Smart-BEEjS

Human-Centric Energy Districts: Smart Value Generation by Building Efficiency and Energy Justice for Sustainable Living

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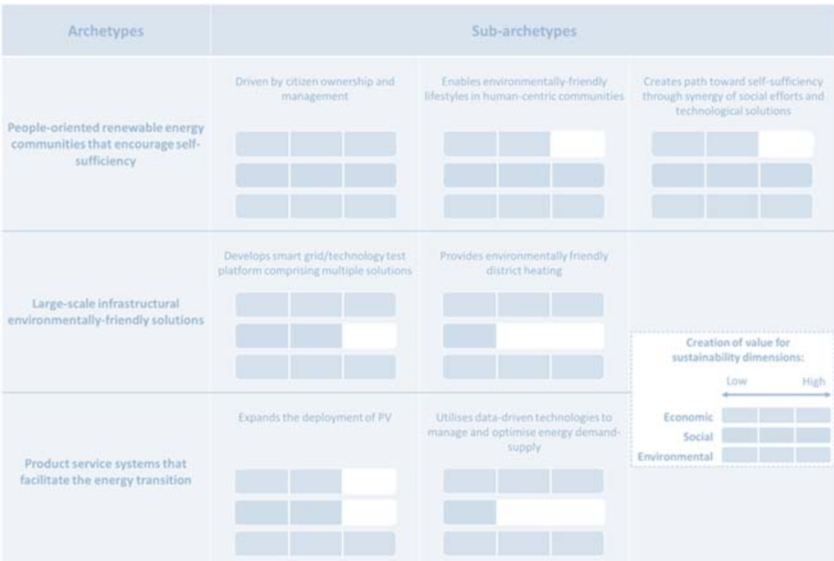
Business Models and Consumers' Value Proposition for PEDs

Value Generation by PEDs:
Best Practices Case Study Book



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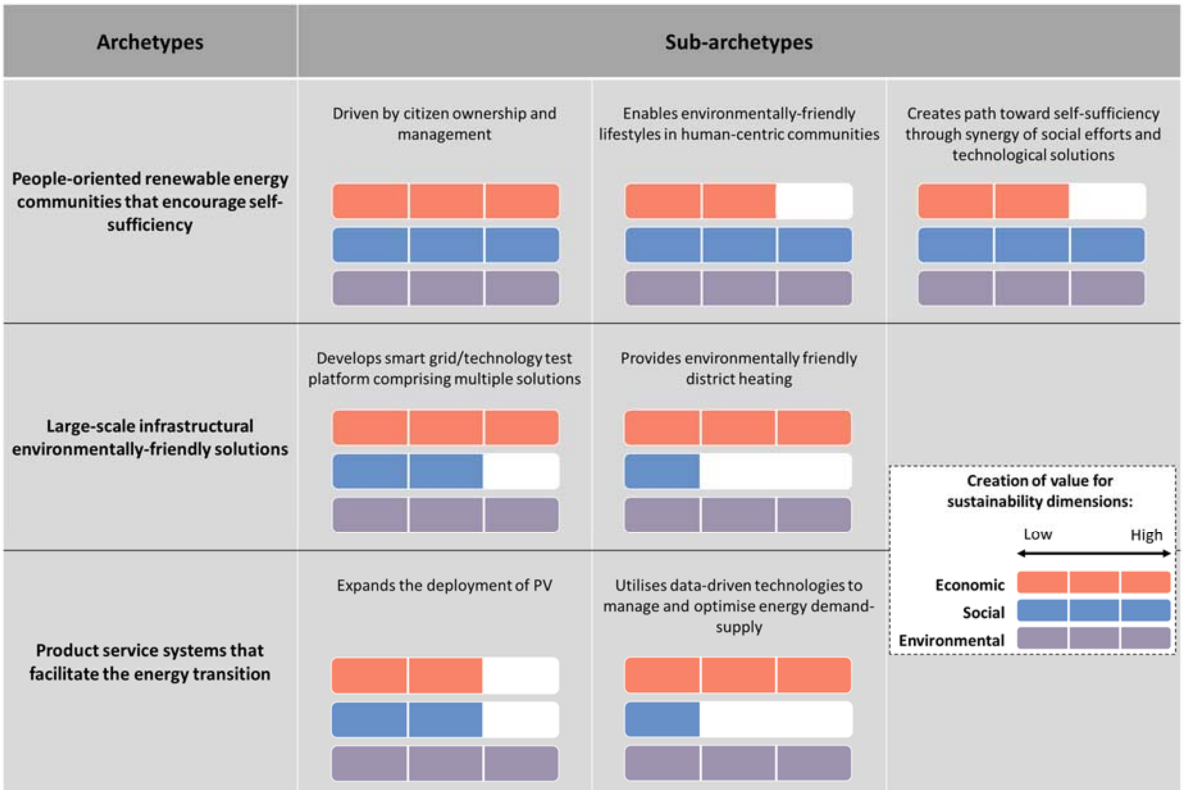
Executive Summary

