
MSW-incenaration plant	*6.819 €*	*87.201 €/year*
Heat consumer-1	*6.819 €*	*87.201 €/year*
Heat consumer -2	*6.819 €*	*87.201 €/year*
PRP	*NA*	*50.341 €/year*
Intraday market	*NA*	
External aggregator	*NA*	
Day ahead market	*NA*	
TenneT		
DSO		

The analysis shows that the viability of the business model is sensitive to the CAPEX and the OPEX. It is also sensitive to the price volatility of the electricity markets and the availability of flexibility. The viability of the use values, in particular the CO_2 avoided, is largely sensitive to the amount of heat consumed. The higher the amount of heat consumed, the higher the amount of CO_2 avoided. The estimation of the avoided CO_2 includes the direct emissions only.

The amount of CO_2 avoided is a result of the displacement of energy produced by other fossil fuels. However, this does not mean that combusting municipal solid waste does not emit CO_2. Combusting one tonne of MSW emits approximately 2700 Kg CO_2 [134]. This emission is not considered while accounting for use value because the CO_2 will be emitted irrespective of the heat and electricity produced from the municipal solid waste, as the waste must be burnt.

Table 5.8 Expert evaluation of the four perspectives for viability

Evaluation criteria	***Expert 1***	***Expert 2***
Viability of the service concept	+	++
Viability of the focal firm	+/-	+/-
Viability of the business ecosystem	+/-	+/-
Viability of the technology architecture	++	+
Overall viability of the business model	**+/-**	**+/-**

++ very positive; + positive; +/- neutral; - negative; -- very negative

The above table shows that experts evaluated the service concept and technology architecture positively. Moreover, service concepts and information services as conceptualised above already exist for the greenhouses, such as Agro energy's flex products [135]. However, both experts have a neutral position towards the viability of the focal firm, and consequently the viability of the business ecosystem. The experts had doubts about the profitability of the focal actor because of the risks involved in trading on the short-term energy markets and the uncertainties around the investment necessary in the physical technologies for automating the process of routeing the steam between the steam turbine and heat consumers. Moreover, both experts concurred with the sensitivity analysis that if the volatility and the quantity of flexibility sold on the markets increased, the viability of the business model would improve. Consequently, the municipal solid waste incinerator and its heat customers will have to trade more flexibility, either by increasing the flexibility they offer or by attracting more flexible heat consumers to the industrial park. Expert 1 was very positive about the technological architecture and thought it definitely viable. Expert 2 was a little less positive because he was not entirely sure about the municipal solid waste incinerator's technological capability to increase or decrease the production of electricity within the specified time constraints. The experts were of the opinion that the business model is interesting and should be further investigated, especially considering the growing need for flexibility. Future investigations should focus on obtaining exact cost estimations from potential suppliers as well as a deeper understanding of the municipal solid waste incinerator's technological capabilities to regulate the production of electricity within the specified time constraints.

The municipal solid waste incineration plant and its partner firms are currently exploring how to implement the above-designed business model. They are assessing their capabilities, such as the ability to regulate the amount of electricity they produce within the time constraints. Besides, the business model had yet to be presented to higher management.

5.5 Reflection on the validity of the business model design framework for viability

For the business model design framework for viability to be valid, it has to meet its objective [30], [34], which is to successfully facilitate the design and evaluation of a viable business model for multi-commodity energy systems. Therefore, this section reflects on how the business model design framework for viability facilitated the process of designing and evaluating the viable business model and on the validity of the business model design framework for viability.

Applying the business model design framework for viability to design and evaluate the business model for the multi-commodity energy system was a complex, challenging, and iterative process. Even though it provides several constructs to facilitate the design process of a viable business model (e.g., elements of business model design, design choices, and perspectives), it largely remains a creative process. Nevertheless, it provides the business model designer with a structured and systematic way to approach the design and evaluation process. It also provides the designer with tools such as configuration techniques and evaluation criteria, which significantly facilitate the design and evaluation of viable business models.

Adopting a clean slate approach to designing business models for complex systems such as multi-commodity energy systems can be extremely difficult. Hence, using the business model design framework for viability, which facilitates learning from other multi-commodity energy systems, greatly facilitated the design process. The reference model technique helped to clarify the value creation logic of other multi-commodity energy systems. The technique provided the business model designer with a good starting point to design the business models. As a deduction, the activity of reference models of similar business models was useful. Furthermore, the evaluation criteria — in particular the capabilities criteria — clearly led to a critical evaluation by the experts.

The business model design framework for viability deconstructs the complexity of the design process into four perspectives. Moreover, it systematically stores the design choices and the motivation behind them in a transparent and traceable manner. Additionally, elements such as configuration techniques facilitate the design process by creating reference models of successful business models that are similar. The framework also facilitated a holistic approach to value by helping to evaluate the viability of the business model in terms of use and exchange values. Hence, the business model design framework for viability facilitates the process of designing business models of multi-commodity energy systems in a systematic, transparent, and traceable manner.

As demonstrated above, the business model design framework for viability was able to facilitate the design of a business model and identify the conditions under which it could potentially be viable (for instance, the market conditions, and technological capabilities). From the following statements, it is clear that the business model design framework for viability describes the business model in a clear and understandable manner, while facilitating the design of realistic business models in a transparent and traceable manner. "*I think this..... a realistic* [business] *model.......We did some other analysis which showed something similar*" – Expert 1. "*The* [business model] *idea seems promising. The extent to which profits are made depends on the circumstances and agreements.*"– Expert 2. The experts also found the four perspectives synthesised using the business model design framework for viability to be useful and were of the opinion that using them leads to a more complete description of the business model. They also thought that the *design choices* and the *elements of business model design* contributed towards a realistic business model design.

The business model design framework for viability is an extensive method that has proven to effectively grasp and deal with the complexity of multi-commodity energy systems. However, the use of all four perspectives to design and evaluate simple business models might be excessive. Nevertheless, the business model design framework for viability is a useful tool for designers and analysts for designing and evaluating business models of multi-commodity energy systems. Based on the above analysis, the business model design framework for viability is successfully corroborated for designing and evaluating business models for multi-commodity energy systems.

5.6 Conclusion

Chapter 5 answers research question SQ4: *"How to validate a framework for designing and evaluating a viable business model for energy enterprises in a business ecosystem?"* To answer SQ4, the business model design framework for viability was used to design a viable business model for a multi-commodity energy system.

The business model was designed for an industrial park in the north of the Netherlands. The industrial park is a multi-commodity energy system with multiple stakeholders who want to shift their business model where flexibility is the key value driver.

The application of the business model design framework for viability to design the viable business model was successful. The four business model design perspectives were useful in approaching the business model design process systematically. The configuration techniques, in particular, the reference model technique, were very useful in creating the first iteration. Additionally, evaluating the capabilities of the stakeholders to implement the business model led to a critical evaluation of the business model. The critical evaluation by the experts shows that the business models designed using the framework provided them with in-depth insight into the business model, which allowed for a critical evaluation of its viability. The experts also found that the business model designed using the framework was realistic.

The industrial park did not immediately implement the designed business model. However, the stakeholders in the industrial park are assessing their capabilities to do so. Even though the business model was not implemented and operated by the stakeholders in the industrial park, the designed business model provides a clear and vivid description of how flexibility can be successfully harvested and exploited. Furthermore, the experts evaluating the business model thought that it had potential and the industrial park should investigate the designed business model further. Hence, the business model design framework for viability is successfully corroborated in the context of multi-commodity energy systems.

Chapter 6

Conclusion

6.1 Introduction

The energy industry is undergoing rapid change due to factors such as climate change, changing customer needs, the advent of new technologies, and changing government policies. To deal with these changes, energy businesses need to explore new business models that are different from their traditional ones. The energy businesses also need new business models to introduce new products and services into the market successfully. The success of these new models will depend on their ability to include a wider set of stakeholders and to create not only exchange (monetary) value but also a broader set of use values, such as social and environmental benefits. Consequently, energy businesses should be able to design, evaluate, implement, and improve their business models that create value for all the stakeholders involved such that they are motivated to be a part of the business model. The above context leads to the following research goal, which was to facilitate viable energy business models in a business ecosystem setting.