The EU's SET Plan has proposed the development of Positive Energy Districts (PEDs) to achieve the transition towards a more sustainable energy system through the adoption of renewable energy technologies and energy efficiency measures. PEDs are envisioned to be neighbourhoods that utilise such technologies and create an environment that enables citizens to lead environmentally-friendly lifestyles. At their core, PEDs create value across three sustainability dimensions: environmental, social, and economic.

PEDs and PED-like projects can be developed in a variety of ways and are a product of the physical, social, and economic characteristics of the environment. Innovative business models – the configurations in which value is created, delivered, and captured – are integral to leveraging these contextual characteristics in order to achieve the goals of PEDs. This study aims to identify best practice cases and categorise them into archetypes of business models operating in PEDs in order to summarise the opportunities available in PED creation.

The authors synthesise existing literature in the area of sustainable business models to develop a conceptual framework that analyses the extent to which the value dimensions of business models address the economic, social, and environmental dimensions of sustainability, with a focus on PEDs. This allows the building blocks of the original business model canvas to be modified and extended. The authors use a qualitative analytical approach, to a set of selected European cases, through the lens of the conceptual framework to identify business model archetypes of PEDs and PED-like projects.

Three business model archetypes and seven sub-archetypes have been identified:



Summary of identified archetypes and sub-archetypes of business model opportunities in PEDs

The authors find that the aims of the business models under the archetypes and sub-archetypes vary in priorities. For example, while the *People-oriented renewable energy communities that encourage* *self-sufficiency* archetype is heavily focused on creating value for the community, the other two archetypes are more centred on creating environmental and economic value. Nevertheless, the resulting outcomes are multi-dimensional in their value creation.

The identified archetypes and their sub-archetypes showcase the diversity of opportunities that are available in designing a business model that creates social, environmental, and economic value in PEDs or PED-like projects. Further, the key features of the sub-archetypes demonstrate which business model elements are critical in achieving their aims, whether it is stakeholder partnerships or technological innovation. This understanding is important as it can determine the source and magnitude of investment dedicated to the development of the PED.

The contribution of this study lies in the creation of a common understanding of the possibilities present in PED development through the identification of the relevant business model archetypes. The future deliverable of this work package will use these business model archetypes to build an open source web-based tool that can serve as a starting point for PED development discussions among citizens, municipalities, investors, and other stakeholders.

1 Introduction

The EU's Strategic Energy Technology (SET) Plan [1] proposes the development and implementation of Positive Energy Districts (PEDs) to facilitate the transition towards a climate neutral energy system[1]. As part of the smart cities and communities concept (SET-Plan Action 3.2), PEDs are described as districts with annual net-zero energy import and net-zero CO_2 emissions, working towards an annual local surplus production of renewable energy, at an affordable level [1]. They enable energy cost reductions and improvements in performance of low carbon energy technologies through efficient and flexible energy consumption. In this way, the PED concept addresses the environmental dimension by setting energy goals, while simultaneously focusing on economic and social dimensions, such as reduced energy costs, access to affordable living, and a built environment that aims at encouraging the adoption of lifestyles that reduce greenhouse gas (GHG) emissions. These values may be supported in a multitude of ways: through incentives for the transition to electric vehicles; the production of own energy from renewable resources such as solar and wind; the replacement of fossil fuels based technologies with more sustainable ones, such as heat pumps for heating; and/or management of energy consumption through smart technology. The successful planning, deployment, and replication of PEDs will partially rely on the development of sustainable business models[2]. A business model is defined as the basis "*of how an organisation creates, delivers, and captures value"* [2].

The aim of this study is two-fold:

1. to identify best practice business models for energy generation, distribution, and management in PEDs or PED-like[3] environments;
2. to categorise these business models into archetypes illustrating the different priorities that might emerge and their tendency to lead to socially inclusive propositions.

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[1] The defining aspects, or "building blocks" of PEDs according to the SET-Plan [1] are:

- A PED is embedded in an urban and regional energy system, preferably driven by renewable energy sources (RES), in order to provide optimised security and flexibility of supply.
- A PED is based on a high level of energy efficiency, in order to keep annual local energy consumption lower than the amount of locally produced renewable energy.
- Within the regional energy system, a PED enables the use of renewable energy by offering optimised flexibility and in managing consumption and storage capacities on demand. Active management will allow for balancing and optimisation, peak shaving, load shifting, demand response and reduced curtailment of RES, and district-level self-consumption of electricity and thermal energy.
- A PED couples the built environment, sustainable production and consumption, and mobility to reduce energy use and greenhouse gas emissions and to create added value and incentives for the consumer. E.g., PEDs facilitate increased EV charging capability within the district and ensure that the impact of EVs on the distribution will be minimised by using local generation where possible.
- A PED makes optimal use of elements such as advanced materials, local RES and other low carbon energy sources (e.g. waste heat from industry and service sector, such as data centres), local storage, smart energy grids, demand-response, cutting edge energy management (electricity, heating and cooling), user interaction/involvement and Information and Communication Technology (ICT).
- PED should offer affordable living for the inhabitants.

[2] A business model can be seen as a framework that describes how a firm creates and delivers value via a number of elements (e.g. key partners, key activities, key resources, value propositions, customer relationships, channels, customer segments, cost structure, and revenue streams[ii]).

[3] PED-like projects refer to projects which are not fully implemented but resemble or aspire to be PEDs or projects that can contribute to PED building blocks.

Several authors advocate a transition from the earlier business model definition to definitions that incorporate the concept of sustainable systems [3][4] [5][6] or focus on environmental aspects, such as waste and pollution minimisation while underscoring social value (e.g. the circular economy model) [7][8][9]. Additionally, authors have created new frameworks for analysis that modify and extend the building blocks of the original business model canvas [10] [11]. Despite the variation in business model definitions, there is a common emphasis on the inclusion of value proposition, value creation and delivery, and value capture as guiding components in the business model [10]. These value dimensions can be used as an analytical tool for identifying different business model archetypes [8][9]. At the same time, business model research often addresses and analyses sustainability dimensions of business models and archetypes [8][9][12][13]. The analysed sustainability dimensions in this study are categorised into economic, social, and environmental dimensions [3][4][14].

To achieve the aim of the study, the authors designed a conceptual framework (Figure 1-1) that allows for the classification of information and, eventually, categorisation into PED business model archetypes. The application of the conceptual framework to the general definition of PEDs shows how their goals fit across the sustainability dimensions. Each value dimension can create an impact in the economic, environmental, and social dimensions to varying extents and is described by key components (bolded in Figure 1-1).

In identifying archetypes, the authors seek to develop a common language for policymakers, entrepreneurs, and citizens, encouraging replication and promoting the deployment of PEDs. Each business model archetype is representative in the way it creates, delivers, and captures value – described by the value proposition, value creation and delivery, and value capture columns in the framework – and how these address economic, social, and environmental dimensions.

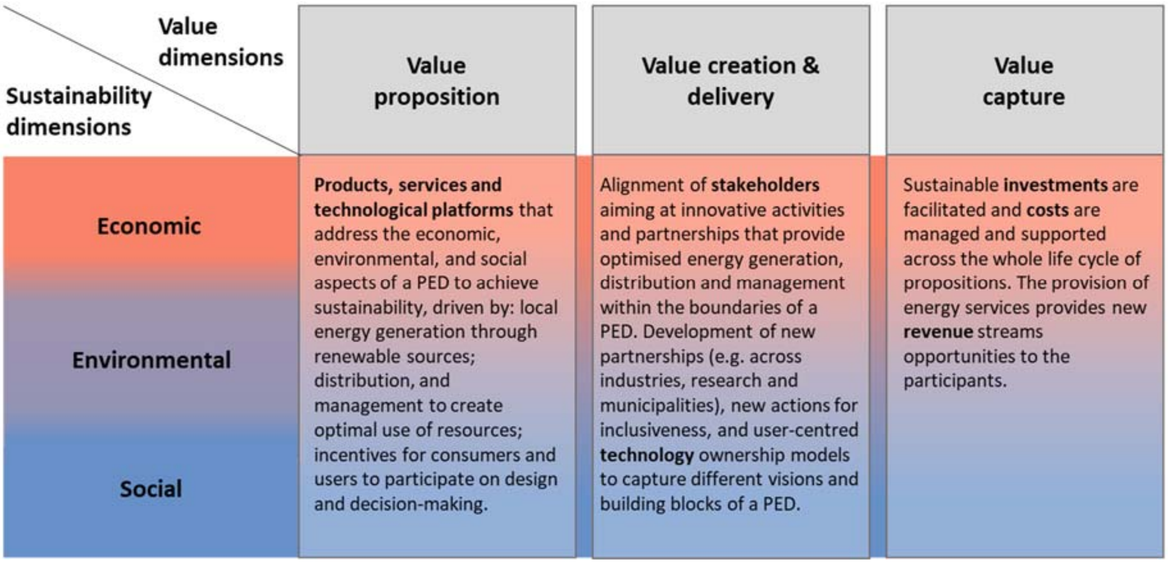

Figure 1-1. Conceptual framework of PED business models categorisation synthesised and adapted from academic literature [2][8][10][12] and PED framework [1].