A review of existing business model ontologies shows that they do not sufficiently facilitate the design and evaluation of viable business models. Designing business models in a complex and systemic setting such as the energy industry requires the designer to approach the business model design process from multiple perspectives, such as the service/product, focal actor, business ecosystem, and the technology perspectives. The business model ontologies and modelling techniques usually adopt a single perspective for designing business models. Current business model ontologies largely ignore or inconsistently apply the elements of business model design such as design principles, configuration techniques, assumptions, and business rules. Furthermore, the systemic nature of the energy industry requires the business models to be inclusive of a broader set of stakeholders and to create a wider set of values than just exchange value (monetary value). It is crucial that the above shortcomings be addressed to facilitate the design and evaluation of viable business models.

Hence, there is a need for a comprehensive business model design framework for viability that can bridge the above deficiencies. The above context led to the main research question: RQ *"How to develop a validated framework for designing and evaluating viable business models for energy enterprises in a business ecosystem"*. The main research question was further split into the following four sub-research questions: SQ1, *"What are the requirements put on a framework to design and evaluate viable business models in a business ecosystem?"*; SQ2, "How to design a viable business model?"; SQ3, *"How to evaluate the designed business model for viability?";* and SQ4, *"How to validate a framework for designing and evaluating viable business models for energy enterprises in a business ecosystem?".*

Answering the four sub-research questions will answer the main research question. To answer research question SQ1, a review of the state of the art literature was performed to derive a set of criteria that an ideal tool for designing and evaluating viable business models should possess. Next, current business model ontologies were assessed against the derived criteria. The assessment process revealed that none of the business model ontologies fully supported the design and evaluation of viable business models. The derived criteria also function as input to develop the business model design framework for viability. To answer research question SQ2, a business model design framework for viability is proposed. The new framework is developed based on the criteria identified while answering SQ2. The newly developed framework approaches the business model design from multiple perspectives, adds the missing elements of business model design, and adopts a broader approach to value. To answer research question SQ3, the newly proposed framework is theoretically assessed against the criteria derived while answering question 1. The evaluation results showed that the business model design framework for viability satisfied all of the criteria. To answer research question SQ4, the business model design framework for viability was applied to design and evaluate business models for two case studies that included a mono-commodity energy system and a multi-commodity energy system. The business model design framework for viability successfully facilitated the process of designing and evaluating viable business models for both case studies.

As demonstrated in Chapter 4, the application of the business model design framework for viability to the mono-commodity energy system, the community-owned solar farm case, resulted in a viable business model. The framework facilitated a broader approach to value, allowing for the creation and capture of both use and exchange value. The four perspectives and the elements of business model design helped to design realistic, viable business models. The business ecosystem perspective and the eliminate waste configuration technique were very useful in exploring viable alternative configurations of the business model. The four perspectives, the detailed description of the design choices, and the description of the elements of business model design provided in-depth insight into the business model and facilitated a critical evaluation of the designed business model. Four experts evaluated the viability of the business model positively, although one of them expressed concerns about Grunneger Power's ability to perform energy retail activities in the business model. Grunneger Power did implement the designed business model; however, they soon made an iteration in their business model to avoid the risks identified by the expert during the evaluation process.

The application of the business model design framework for viability to design business models for more complex multi-commodity energy system was successful. The framework for viability was able to systematically handle the complexity of designing a viable business model for multi-commodity energy systems, with the reference model technique being particularly useful. This technique facilitates the process of learning from other successful multi-commodity energy systems. Furthermore, a description of the four perspectives, elements of business model design, and design choices facilitated the process of evaluating the business model. The description of the business model gave the experts the in-depth insight that led to a critical evaluation of it. The experts were neutral about the viability of the business model because there was some uncertainty about the technical capabilities of the municipal solid waste incinerator's ability to increase or decrease electricity and heat production based on supply and demand dynamics within the desired time constraints. Furthermore, the revenue in the business model largely depends on the price of electricity on the energy markets, their volatility, and the availability of flexibility. Nevertheless, the business model design framework for viability was able to provide sufficient insight into the designed business models to facilitate a critical assessment. The experts also thought that the designed business model was realistic. Hence, the business model design framework for viability was able to facilitate the design and evaluation of realistic business models.

The application of the business model design framework for viability was successful in both cases. The business model was also implemented in the case of the community-owned solar farm. Furthermore, the experts in the multi-commodity case thought that the business model designed using the framework was realistic. Therefore, the application of the framework leads to realistic business models. Hence, the business model design framework for viability is validated.

6.2 Reflection on the validity of the business model design framework for viability

The business model design framework for viability is more comprehensive than current business model ontologies and modelling techniques. From Table 2.10, it is evident that both usually approach the business model design from one perspective only. The results of the theoretical evaluation of the business model design framework for viability presented in Table 3.2 show that the framework addresses multiple perspectives, elements of business model design, design choices, and evaluation criteria that are ignored or addressed in a dispersed manner by current business model ontologies and modelling techniques. Moreover, the business model design framework for viability builds on well-established business model ontologies and modelling techniques by using them to operationalise the service/product, focal actor, business ecosystem, and technology perspectives. It leverages the strengths of the different business model ontologies and modelling techniques to create a more comprehensive description of the business models when compared to the descriptions created by the current business model ontologies. As a result, the business model design framework for viability provides deeper insights into the business models, which in turn facilitates critical evaluation of them. Therefore, the business model design framework for viability is more comprehensive than the current business model ontologies. From the above argument, it can also be concluded that the framework enables the business model designer to address business model design issues that would have otherwise been ignored or overlooked had current business model ontologies been used. Consequently, the business model design framework for viability is in a better position to facilitate the design and evaluation of viable energy business models in a business ecosystem setting. The mindless application of the business model design framework for viability will not lead to a viable business model. The business model design process is inherently creative and iterative, and like any other design tool, the result of applying the business model design framework for viability largely depends on the creativity and skill of the business model designer. However, the business model design framework for viability helps to approach the business model design process in a systematic, transparent, and traceable manner.

The business model design framework for viability has proven to be an effective tool for designing and evaluating energy business models in complex business ecosystem settings. As demonstrated in Chapters 4 and 5, the framework for viability could systematically handle the complexity of designing and evaluating viable business models in a business ecosystem setting. Its application also led to realistic business models. Grunneger Power implemented the output of the business model design framework for viability in Chapter 4, in the business model for the community-owned solar farm. After implementing the business model, Grunneger Power made another design iteration to their business model to outsource the energy retail activity to a new subsidiary called the NLD. NLD was formed to avoid the risks identified during the evaluation process of the business model. The iteration also shows how hard it is to design business models that require no tweaking once they are implemented. The experts evaluated the output of the business model design framework for viability in Chapter 5 positively. One of the experts believed the resulting business model for the industrial park to be realistic, and it was similar to an analysis performed by the expert. In both the cases in Chapters 4 and 5, the designed business models were clear and understandable, which allowed the experts to carry out a critical assessment of the business models. Hence, the business model design framework for viability is in a better position to facilitate the design and evaluation of viable energy business models in a business ecosystem setting than current business model ontologies. However, the application of the framework for designing and evaluating business models in simpler setting might be excessive.

In accordance with design science research principles, this research has contributed a validated meta artefact to theory, i.e., the business model design framework for viability.

6.3 Reflection on design science research

The design science research was very useful in developing the business model design framework for viability. Furthermore, the approach proposed by Peffers et al. [34] had a major influence on the formulation of the sub-research questions and the research design. The six phases helped guide the research systematically. The chosen approach emphasises the validation aspect of the design process by focusing on demonstration and evaluation. However, the approach largely ignores ex-post reflection on contributions to the body of knowledge. Of course, it can be argued that the approach allows for developing a validated artefact, which itself is a contribution to theory, and ex-ante reflection on the gap highlights the contribution to the body of knowledge. Nevertheless, not everything goes according to plan, and it is precisely in such situations that an ex-post reflection on the contribution to knowledge can be valuable.

The business models designed using the business model design framework for viability were evaluated using expert opinion. However, design science research provides no guidelines on the number of expert opinions necessary to evaluate the business models. Hence, the number of experts chosen to evaluate the business models was arbitrary. Guidelines on the above issue would greatly help researchers.

6.4 Future research

Future research should focus on more in-depth validation of the business model design framework for viability and its components in the energy domain. Thus far it has been applied by a limited user group; hence, future research should focus on multiple users testing the framework. Another interesting research question is if and how the business model design framework for viability is relevant for designing and evaluating viable business models for other domains in business ecosystem settings. For example, the health care sector has several similarities to the energy industry: it is heavily regulated; multiple stakeholders are involved; it is under increasing pressure to find new and innovative business models; and rapid technological innovations are occurring in the field.

References

[1] EIA, "International Energy Outlook 2016," 2016.

[2] M. Valocchi, J. Juliano, and A. Schurr, "Switching perspectives: creating new business models for a changing world of energy," in *Smart Grid Applications and Developments*, Springer, 2014, pp. 165–182.

[3] J. Elkington, "Cannibals with forks," *triple bottom line 21st century*, 1997.

[4] European Commission, "Paris Agreement - European Commission," 2016. [Online]. Available: https://ec.europa.eu/clima/policies/international/negotiations/paris/index_en.htm. [Accessed: 03-Nov-2016].

[5] European Commission, "Best practices on Renewable Energy Self-consumption." European Commission, Brussels, 2015.

[6] B. Edvardsson and J. Olsson, "Key Concepts for New Service Development," *Serv. Ind. J.*, vol. 16, no. 2, pp. 140–164, 1996.

[7] J. F. Moore, "Predators and Prey: A New Ecology of Competition," *Harv. Bus. Rev.*, vol. 71, no. 3, pp. 75–86, 1993.

[8] M. E. Porter and M. R. Kramer, "CREATING SHARED VALUE," *Harv. Bus. Rev.*, vol. 89, no. 1/2, pp. 62–77, 2011.

[9] D. P. Lepak, K. G. Smith, and M. S. Taylor, "VALUE CREATION AND VALUE CAPTURE: A MULTILEVEL PERSPECTIVE," *Acad. Manag. Rev.*, vol. 32, no. 1, pp. 180–194, 2007.

[10] A. Osterwalder and Y. Pigneur, "CLARIFYING BUSINESS MODELS: ORIGINS, PRESENT, AND FUTURE OF THE CONCEPT," *Commun. AIS*, vol. 2005, no. 16, pp. 1–25, 2005.

[11] J. Magretta, "Why Business Models Matter," *Harv. Bus. Rev.*, vol. 80, no. 5, pp. 86–92, 2002.

[12] D. J. Teece, "Business Models, Business Strategy and Innovation," *Long Range Plann.*, vol. 43, no. 2–3, pp. 172–194, 2010.

[13] A. Osterwalder, Y. Pigneur, and T. Clark, *Business model generation.* Hoboken, New Jersey: John Wiley & Sons, Inc., 2010.

[14] A. D'Souza, N. R. T. P. Van Beest, G. B. Huitema, J. C. Wortmann, and H. Velthuijsen, *A Review and Evaluation of Business Model Ontologies: A Viability Perspective.* Springer, 2014.

[15] H. Chesbrough, W. Vanhaverbeke, and J. West, *Open Innovation: Researching a New Paradigm.* Oxford University Press, 2006.

[16] R. Amit and C. Zott, "VALUE CREATION IN E-BUSINESS," *Strateg. Manag. J.*, vol. 22, no. 6/7, p. 493, 2001.

[17] A. G. Pateli and G. M. Giaglis, "A research framework for analysing eBusiness models," *Eur. J. Inf. Syst.*, vol. 13, no. 4, pp. 302–314, 2004.

[18] A. Osterwalder, "The business model ontology: A proposition in a design science approach," 2004.

[19] M. Lund and C. Nielsen, "The evolution of network-based business models illustrated through the case study of an entrepreneurship project," 2014.

[20] B. Demil and X. Lecocq, "Business model evolution: in search of dynamic consistency," *Long Range Plann.*, vol. 43, no. 2, pp. 227–246, 2010.

[21] A. D'Souza, N. R. T. P. van Beest, G. B. Huitema, J. C. Wortmann, and H. Velthuijsen, "An Assessment Framework for Business Model Ontologies to Ensure the Viability of Business Models," in *16th International Conference on Enterprise Information Systems*, 2014, pp. 226–235.

[22] J. Gordijn and J. M. Akkermans, "Value-based Requirements Engineering," VU University Amsterdam, Amsterdam, 2002.

[23] M. Uschold and M. Gruninger, "Ontologies: Principles, methods and applications," *Knowl. Eng. Rev.*, vol. 11, no. 2, pp. 93–136, 1996.

[24] A. D'Souza, J. C. Wortmann, G. Huitema, and H. Velthuijsen, "A business model design framework for viability; a business ecosystem approach," *J. Bus. Model.*, vol. 3, no. 2, pp. 1–29, 2015.

[25] J. Gordijn, A. Osterwalder, and Y. Pigneur, "Comparing two Business Model Ontologies for Designing e-Business Models and Value Constellations," *18th Bled eConference eIntegration in Action*. Bled, Slovenia, 2005.

[26] C. Weiller and A. Neely, "Business model design in an ecosystem context," *Univ. Cambridge, Cambridge Serv. Alliance*, 2013.

[27] "ISO/IEC/IEEE Systems and software engineering -- Architecture description," *ISO/IEC/IEEE 42010:2011(E) (Revision of ISO/IEC 42010:2007 and IEEE Std 1471-2000)*. pp. 1–46, 2011.

[28] J. A. Zachman, "A framework for information systems architecture," *IBM Syst. J.*, vol. 26, no. 3, pp. 276–292, 1987.

[29] P. B. Kruchten, "The 4+ 1 view model of architecture," *IEEE Softw.*, vol. 12, no. 6, pp. 42–50, 1995.

[30] A. R. Hevner, S. T. March, J. Park, and S. Ram, "Design science in information systems research," *MIS Q.*, vol. 28, no. 1, pp. 75–105, 2004.

[31] P. Offermann, S. Blom, M. Schönherr, and U. Bub, "Artifact types in information systems design science-a literature review," in *International Conference on Design Science Research in Information Systems*, 2010, pp. 77–92.

[32] J. Iivari, "Distinguishing and contrasting two strategies for design science research," *Eur. J. Inf. Syst.*, vol. 24, no. 1, pp. 107–115, 2015.

[33] V. K. Vaishnavi and W. Kuechler, *Design science research methods and patterns: innovating information and communication technology*. Crc Press, 2015.

[34] K. Peffers, T. Tuunanen, M. A. Rothenberger, and S. Chatterjee, "A design science research methodology for information systems research," *J. Manag. Inf. Syst.*, vol. 24, no. 3, pp. 45–77, 2007.

[35] S. Gregor and A. R. Hevner, "Positioning and presenting design science research for maximum impact.," *MIS Q.*, vol. 37, no. 2, pp. 337–355, 2013.

[36] P. Järvinen, "Action research is similar to design science," *Qual. Quant.*, vol. 41, no. 1, pp. 37–54, 2007.

[37] M. Sein, O. Henfridsson, S. Purao, M. Rossi, and R. Lindgren, "Action design research," 2011.

[38] J. Iivari and J. Venable, "Action research and design science research-Seemingly similar but decisively dissimilar.," in *ECIS*, 2009, pp. 1642–1653.

[39] J. Iivari, “A paradigmatic analysis of information systems as a design science,” *Scand. J. Inf. Syst.*, vol. 19, no. 2, p. 5, 2007.

[40] V. Belton and T. J. Stewart, *Multiple Criteria Decision Analysis: An Integrated Approach.* Kluwer Academic Publishers, 2002.

[41] J. Gordijn and J. M. Akkermans, “Value-based requirements engineering: exploring innovative e-commerce ideas,” *Requir. Eng.*, vol. 8, no. 2, pp. 114–134, 2003.

[42] M. Stickdorn and J. Schneider, *This is Service Design Thinking: Basics, Tools, Cases.* Wiley, 2012.

[43] Z. Kraussl, “OPerationalized ALignment: Assessing feasibility of value constellations exploiting innovative services,” Vrije Universiteit, Amsterdam, 2011.

[44] H. Bouwman, H. De Vos, and T. Haaker, *Mobile service innovation and business models*, vol. 2010. Springer, 2008.

[45] V. Allee, “A Value Network Approach for Modeling and Measuring Intangibles,” *The Transparent Enterprise. The value of Intangibles.* Madrid, Spain, 2002.

[46] P. Weill and M. R. Vitale, *Place to space: Migrating to eBusiness Models.* Harvard Business Press, 2001.

[47] M. Rother and J. Shook, *Learning to See: Value-Stream Mapping to Create Value and Eliminate Muda: Version 1.3 June 2003.* Lean Enterprise Institute, 2003.

[48] W. E. McCarthy, “The REA accounting model: A generalized framework for accounting systems in a shared data environment,” *Account. Rev.*, pp. 554–578, 1982.

[49] M. M. Al-Debei and D. Avison, “Developing a unified framework of the business model concept,” *Eur. J. Inf. Syst.*, vol. 19, no. 3, pp. 359–376, 2010.