<u>Value proposition</u> describes **products and services** provided in the business model to generate economic return [7]. The nature of PEDs enables a complex set of propositions of products, services, and technological platforms that might be linked to economic, environmental, and/or social values depending on the priorities of each PED and PED-like project. The main aim of these propositions, under a sustainable perspective, is to achieve an annual positive energy balance while providing positive social and environmental benefits to the community. This aim is the cornerstone, providing opportunities for energy services, flexibility, and sustainable consumption that can reduce GHG

emissions and create revenue streams from optimised or even reduced energy costs. These services, in combination with further incentives and the inclusion of the citizens/users in the design and decision-making process, facilitate a sustainable and affordable living environment in line with the PED vision.

These propositions are achieved by a value creation and delivery process that optimises local energy generation, distribution, and management, based on renewable energy sources. Value creation and delivery is the central process by which the value proposition is implemented in a business model [7]. According to the literature, this dimension is supported by the key value chain elements of resources, technologies, channels, partners, key competencies and key capabilities [9]. However, varying localised contexts of PEDs make it challenging to find one standardised arrangement for these elements. Different configurations can capture various visions and building blocks of a PED project. Value creation and delivery in PEDs include activities and partnerships that aim to provide local energy and optimise supply and demand. In this study, value creation and delivery is described by **stakeholder relationships and technologies** used. These two key elements vary according to each project and depend on the drivers, stakeholders, and size (area and beneficiaries).

The value creation and delivery process creates value in the economic dimension by offering renewable energy generation, distribution, and management in a way that provides financial opportunities for both the customer and the service provider. These energy products and services also create environmental benefits. For example, environmental value is delivered by substituting traditional energy sources with renewable ones, including innovative smart technologies that enable energy efficiency (i.e. optimising energy use by leveraging data), or promoting change in individual energy consumption behaviour. These approaches reduce a community's environmental footprint and contribute to the wider societal need for reduced energy consumption and GHG emissions to mitigate climate change. Value is created through stakeholder partnerships – prosumers, end-users, technology owners and other partners – who take a leading role in achieving the sustainable energy transition [3]. Further, these partnerships between stakeholders reduce costs, bring investment, and enable cooperative structures of ownership that involve members as economic beneficiaries. Citizen participation is also critical to raising awareness around energy use and citizens are included in decision-making and planning processes. Hence, this framework recognises partnerships between different stakeholders as a way to promote greater social inclusiveness, to increase energy affordability [15], and to consider stakeholders' needs, maximising value for all.

Value capture for a sustainable business model is defined as the leveraging of **cost structure, investments, and revenue streams** that result from the products and services provided to the users and consumers in order to contribute to the environment and society [7]. Financial flows within a PED will vary depending on whether a PED or PED-like area is newly built or just being expanded, renovated, or transformed. Environmental value is captured through the reduced costs of carbon emissions, investments in 'green' technology, and revenues from clean energy generation. Economic value is captured through energy cost reductions via energy efficiency, new revenue streams for prosumers and technology owners through energy generation and distribution, and creation of jobs [16]. Partnerships between stakeholders can create and deliver the economic values of PEDs through investments in new technologies, enabling end-users to become prosumers and profit from the PED energy services.

It is important to note the two-fold creation and capture of economic value that occurs for the product or service provider in the business model and the user of the products and services. While creation of economic value in the sustainability dimension is traditionally seen as the creation of local jobs or access to affordable energy, these benefits may stem from the economic value that the product or service provider receives. For example, reduced operation costs can lead to reduced energy prices for consumers, thus enabling energy affordability. In this study, the authors recognise this relationship and take economic sustainability to encompass all of these characteristics. Within the concept of the business model, creation of value in the economic dimension can include revenues for product or service providers and costs for consumers. However, economic value can also refer to benefits that are accrued to the individual and community, such as job creation or growth of the local economy.

To identify business model archetypes of operating PEDs, the authors used a qualitative abductive approach, analysing a set of case studies through the lenses of the conceptual framework. A collective case study approach enabled the authors to identify differences between multiple cases. Instrumental case studies are later used to present archetypes connected to particular cases [17].