[50] D. Tapscott, D. Ticoll, and A. Lowy, “Digital Capital: Harnessing the Power of Business Webs (Hardcover),” *Harvard Bus. Sch. Press Books*, p. 1, 2000.

[51] C. Zott, R. Amit, and L. Massa, “The Business Model: Recent Developments and Future Research,” *J. Manage.*, vol. 37, no. 4, pp. 1019–1042, 2011.

[52] M. Heikkilä, “Coordination of complex operations over organisational boundaries,” university of Jyväskylä, Jyväskylä, 2010.

[53] P. Ritala, V. Agouridas, D. Assimakopoulos, and O. Gies, “Value creation and capture mechanisms in innovation ecosystems: a comparative case study,” *Int. J. Technol. Manag.*, vol. 63, no. 3–4, pp. 244–267, 2013.

[54] D. Lavie, “Alliance portfolios and firm performance: A study of value creation and appropriation in the US software industry,” *Strateg. Manag. J.*, vol. 28, no. 12, pp. 1187–1212, 2007.

[55] J. Heikkilä, P. Tyrväinen, and M. Heikkilä, “Designing for performance-a technique for business model estimation,” in *EBRF 2010 conference proceedings*, 2010.

[56] W. Stubbs and C. Cocklin, “Conceptualizing a ‘sustainability business model,’” *Organ. Environ.*, vol. 21, no. 2, pp. 103–127, 2008.

[57] J. W. Ross, P. Weill, and D. C. Robertson, *Enterprise Architecture as Strategy: Creating a Foundation for Business Execution.* Harvard Business School Press, 2006.

[58] C. Bowman and V. Ambrosini, “Value Creation Versus Value Capture: Towards a Coherent Definition of Value in Strategy,” *Br. J. Manag.*, vol. 11, no. 1, pp. 1–15, 2000.

[59] A. D'Souza, H. Velthuijsen, J. C. Wortmann, and G. B. Huitema, "Developing a viable business model for community owned solar farms in the Netherlands," in *USE: Understanding small enterprises*, 2015.

[60] L. Massa, C. Tucci, and A. Afuah, "A CRITICAL ASSESSMENT OF BUSINESS MODEL RESEARCH," *Acad. Manag. Ann.*, p. annals-2014, 2016.

[61] J. Nicholls, E. Lawlor, and T. Goodspeed, "A guide to social return on investment ." The SROI Network Limited, p. 102, 2012.

[62] S. Gould, M. O. ' Sullivan, C. Tilley, and N. Topazio, "BUSINESS MODEL BACKGROUND PAPER," 2013.

[63] A. G. Pateli and G. M. Giaglis, "A Framework for Understanding and Analysing eBusiness Models," *16th Bled eCommerce Conference eTransformation.* Bled, Slovenia, 2003.

[64] B. W. Wirtz, A. Pistoia, S. Ullrich, and V. Göttel, "Business models: Origin, development and future research perspectives," *Long Range Plann.*, vol. 49, no. 1, pp. 36–54, 2016.

[65] G. George and A. J. Bock, "The business model in practice and its implications for entrepreneurship research," *Entrep. theory Pract.*, vol. 35, no. 1, pp. 83–111, 2011.

[66] H. Chesbrough and R. Rosenbloom, "The role of the business model in capturing value from innovation: evidence from Xerox Corporation's technology spin-off companies," *Ind. Corp. Chang.*, vol. 11, no. 3, pp. 529–555, 2002.

[67] A. D'souza, J. Kabbedijk, D. Seo, S. Jansen, and S. Brinkkemper, "Software-as-a-Service: Implications for Business and Technology in Product Software Companies," in *Proceedings of the Pacific Asia Conference on Information Systems (PACIS)*, 2012, p. Paper 140.

[68] D. Ma, "The business model of' software-as-a-service,'" in *Ieee international conference on services computing (scc 2007)*, 2007, pp. 701–702.

[69] R. Casadesus-Masanell and F. Zhu, "Business model innovation and competitive imitation: The case of sponsor-based business models," *Strateg. Manag. J.*, vol. 34, no. 4, pp. 464–482, 2013.

[70] V. Kumar, "Making'Freemium'Work," 2014.

[71] T. Helms, M. Loock, and R. Bohnsack, "Timing-based business models for flexibility creation in the electric power sector," *Energy Policy*, vol. 92, pp. 348–358, 2016.

[72] L. Hall, "IT Key Metrics Data 2013: IT Enterprise Summary Report," Gartner, Inc, 2013.

[73] S. Hall and K. Roelich, "Business model innovation in electricity supply markets: The role of complex value in the United Kingdom," *Energy Policy*, vol. 92, pp. 286–298, 2016.

[74] L. Okkonen and N. Suhonen, "Business models of heat entrepreneurship in Finland," *Energy Policy*, vol. 38, no. 7, pp. 3443–3452, 2010.

[75] M. E. Porter, "Strategy and the Internet," *Harv. Bus. Rev.*, vol. 79, no. 3, pp. 62–78, 2001.

[76] C. Zott and R. Amit, "Business model design and the performance of entrepreneurial firms," *Organ. Sci.*, vol. 18, no. 2, pp. 181–199, 2007.

[77] C. Zott and R. Amit, "The fit between product market strategy and business model: implications for firm performance," *Strateg. Manag. J.*, vol. 29, no. 1, pp. 1–26, 2008.

[78] J. C. Henderson and N. Venkatraman, "Strategic alignment: Leveraging information technology for transforming organizations," *IBM Syst. J.*, vol. 38, no. 2/3, p. 472, 1999.

[79] J. Gordijn, H. Akkermans, and H. Van Vliet, "Value based requirements creation for electronic commerce applications," in *System Sciences, 2000. Proceedings of the 33rd Annual Hawaii International Conference on*, 2000, p. 10 pp. vol.1.

[80] P. Weill and M. R. Vitale, "What IT Infrastructure Capabilities are Needed to Implement E-Business Models?," *MIS Q. Exec.*, vol. 1, no. 1, 2002.

[81] B. Chandrasekaran, J. R. Josephson, and V. R. Benjamins, "What are ontologies, and why do we need them?," *Intell. Syst. IEEE*, vol. Jan/Feb 19, 1999.

[82] T. R. Gruber, "Toward principles for the design of ontologies used for knowledge sharing?," *Int. J. Hum. Comput. Stud.*, vol. 43, no. 5, pp. 907–928, 1995.

[83] S. Mäkinen and M. Seppänen, "Assessing business model concepts with taxonomical research criteria: A preliminary study," *Manag. Res. News*, vol. 30, no. 10, pp. 735–748, 2007.

[84] S. Lambert, "A conceptual model analysis framework: analysing and comparing business model frameworks and ontologies," in *14th International business information management association conference* , 2010.

[85] A. Osterwalder, Y. Pigneur, G. Bernarda, and A. Smith, *Value proposition design: how to create products and services customers want.* John Wiley & Sons, 2014.

[86] B. E. Bürdek, *Design: History, theory and practice of product design.* Walter de Gruyter, 2005.

[87] T. H. Davenport and L. Prusak, *Information ecology: Mastering the information and knowledge environment.* Oxford University Press, 1997.

[88] C. Baden-Fuller and S. Haefliger, "Business Models and Technological Innovation," *Long Range Plann.*, vol. 46, no. 6, pp. 419–426, 2013.

[89] H. E. Eriksson and M. Penker, *Business Modeling with UML: Business Patterns at Work.* Wiley, 2000.

[90] R. S. Adhikari, N. Aste, and M. Manfren, "Multi-commodity network flow models for dynamic energy management – Smart Grid applications," *Energy Procedia*, vol. 14, no. 0, pp. 1374–1379, 2012.

[91] R. Casadesus-Masanell and J. E. Ricart, "How to Design A Winning Business Model," *Harv. Bus. Rev.*, vol. 89, no. 1/2, pp. 100–107, 2011.

[92] J. De Kleer, "An assumption-based TMS," *Artif. Intell.*, vol. 28, no. 2, pp. 127–162, 1986.

[93] M. Rother and J. Shook, *Learning to see: Value stream mapping to add value and eliminate muda*, vol. 1.2. Brookline, Massachusetts, USA, 1999.

[94] K. Ojasalo and J. Ojasalo, "Adapting business model thinking to service logic: an empirical study on developing a service design tool," *Nord. Sch.*, p. 309, 2015.

[95] M. Lund and P. K. Hansen, "Parallel Development of Products and New Business Models," *DS 81 Proc. Nord. 2014, Espoo, Finl. 27-29th August 2014*, 2014.