2 Framework of analysis

In this study, the conceptual framework is used as an analytical tool in order to categorise business models for energy generation, distribution, and management in PED or PED-like projects into distinct business model archetypes. Secondary data was collected for information gathering, evidence building, and identification of best practice cases of business models for energy generation and management in PED or PED-like projects. The authors used the *JPI Urban Europe's Booklet of PEDs* as a starting point for information and case study collection, but the research was further expanded to online databases and platforms focused on renewable energy projects, journals in business management, environmental science, and urban planning domains, and reports and deliverables produced by EU projects and initiatives working with renewable energy communities such as PEDs. Lastly, websites, conference presentations, newspaper articles, and national magazines were explored for additional information.

The case study selection was guided by a set of criteria (derived from the SET-Plan definition of PEDs). Selected business models were expected to:

- contribute to **energy generation, distribution, and management**, especially in a PED-context;
- have been **implemented** (i.e., they should be operational and not proposed just as designs or ideas for the future);
- aim to address **social and human-centric aspects**;
- have a focus on **Europe.**

Cases needed to satisfy all four criteria to be selected.

The authors then identified and codified shared characteristics across the selected cases. The codifications were cross-validated through a process in which all authors coded the examples independently and discussed the results. Following other studies on sustainable business models, the authors disentangled these characteristics into common *elements,* which share a similar purpose to the business model building blocks: products and services, technology, stakeholders, and financial aspects (investment, costs, and revenue streams). In line with other analyses [18][19][20], the set of common PED elements was grouped according to value proposition, value creation and delivery, and value capture.

Figure 2-1 shows the process of case study selection, codification of elements, and placement of these elements in the business model schematic under the lenses of the conceptual framework. Hence, the figure provides an overview of the methodology that led to the analysis of the cases and their grouping into archetypes. The business model schematic (represented by the arrow) demonstrates how the common business model elements identified by the authors fall into the three value dimensions. Each value dimension has the potential to create economic, social, and environmental value through a combination of these elements. Analysis of these elements within the value dimensions helps explain how a case's business model creates value in the economic, social, and environmental dimensions. A matrix (see Appendix B) of all identified case studies was constructed to identify the key values of each business model. Thematic analysis was then used to identify and demonstrate commonalities and differences among the cases' business models.

Based on this process, the authors were able to group the cases according to the key features of their business model. Considerations of the complexity and scale of the cases, the enabler of the business model, and the relation to the sustainability dimensions have led to further grouping of a higher order. As a result, archetypes and subsequent sub-archetypes were identified based on this analysis.