[96] P. Timmers, "Business models for electronic markets," *Electron. Mark.*, vol. 8, no. 2, pp. 3–8, 1998.

[97] P. Ballon, "Business modelling revisited: the configuration of control and value," *info*, vol. 9, no. 5, pp. 6–19, 2007.

[98] S. Sharma and J. A. Gutiérrez, "An evaluation framework for viable business models for m-commerce in the information technology sector," *Electron. Mark.*, vol. 20, no. 1, pp. 33–52, 2010.

[99] C. Baden-Fuller and M. S. Morgan, "Business models as models," *Long Range Plann.*, vol. 43, no. 2, pp. 156–171, 2010.

[100] A. B. Jensen, "Do we need one business model definition?," *J. Bus. Model.*, vol. 1, no. 1, pp. 61–84, 2014.

[101] N. D. Fowkes and J. J. Mahony, *An introduction to mathematical modelling*. Wiley Chichester, 1994.

[102] P. Mancarella, "MES (multi-energy systems): An overview of concepts and evaluation models," *Energy*, vol. 65, pp. 1–17, 2014.

[103] G. Power, "Website," 2014. [Online]. Available: http://www.grunnegerpower.nl/. [Accessed: 01-Jan-2014].

[104] P. Asmus, "Exploring New Models of Solar Energy Development," *Electr. J.*, vol. 21, no. 3, pp. 61–70, 2008.

[105] J. Huijben and G. P. J. Verbong, "Breakthrough without subsidies? PV business model experiments in the Netherlands," *Energy Policy*, vol. 56, pp. 362–370, 2013.

[106] J. L. Sawin and F. Sverrisson, "RENEWABLES 2014 GLOBAL STATUS REPORT," Renewable Energy Policy Network for the 21st Century, Paris, France, 2014.

[107] L. Frantzis, S. Graham, R. Katofsky, R. Sawyer, and N. R. E. Laborotory, "Photovoltaics Business Models," National Renewable Energy Laborotory, Burlington, Massachusetts, 2008.

[108] J. Schoettl and L. Lehmann-Ortega, "Photovoltaic business models: threat or opportunity for utilities," *Handb. Res. energy Entrep. Edward Elgar, Cheltenham*, pp. 145–171, 2011.

[109] "De regeling in het kort," 2015. [Online]. Available: http://www.hieropgewekt.nl/kennis/verlaagd-tarief/de-regeling-het-kort.

[110] W. Kuckshinrichs, T. Kronenberg, and P. Hansen, "The social return on investment in the energy efficiency of buildings in Germany," *Energy Policy*, vol. 38, no. 8, pp. 4317–4329, 2010.

[111] K. Maas, *Corporate social performance: from output measurement to impact measurement*, no. EPS-2009-182-STR. 2009.

[112] EEX, "No Title," *Ecarbix index*, 2017. [Online]. Available: These carbon markets are criticized for not reflecting the true price of carbon. [Accessed: 09-Feb-2017].

[113] A. D. Ellerman, C. Marcantonini, and A. Zaklan, "The EU ETS: Eight years and counting," 2014.

[114] F. C. Moore and D. B. Diaz, "Temperature impacts on economic growth warrant stringent mitigation policy," *Nat. Clim. Chang.*, vol. 5, no. 2, pp. 127–131, 2015.

[115] EPA, "The Social Cost of Carbon:Estimating the Benefits of Reducing Greenhouse Gas Emissions." [Online]. Available: https://www.epa.gov/climatechange/social-cost-carbon. [Accessed: 13-Feb-2017].

[116] D. of energy and climate Change, "Updated short-term traded carbon values used for UK public policy appraisal," 2015.

[117] RVO, "Korting voor lokaal opgewekte energie," 2014. [Online]. Available: http://www.rvo.nl/actueel/nieuws/korting-voor-lokaal-opgewekte-energie.

[118] Eneco and Eneco, "Jaarverslag 2013," Eneco, Rotterdam, 2014.

[119] Essent and E. N.V., "MVO Verslag Essent 2013," Essent N.V., 's-Hertogenbosch, The Netherlands., 2013.

[120] OFGEM, "Understanding the profits of the big energy suppliers," 2014. [Online]. Available: https://www.ofgem.gov.uk/gas/retail-market/monitoring-data-and-statistics/understanding-profits-big-energy-suppliers.

[121] ECN and E.-N. and N. N. ECN, "Energie Trends 2012," 2012.

[122] M. Lankhorst, *Enterprise Architecture at Work: Modelling, Communication and Analysis*. Springer, 2012.

[123] EURELECTRIC, "Regulation for Smart Grids," 2011.

[124] A. Bachmaier, S. Narmsara, J.-B. Eggers, and S. Herkel, "Spatial distribution of thermal energy storage systems in urban areas connected to district heating for grid balancing—A techno-economical optimization based on a case study," *J. Energy Storage*, 2016.

[125] E. Fabrizio, V. Corrado, and M. Filippi, "A model to design and optimize multi-energy systems in buildings at the design concept stage," *Renew. Energy*, vol. 35, no. 3, pp. 644–655, 2010.

[126] E. Dall'Anese, P. Mancarella, and A. Monti, "Unlocking Flexibility: Integrated Optimization and Control of Multienergy Systems," *IEEE Power Energy Mag.*, vol. 15, no. 1, pp. 43–52, Jan. 2017.

[127] K. Bouw, A. D'Souza, and C. Van Someren, "A flexible business model for the ETP Wijster," Groningen, 2016.

[128] USEF Foundation, "USEF: the Framework specifications 2015." p. 195, 2015.

[129] EDSN, "'STROOMOPWAARTS' ." EDSN, Baarn, The Netherlands, p. 45, 2013.

[130] TenneT, "Balance responsibility," 2016. [Online]. Available: http://www.tennet.eu/electricity-market/dutch-market/balance-responsibility/. [Accessed: 04-Aug-2016].

[131] B. Wismans, C. van Houten, and F. Nobel, "Preparation of E-programmes Instruction manual," no. december. TenneT, 2010.

[132] APX, "Continuous Markets: Intraday," 2016. [Online]. Available: https://www.apxgroup.com/trading-clearing/continuous-markets-intraday/. [Accessed: 11-Aug-2016].

[133] APX, "Day-Ahead auction," 2016. [Online]. Available: https://www.apxgroup.com/trading-clearing/day-ahead-auction/. [Accessed: 11-Aug-2016].

[134] E. Politiek and J. Kupfemagel, "Ketenanalyse afval verbranden CO 2 -prestatieladder," Deventer, 2016.

[135] Agroenergy, "Products," *agroenergy.nl*, 2016. [Online]. Available: http://www.agro-energy.nl/Producten.aspx. [Accessed: 04-Oct-2016].

Appendix

Description of the information services modelling technique

The goal of the information service modelling technique is to depict the information systems architecture that is necessary to support the business model in a business ecosystem context. The technique mainly focuses on modelling the roles, information services, information exchange relationships, and information exchanged to support the design of viable business models.

As opposed to other business modelling techniques such as BPMN and actor activity diagram, the information services modelling technique does not focus on modelling the internal processes of organisations or sequences of activities and information exchanges among the actors. It focuses on depicting the roles, the information services assigned to the roles, and the information exchange relationships among them that are necessary for a viable business model.

Rules for modelling information services for business ecosystems

- The information service is assigned to a role.
- A role can own and operate zero or more information services.
- The information services exchange information via information exchange relationships.
- The information exchange relationships can be between two or more roles and or information services.
- Information is exchanged with information services and/or with the roles via the information exchange relationships.