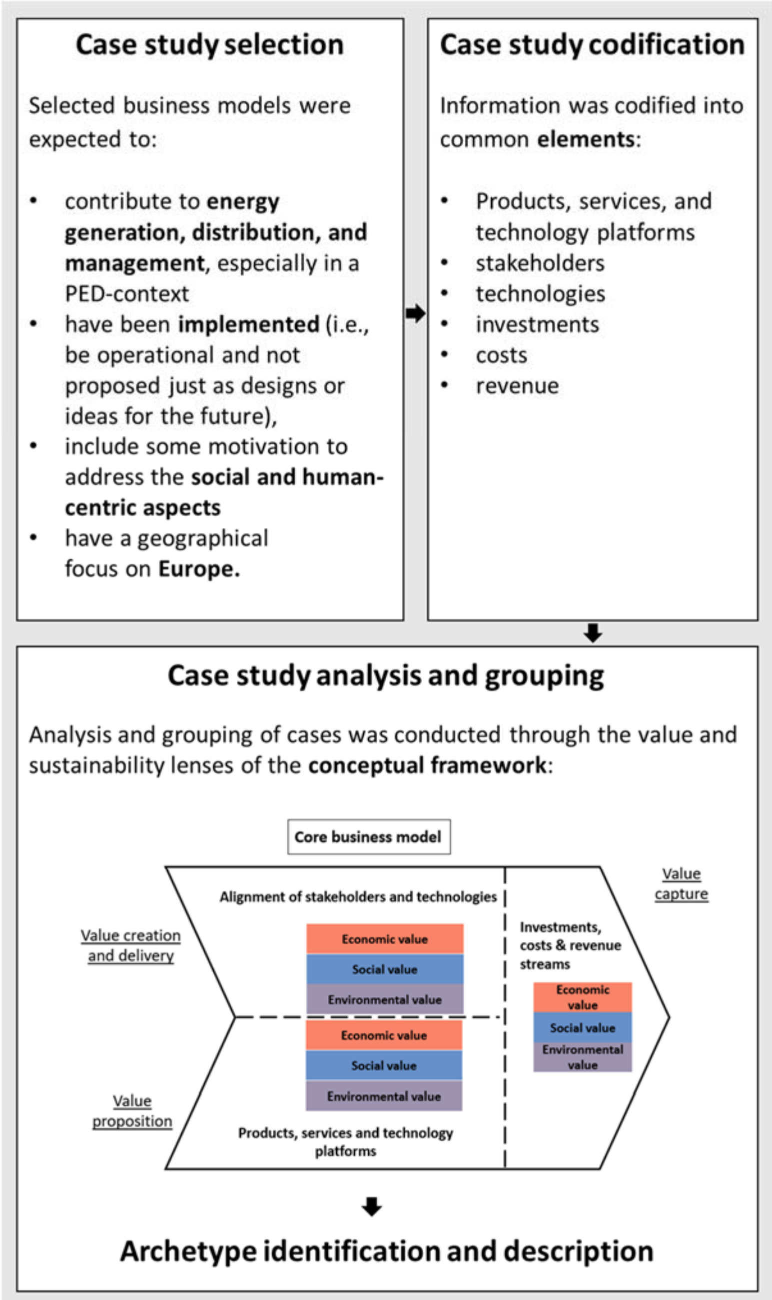

Figure 2-1. Overview of steps taken in archetype identification.

3 Case studies

Applying the criteria discussed in the previous section, the authors have identified 20 best practice PED or PED-like cases in Europe. The analysis of the cases through the iterative process of codification and grouping of common elements revealed similarities and differences among the case studies. In addition to natural differences in scale and complexity, the key stakeholders that drive and initiate these projects present a main difference in the perspective that the business models can take. This has implications for the creation of value across the sustainability dimensions (e.g. what type of value is created, for whom, and to what extent).

This section is divided into seven sub-sections that exemplify these differences. Each section provides a full overview of a "representative case", highlighting the business model elements that have helped the project achieve its goals and describing the value that has been created for the sustainability dimensions. Short descriptions of cases that share similar objectives and value propositions follow these representative case studies to present further key differences and similarities across cases. Key features of the representative case studies' value dimensions are presented in the business model schematics, while the business model schematics for the remaining case studies can be found in Appendix A. Table 3-1 presents this grouping of case studies into representative case studies and other cases with similar features.

Table 3-1. List of case studies sorted by representative ones

Representative case studies	Case studies with similar key features in its value dimensions
***Cooperative Deltawind*, the Netherlands**	*Isle of Eigg*, the UK
***Hunziker Areal*, Switzerland**	*District of Vauban*, Germany La Fleuriaye (Carquefou), France
***Samsø Island*, Denmark**	*The Orkney Islands*, the UK *Schoonschip*, the Netherlands *Aardehuizen*, the Netherlands
***IssyGrid*, France**	*Smart Energy Åland*, Finland
***Händelö Industrial Park*, Sweden**	*Pozo Barredo*, Spain *Drammen*, Norway
***Egni Co-op*, the UK**	*Partagélec*, France *Coopem*, Belgium *Legendre Energie*, France
***Enedis*, France**	*Spectral*, the Netherlands

3.1 Cooperative Deltawind, the Netherlands: citizen-led cooperative to achieve environmental goals

The case of Cooperative Deltawind was chosen as a representative case study to demonstrate how citizen ownership and management can create and deliver environmental and economic values, with further possibility of achieving energy self-sufficiency. The Isle of Eigg is presented for comparison, as another fully citizen-led initiative in energy management.

Cooperative Deltawind, located on the island of Goeree-Overflakkee, is one of the first and largest renewable energy cooperatives in the Netherlands. It was established in 1989 at the islanders' initiative with the aim to generate and manage their own power in an environmentally-friendly manner [21]. The cooperative was founded in reaction to a number of events – the oil crisis of the 1970s, the report from the Club of Rome, and the Chernobyl nuclear power plant disaster in 1986 [22]. These events became a driver for the islanders to generate their own power through wind energy (Figure 3-1) and achieve energy self-sufficiency.

Figure 3-1. Wind turbines on Goeree-Overflakkee island. [23]

Deltawind's main <u>value proposition</u> was motivated by the goal to protect the environment by eliminating dependency on fossil fuels. Pursuing this goal, the local citizens came together and initiated a cooperative that allowed them to create renewable energy **products and services** through local investments.