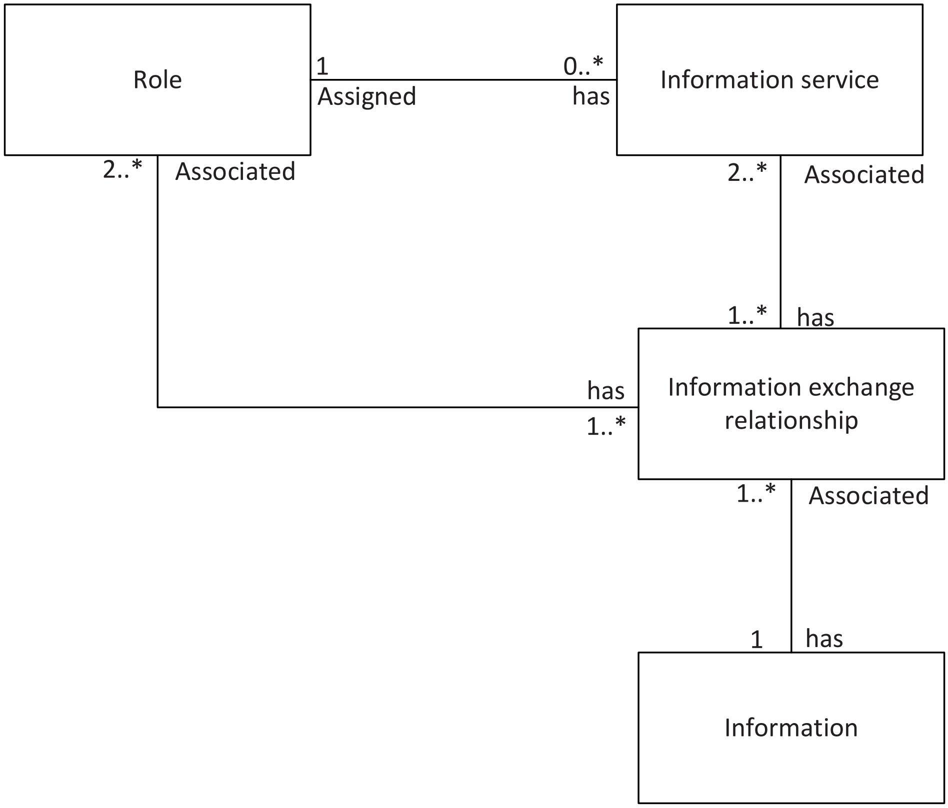


Figure 6.1 Relationship among the objects of the information services modelling technique

English Summary

Introduction

The energy industry is undergoing rapid change due to reasons such as increasing societal and political pressure to reduce CO_2, changing customer needs, changing regulations, and the advent of new technologies. The changes render the traditional business models of energy enterprises obsolete. Consequently, they need to explore viable new business models to ensure their success and long-term survival. The viability of these new business models will depend on their ability not only to create profits for their shareholders but also to create environmental and societal benefits for a broader set of stakeholders in a business ecosystem setting. Developing these viable new business models is complicated because of the increased number of ways transactions can be configured using information and communication technology and the increased number of stakeholders and their competing interests. Therefore, the goal of this research is to facilitate the design of viable energy business models in a business ecosystem setting.

The need for a new business model design framework for viability

In a wide sense, business model ontologies[3] are commonly used to design and evaluate business models. However, a review of existing business ontologies revealed that they do not sufficiently facilitate the design and evaluation of *viable* business models. The business model ontologies especially fall short when it comes to designing and evaluating complex business models. The complexity arises due to the difficulty in formulating balanced, multi-dimensional value propositions, such as financial and non-financial values, satisfying competing interests of stakeholders, formulating systemic value creation logic, and designing a technology architecture that supports the value creation logic. Besides, the existing business model ontologies mostly ignore important design elements such as design choices, design principles, configuration techniques,

3 The term “business model ontology” is used in a wide sense to refer to business model ontologies, tools, and methods used to design and evaluate business models; for more details see Section 1.2.2.

assumptions, and business rules. Additionally, the design of complex business models requires the business model designer to approach the business model design process from multiple perspectives (viz., service/product, focal actor, business ecosystem, and technology perspectives), because it is hard to address the complexity of designing viable business models from just one perspective. Ignoring financial and non-financial values, elements of business model design, and design perspectives could lead to unviable business models and eventually to the demise of the firms involved in the business model. On that account, it is necessary to explicitly consider the four perspectives, the elements of business model design, and the financial and non-financial values during the design process.

To design viable business models, therefore, a comprehensive business model design tool is needed that explicitly considers design perspectives, elements of business model design ,and financial and non-financial values. Furthermore, the intended tool should facilitate the design process in a transparent and traceable manner.

The business model design framework for viability

This research seeks to address the above deficiencies by developing and validating a business model design framework for viability. The framework helps the business model designer to transform a business idea into a viable business model. It guides the business model designer through a series of systematic steps that results in a business model design. The framework also helps to evaluate the newly designed business model for viability, as well as the subsequent iterations necessary for a viable business model.

The framework approaches the business model design process from the perspectives of service/product, focal firm, business ecosystem, and technology. These perspectives are operationalised with the help of well-established business model ontologies and modelling techniques. To operationalise the different perspectives, the framework builds on well-established business model ontologies and modelling techniques, such as business model canvas, e3-value, and service blueprint. Building on these ontologies and techniques allows the framework to capitalise on their strengths, which are their formalism, rigour, and acceptance by professionals. Furthermore, the framework adds much-needed elements of business model design such as design principles, business rules, configuration techniques, and assumptions. The framework also adopts a broader approach to value, in that it considers not only monetary value but also values such as environmental and social benefits. Hence, the business model design framework for viability is a more comprehensive business model tool, as it approaches the business model design process from different perspectives, adds the much-needed elements of business model design, and adopts a broader approach to value. Therefore, the business model design framework for viability is in a better position to facilitate the design of viable business models than other approaches.

Methods and research design

The design science research approach is used to develop the business model design framework for viability. This approach is chosen because the intention is to develop a framework (an artefact) that addresses the problem described above. The design science research approach is adept at facilitating the development of robust artefacts that address a specific issue or a class of problems. And so, the design science research approach is used to develop the business model design framework for viability.

The business model design framework for viability was developed in phases according to the design science research approach proposed by Peffers et al. [34]. First, the problem was identified, and the motivation for solving the problem was made explicit. Second, the objectives of the solution were defined. To identify the problem and define the objectives of the solution, a literature review was carried out. Next, a list of criteria that an ideal business model design and evaluation tool should satisfy were derived from the literature. Following the derivation of the criteria, well-established business model ontologies were assessed against these criteria. The evaluation showed that none of the business model ontologies fully satisfied all of the criteria. The results of the evaluation are not surprising, as in the strict sense, the business model ontologies are not developed for supporting the process of designing and evaluating viable business models. Even when the term "business model ontology" is used in the wide sense to encompass tools and methods used to design and evaluate business models such as the business model canvas and the e3-value, they do not satisfy all of the criteria. The business model ontologies fail to do so because they usually adopt a single perspective to design and evaluate business models, such as the focal actor or business ecosystem perspective. Besides, the business model ontologies also largely ignores elements of business model design such as business rules and configuration techniques.

Third, the business model design framework for viability was developed. The identified criteria were used as input during the development process. The newly developed business model design framework was then theoretically evaluated against the criteria. The framework satisfied all of the criteria. Fourth, to demonstrate the newly developed business model design framework for viability, it was applied to design and evaluate business models for two cases. Case one was a mono-commodity energy system comprising a community-owned solar farm. Case two was a more complex multi-commodity comprising an industrial park. The business model design framework for viability successfully facilitated the design and evaluation of the two business models. The business models resulting from the application of business model design framework for viability were then presented for evaluation to experts, who evaluated them positively for the most part. Finally, a critical reflection was performed on the validity of the business model design framework for viability.

Validity of the business model design framework for viability

The business model design framework for viability has proven to be an effective tool for designing and evaluating energy business models in complex business ecosystem settings. In both case studies, the framework for viability was able to handle systematically the complexity of designing and evaluating viable business models in a business ecosystem setting. The application of the framework led to realistic business models. In both cases, the business models designed were clear and understandable, which allowed the experts to carry out a critical assessment of them.

In the case of the mono-commodity energy system, the focal firm (i.e., Grunneger Power) implemented the output of the business model design framework for viability, that is the business model for the community-owned solar farm. After implementing it, Grunneger Power made another design iteration to their business model by outsourcing the energy retail activity to a new subsidiary called NLD. Along with other firms like Grunneger Power, NLD was formed to avoid the risks identified during the evaluation process of the business model. This iteration also shows that it is difficult to design business models that require no tweaking once they are implemented. Nevertheless, the framework facilitated the design of a viable business model that was implemented, and it also helped to identify potential risks, which were addressed in a subsequent design iteration of the business model.

In the case of the multi-commodity energy system, the application of the business model design framework for viability led to a realistic business model. The stakeholders did not immediately implement the designed business model. However, the stakeholders in the multi-commodity energy system are assessing their capabilities to implement the business model. Even though the business model design has not been implemented by the stakeholders, it provides a clear and vivid description of the business model. Furthermore, the experts evaluating the business model think that it is realistic and has potential. They also believe that the stakeholders should investigate the designed business model further.

The analysis presented in this thesis shows that current business model ontologies and modelling techniques usually approach business model design from one perspective only. The business model design framework is more comprehensive than current business model ontologies because it approaches business model design and evaluation from multiple perspectives, while adding missing elements of business model design. The framework also adopts a broader approach to value. Consequently, the business model design framework for viability is in a better position to facilitate the design and evaluation of viable energy business models in a business ecosystem setting. The rote application of the business model design framework for viability will not lead to a viable business model. The business model design process is inherently a creative and iterative, and like any other design tool, the result of applying the business model design framework for viability largely depends on the creativity and skill of the business model designer. However, the business model design framework for viability helps to approach the business model design process in a systematic, transparent, and traceable manner. Also, the application of the framework for designing and evaluating business models in simpler settings might be excessive.

Using design science research principles, this research has contributed to theory a validated meta artefact; i.e., the business model design framework for viability.

Future research

Future research should focus on more in-depth validation of the business model design framework for viability and its components in the energy domain. Thus far, a limited group of users has used it. Hence, future research should focus on multiple users testing the framework. Another interesting research question could be whether the business model design framework for viability is relevant in domains other than energy. For example, the health care sector could be interesting because of its similarities to the energy industry (e.g., it is heavily regulated; multiple stakeholders are involved in providing health care; it is under increasing pressure to find new and innovative business models; and rapid innovations in technology are taking place in the field).

Nederlandse Samenvatting

Inleiding

De energiesector is momenteel erg aan verandering onderhevig als gevolg van onder meer toenemende maatschappelijke en politieke druk om de CO_2 uitstoot te verminderen, veranderingen wat betreft klantbehoeften, veranderende regelgeving, en de opkomst van nieuwe technologieën.

Door al deze veranderingen is het traditionele bedrijfsmodel van energiebedrijven achterhaald. Zodoende bestaat er voor energiebedrijven de noodzaak om na te gaan welke nieuwe bedrijfsmodellen rendabel zijn om hun succes ook op de lange termijn veilig te stellen. De levensvatbaarheid van deze nieuwe bedrijfsmodellen zal afhangen van hun vermogen om naast winst voor hun aandeelhouders, ook maatschappelijke- en milieuvoordelen te realiseren ten behoeve van diverse belanghebbenden binnen een business ecosystem. Het ontwikkelen van dergelijke rendabele bedrijfsmodellen is ingewikkeld vanwege de toename van mogelijke transacties door toepassing van informatie- en communicatietechnologie en de toename van mogelijke belanghebbenden en hun concurrerende belangen. Derhalve is het doel van dit onderzoek het vergemakkelijken van het ontwerpen van rendabele bedrijfsmodellen voor energiebedrijven binnen een business ecosysteem.

De behoefte aan een nieuw 'business model design framework for viability'

Business model ontologieën[4] worden veel gebruikt bij het ontwerpen en evalueren van bedrijfsmodellen. Uit literatuuronderzoek aangaande bestaande business model ontologieën bleek echter dat deze ontologieën de processen van ontwerp en evaluatie van *rendabele* bedrijfsmodellen onvoldoende faciliteren. Ze schieten vooral tekort wanneer het gaat om het ontwerpen en evalueren van *complexe* bedrijfsmodellen. Complexiteit komt voort uit de moeilijkheid om gebalanceerde multidimensionale

---

4 De term business model ontologie wordt toegepast in brede zin om te verwijzen naar business model ontologieën, tools en methodes die worden gebruikt om bedrijfsmodellen te ontwerpen en te evalueren; voor meer informatie, zie Sectie 1.2.2.

waardeproposities te formuleren, zoals financiële en niet-financiële waarden, om verschillende stakeholders en hun concurrerende belangen tevreden te stellen, en om rekening te houden met innovatieve onderliggende technologieën die het eigendom zijn van verschillende stakeholders waarbij het beheer verdeeld is over verschillende verantwoordelijke partijen. Verder bevatten de bestaande business model ontologieën doorgaans niet belangrijke ontwerpelementen zoals ontwerpkeuzes, ontwerpprincipes, configuratie technieken, veronderstellingen, en bedrijfsregels. Bovendien vereist het ontwerpen van complexe bedrijfsmodellen van de ontwerper een benadering waarbij verschillende perspectieven worden meegenomen (bijvoorbeeld dienst/product, centrale actor, business ecosysteem en technologie). De complexiteit van het ontwerpproces van rendabele bedrijfsmodellen wordt geen recht aangedaan door het te benaderen vanuit slechts één perspectief. Het niet meenemen van zowel financiële- als niet-financiële waarden, de bovengenoemde business model ontwerpelementen en verschillende ontwerpperspectieven kan leiden tot onhaalbare, niet-rendabele bedrijfsmodellen, en uiteindelijk zelfs tot het faillissement van de betrokken bedrijven in het bedrijfsmodel. In dat opzicht is het noodzakelijk om de bovengenoemde vier perspectieven, de business model ontwerpelementen, en de financiële en niet-financiële waarden uitvoerig mee te nemen tijdens het ontwerpproces.

Er is dus behoefte aan een methode of hulpmiddel die bij het ontwerpen van levensvatbare bedrijfsmodellen ook expliciet rekening houdt met ontwerpperspectieven, bedrijfsmodel ontwerpelementen, en financiële en niet-financiële waarden. Een dergelijk hulpmiddel zou verder ook ten goede moeten komen aan de transparantie en traceerbaarheid van het ontwerpproces.

The business model design framework for viability

Dit onderzoek richt zich op de bovengenoemde tekortkomingen door middel van het ontwikkelen en valideren van een 'business model design framework for viability': een raamwerk voor het ontwerpen van levensvatbare bedrijfsmodellen. Dit raamwerk helpt de ontwerper van een bedrijfsmodel om een bedrijfsidee om te zetten in een bedrijfsmodel dat kansrijk is in het echt. Het raamwerk biedt de ontwerper een serie systematische stappen welke resulteren in een bedrijfsmodel. Het raamwerk maakt het ook mogelijk om het nieuwe bedrijfsmodel en de eventueel daaropvolgende noodzakelijke aanpassingen te evalueren, om zodoende vast te stellen in hoeverre het bedrijfsmodel levensvatbaar is.

Het raamwerk benadert het ontwerpproces van bedrijfsmodellen vanuit de volgende perspectieven: dienst/product; centrale onderneming; bedrijfsecosysteem; en technologie. Deze perspectieven worden geoperationaliseerd aan de hand van gevestigde ontologieën aangaande bedrijfsmodellen en modelleringstechnieken. Het raamwerk bouwt dus voort op gevestigde ontologieën en modelleringstechnieken, zoals business model canvas, e3-value, en service blueprint om de verschillende perspectieven te operationaliseren. Gevestigde ontologieën en modelleringstechnieken worden gekenmerkt door hun systematische benadering en logica en zijn strikt gedefinieerd en erkend door professionals. Het raamwerk maakt gebruik van deze sterke punten en haalt hier voordeel uit. Bovendien voegt het raamwerk hier ontwerpelementen voor bedrijfsmodellen, zoals ontwerpprincipes, bedrijfsregels, configuratie technieken en aannames aan toe. Het raamwerk hanteert tevens een bredere definitie van 'waarde'. Het beschouwt niet slechts de geldelijke waarde maar ook waarden zoals milieuvoordelen en andere maatschappelijke voordelen. Het 'business model design framework for viability' is dus meer omvattend en uitgebreider, aangezien het raamwerk het ontwerpproces van bedrijfsmodellen benadert vanuit verschillende perspectieven endaarnaast ontwerpelementen toe voegt en een bredere benadering van waarde hanteert. Er kan dan ook gesteld worden dat het 'business model design framework for viability' beter in staat is om het ontwerpen van rendabele bedrijfsmodellen te faciliteren.

Onderzoeksmethoden en onderzoeksopzet

Om het 'business model design framework for viability' te ontwikkelen is de aanpak van ontwerpgericht onderzoek toegepast. De keuze hiervoor is gemaakt met het oog op het voornemen om een raamwerk (een artefact) te ontwikkelen om het eerdergenoemde probleem aan te pakken. De ontwerpgerichte onderzoeksmethode is geschikt om de ontwikkeling van robuuste artefacten mogelijk te maken die een specifiek of bepaald type problemen aanpakt. Derhalve is deze methode toegepast om het 'business model design framework for viability' te ontwikkelen.