<u>Value creation and delivery</u> was possible through installation of renewable energy **technology** – in this case, predominantly wind turbines. These wind turbines allowed the island to become energy self-sufficient and climate-neutral and are mainly owned by the citizens. The first wind turbine was installed in 1991 with the help of the first investors and the cooperation of the local energy company EMGO. By 1996, the first wind farm (Battenoert) was built in Nieuwe-Tonge and became the largest in the country at the time [21]. In addition to wind turbines, Deltawind has enhanced the production of renewable energy with the installation of 2,960 solar panels [21]. This solar park is the first ground-based solar park of this scale in the country[21]. Deltawind consists of 2,500 members, mainly private individuals who live on the island and comprise its main **stakeholders** [22]. The cooperative is driven by local enthusiasm and robust engagement and was run by volunteers until the year 2000, when the

development of the second wind farm (Piet de Wit) triggered an increase in the professionalisation of the renewable energy business. All electricity is supplied through a three-party agreement with Eneco. Now, Deltawind owns two wind farms on the island of Goeree-Overflakkee with a total of 22 wind turbines and is part owner of Windpark Krammer [21] which was established in collaboration with Zeeuwind in 2017 and is the largest citizens' initiative in the Netherlands [24]. The power generated by Deltawind's wind farms is supplied to half of the island's 22,000 households.

This partnership between the islanders created not only social but also economic benefits. This constitutes the *value capture* of the Deltawind business model. Deltawind requires a membership fee to join the cooperative and is currently made up of 1566 members who have **invested** 3.9 million Euros through loans [25]. These were issued for Windpark Krammer and supervised by the Netherlands Authority for the Financial Markets, which is a novelty for the cooperatives [24]. In return, the members are engaged in a profitable business, receiving a yearly **revenue** of 6% from the dividends. Figure 3-2 illustrates how the cooperative, driven by strong citizen engagement, can significantly contribute to the environmental goals and energy transition of the country. This example highlights the importance of a combination of innovative technologies and active local participation.

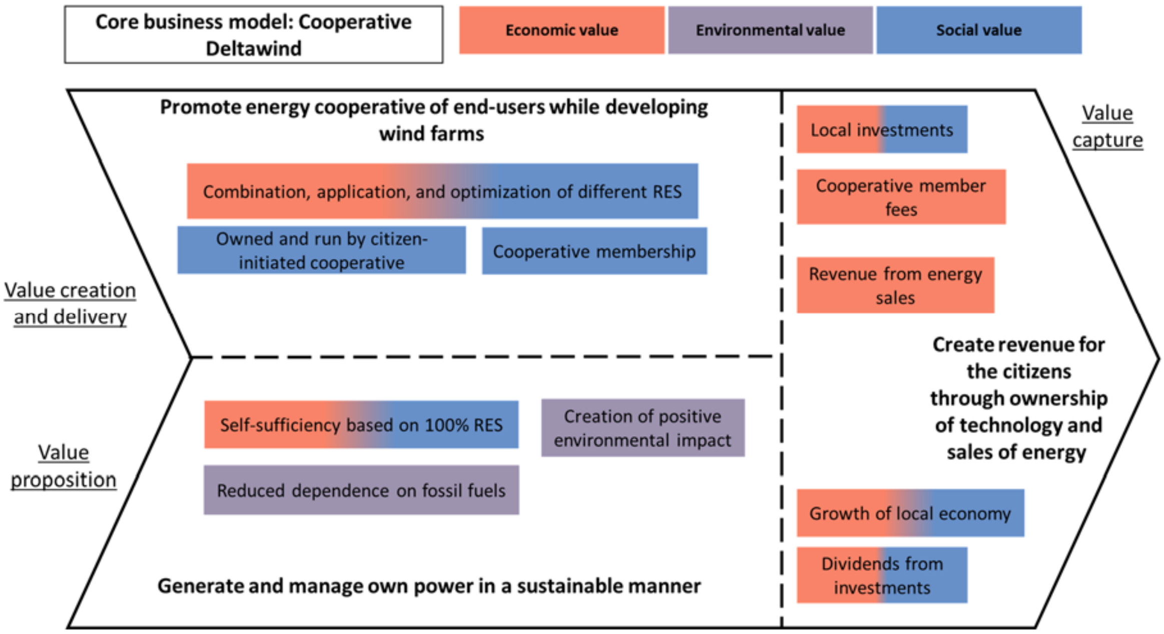

Figure 3-2. Deltawind business model through the lenses of the conceptual framework representing value and sustainability dimensions

3.1.1 Isle of Eigg, the UK

The Scottish Isle of Eigg has historically been dependent on expensive fossil fuels shipped to the island. However, in 2004, the islanders began taking steps to transition to a self-sufficient island powered by renewables. Similar to the Cooperative Deltawind, the Isle of Eigg has been driven by strong citizen engagement. Today, more than 90% of the island's electricity is locally-produced by three hydroelectric plants, four wind turbines, and solar PV. The island also has storage capacity through batteries which balance supply and demand and two back-up diesel generators. This has allowed the island's 96 residents to achieve 24-hour electrification and self-sufficiency [26]. Part of the success has been due to funding from the EU, investment from the islanders, and a bank loan. The island's energy infrastructure is owned by Eigg Electric, a subsidiary of the Isle of Eigg Heritage Trust (set up by the islanders in 1997 when they successfully bought the island). The size of the island allows residents to be in control of their energy management and to work together to decide on various aspects of the energy system, including pricing. Residents have voted to allow each household to use a maximum of 5kW at one time and businesses are allowed 10 kW. If consumption exceeds this maximum, the consumer's electricity is cut off, and they must pay a fine. However, meters provide the necessary information to prevent this from happening often [26]. Although similar in some respects to Cooperative Deltawind, the Isle of Eigg differs in the scale of the project since it serves a much smaller population.