Het 'business model design framework for viability' is in fasen ontwikkeld, in overeenstemming met de ontwerpgerichte onderzoeksmethode, zoals aangedragen door Peffers et al. [1]. Eerst is het probleem geïdentificeerd en is de motivatie om dit probleem op te lossen toegelicht. Vervolgens zijn de doelstellingen van de oplossing bepaald. Door middel van literatuuronderzoek kon het probleem geïdentificeerd worden en konden de doelstellingen van de oplossing bepaald worden. Op basis van dit literatuuronderzoek is ook een lijst met criteria opgesteld waaraan een ideaal hulpmiddel voor het ontwerpen en evalueren van een bedrijfsmodel zou moeten voldoen. Vervolgens zijn gevestigde ontologieën beoordeeld naar aanleiding van die criteria. Hieruit bleek dat geen van de bestaande ontologieën aangaande bedrijfsmodellen volledig aan al deze criteria voldoet. De resultaten van deze evaluatie zijn op zich niet verrassend, aangezien de betreffende ontologieën niet ontwikkeld zijn om het proces van het ontwerpen en evalueren van levensvatbare bedrijfsmodellen te ondersteunen. Zelfs als deze ontologieën in brede zin worden opgevat en hieronder ook hulpmiddelen en methodes worden verstaan die gebruikt worden om bedrijfsmodellen te ontwerpen en te evalueren, zoals business model canvas en de e3-value, voldoen ze nog steeds niet aan al deze criteria. De ontologieën komen niet tegemoet aan alle criteria omdat ze doorgaans vanuit slechts één perspectief kijken naar het ontwerpen en evalueren van bedrijfsmodellen, zoals het centrale onderneming perspectief of het bedrijfsecosysteem perspectief. Bovendien schenken de ontologieën ook weinig tot geen aandacht aan ontwerpelementen van bedrijfsmodellen zoals bedrijfsregels, aannames en configuratietechnieken.

Na bovengenoemde stappen is het ‘business model design framework for viability’ ontwikkeld. De criteria dienden als input voor het ontwikkelproces, waarna het nieuwe raamwerk achteraf theoretisch is beoordeeld op basis van de criteria. Hieruit bleek dat het raamwerk aan alle gevonden criteria voldoet.

Om de werking van het nieuwe ‘business model design framework for viability’ in de praktijk aan te tonen, is het toegepast bij het ontwerpen en evalueren van bedrijfsmodellen in twee casussen. De eerste casus was een mono commodity energiesysteem, namelijk een lokaal energie initiatief, in dit geval een zonneboerderij. De tweede, meer complexe casus, betreft een multi-commodity energiesysteem, namelijk een industriegebied. Het ‘business model design framework for viability’ heeft met succes de processen van ontwerp en evaluatie van deze twee bedrijfsmodellen ondersteund. De bedrijfsmodellen, die in wezen de output zijn van het raamwerk, zijn vervolgens ter evaluatie voorgelegd aan experts. De experts hebben de bedrijfsmodellen grotendeels positief beoordeeld. Ten slotte is er kritisch gereflecteerd op de geldigheid en juistheid van het ‘business model design framework for viability’.

Validiteit van the business model design framework for viability

Het ‘business model design framework for viability’ heeft bewezen een effectief hulpmiddel te zijn voor het ontwerpen en evalueren van bedrijfsmodellen voor energiebedrijven binnen een complex bedrijfsecosysteem. Het raamwerk was in beide casussen in staat om de complexiteit van het ontwerpen en evalueren van rendabele bedrijfsmodellen binnen een bedrijfsecosysteem op systematische wijze te behandelen. Door toepassing van het raamwerk zijn er levensvatbare bedrijfsmodellen uitgewerkt. De bedrijfsmodellen waren in beide gevallen helder en begrijpelijk, wat het voor de experts mogelijk maakte om deze bedrijfsmodellen aan een kritische beoordeling te onderwerpen.

In de casus van het mono-commodity energiesysteem heeft het betreffende bedrijf (nl. Grunneger Power) de uitkomst van het 'business model design framework for viability', namelijk het bedrijfsmodel voor de zonneboerderij, daadwerkelijk geïmplementeerd. Nadat ze dit bedrijfsmodel hadden geïmplementeerd heeft Grunneger Power het ontwerp van het bedrijfsmodel nog enigszins aangepast door hun retailactiviteiten uit te besteden aan NLD, een nieuwe duurzame coöperatieve energieleverancier. NLD is gezamenlijk opgericht door soortgelijke coöperaties en initiatieven als Grunneger Power, onder meer om risico's, die ook naar voren kwamen uit het evaluatie proces van het bedrijfsmodel, te vermijden. Dit voorbeeld laat ook zien dat het moeilijk is om bedrijfsmodellen te ontwerpen die, nadat ze geïmplementeerd zijn, geen kleine aanpassingen meer vereisen. Wat dat betreft is het een iteratief (ontwerp)proces. Desalniettemin heeft het raamwerk het ontwerpen van een levensvatbaar bedrijfsmodel goed ondersteund. Daarnaast heeft het bijgedragen aan het herkennen van de potentiële risico's welke zichtbaar werden als gevolg van het iteratief ontwerpproces.

In de casus van het multi-commodity energiesysteem heeft de toepassing van het 'business model design framework for viability' ook geresulteerd in een levensvatbaar bedrijfsmodel. De belanghebbenden zijn in dit geval echter niet direct overgegaan op implementatie van het ontworpen bedrijfsmodel. Ze zijn momenteel aan het beoordelen wat hun mogelijkheden zijn om het bedrijfsmodel te implementeren. Hoewel dit bedrijfsmodel dus nog niet daadwerkelijk geïmplementeerd is, is het ontwerp wel voorzien van een heldere en levendige beschrijving. Bovendien zijn de experts die het bedrijfsmodel geëvalueerd hebben van mening dat het een levensvatbaar bedrijfsmodel is dat zeker potentie heeft. Ze geloven ook dat de belanghebbenden er goed aan doen om de mogelijkheden van het ontworpen bedrijfsmodel verder te onderzoeken.

Uit de analyse zoals gepresenteerd is in deze thesis, is gebleken dat de huidige ontologieën over bedrijfsmodellen en daarnaast de bestaande modelleringstechnieken het proces van het ontwerpen van bedrijfsmodellen doorgaans vanuit slechts één perspectief benaderen. Het 'business model design framework for viability' is uitgebreider dan de huidige ontologieën doordat het de processen van ontwerp en evaluatie benadert vanuit verschillende perspectieven. Het voegt ontwerpelementen toe en het hanteert een bredere definitie van het concept waarde. Dientengevolge is het raamwerk beter in staat om het ontwerpen en evalueren van levensvatbare bedrijfsmodellen voor energiebedrijven in een bedrijfsecosysteem te faciliteren. Een volledig mechanistische toepassing van het 'business model design framework for viability' zal echter niet leiden tot een levensvatbaar bedrijfsmodel. Het ontwerpproces is intrinsiek een creatief en iteratief proces, en net als bij elk ander ontwerphulpmiddel, hangt het resultaat van het toepassen grotendeels af van de creativiteit en bekwaamheid van de ontwerper van het bedrijfsmodel. Het 'business model design framework for viability' helpt echter wel om het ontwerpproces op een systematische en transparante wijze aan te pakken. Daarnaast is de toepassing van dit raamwerk wellicht overbodig wanneer het gaat om het ontwerpen en evalueren van bedrijfsmodellen in een meer simpele setting.

In het kader van de ontwerpgerichte onderzoeksmethode heeft dit onderzoek aan de theorie bijgedragen door de ontwikkeling van een gevalideerd meta-artefact, namelijk het 'business model design framework for viability'.

Aanbevelingen voor toekomstig onderzoek

Het is aan te bevelen dat toekomstig onderzoek zich richt op meer diepgaande validatie van het 'business model design framework for viability' en haar componenten binnen de energiesector. Vooralsnog is het 'business model design framework for viability' slechts toegepast door een beperkte groep gebruikers. Toekomstig onderzoek moet uitwijzen of het toepassen van het raamwerk door verschillende gebruikers ook succesvol blijkt. Een andere interessante onderzoeksvraag is: is het 'business model design framework for viability' ook geschikt voor andere sectoren dan de energiesector? In dit opzicht is de gezondheidszorg wellicht een interessant vakgebied, aangezien er verscheidene overeenkomsten zijn met de energiesector. Zo is er in beide sectoren sprake van strenge regelgeving. Daarnaast zijn er doorgaans verschillende belanghebbenden betrokken bij dienstverlening en is er een toenemende druk om te werken aan nieuwe en innovatieve bedrijfsmodellen; en zijn er snelle innovaties op het gebied van technologie etc.