3.2 Hunziker Areal, Switzerland: providing a social and environmentally-friendly place for living and working

The Hunziker Areal case study represents a best practice example for how a holistic approach, which emphasises social and environmental dimensions, can create a human-centric and environmentally-friendly place to live. The District of Vauban and La Fleuriaye are presented alongside Hunziker Areal to underscore how sustainable lifestyles in these districts are encouraged in a variety of ways, with different end goals – through energy efficient technologies, alternate mobility opportunities, and socially inclusive structures.

Hunziker Areal is a 41,000 square meter non-profit housing project located on the site of a former concrete factory in Zurich, Switzerland [27]. The construction of Hunziker Areal was completed in 2014/2015 and since then it has received several awards[1] due to its community-promoting architecture and economic, social, and environmental sustainability [28]. It was the first project of the housing cooperative "mehr als wohnen" (English: "more than housing") aimed at creating a sustainable neighbourhood from wasteland [29] that could serve as a beacon [30] for other non-profit housing developments [31]. It consists of 13 buildings, which provide living space for approximately 1300 citizens from a diverse range of backgrounds and income levels. The project has also created 150 new jobs in the area [27].

Hunziker Areal's <u>value proposition</u> reflects a holistic approach that is driven by the vision to provide an inclusive and environmentally-friendly place for living and working. Thus, the district's **<u>products and services</u>** focus on supporting affordable living, optimising energy management to increase energy efficiency and thermal comfort, and establishing an engaging and participatory environment for citizens (Figure 3-3) [27][32].

Figure 3-3. Impressions of the Hunziker Areal district [33].

[1] including the World Habitat Award 2016-2017 (https://www.world-habitat.org/world-habitat-awards/winners-and-finalists/more-than-housing/)

Hunziker Areal is able to create and deliver its intended social value through its cooperative structure that lies at the centre of the project. In 2007, the city of Zurich and about 50 housing cooperatives of Zurich founded the housing cooperative "mehr als wohnen", the core **stakeholder** of the Hunziker Areal project [28]. The development of Hunziker Areal was a collaborative project that involved several stakeholders (architects, neighbours, founding cooperatives, and the city government) and ensured citizen participation [28]. Additionally, residents need to be members of the cooperative to live in Hunziker Areal [34]. Consequently, the project naturally creates a participatory environment [35], which allows residents to engage with the community. Thus, Hunziker Areal's residents also become stakeholders in the district's development and various initiatives. Further, the district is designed to provide living and working opportunities for people from different social backgrounds, income, and abilities. 20% of the housing facilities are rented out to people with limited income [27].

To fulfil the environmental goals of the housing project, the cooperative partnered with the local Swiss utility supplier EWZ [36], the municipal data centre (OIZ Albis), and Lemon Consult AG [30]. Together, these partnerships help to achieve the cooperative's low energy – low tech approach [28]. This approach relies on conscious energy consumption by citizens, as well as energy efficiency and the application of different **technologies**: Minergie-certified buildings, district heating that uses warm exhaust air from OIZ Albis located next to the project, collective self-consumption of local green energy from rooftop solar PV (ewz. solarsplit), and smart optimisation platforms for energy and heating [27][30]. The residents can decide their source of electricity, but are encouraged to use the local self-consumption concept [36]. Mobility solutions and the possibility to satisfy living and working needs within the district allow the citizens to minimise their mobility-related energy consumption [27][32]. Together, these approaches have led the district to comply with 2000-watt society energy measures. The cooperative consults Lemon Consult AG to keep track of the district's energy compliance [27][30].

Hunziker Areal's self-consumption model allows citizens to capture value through reduced energy **costs** in comparison to traditional energy supply [36]. The creation of micro jobs, democratic participation processes, and membership rights contribute to social sustainability and to the provision of an attractive living environment. As the owner of the photovoltaic (PV) system, the cooperative receives **revenue** from its energy sales to the citizens and to the grid and a quarterly credit for its solar electricity from EWZ [36]. The cooperative benefits economically from its heating concept that has generated savings of up to 30% / 40'000CHF of yearly heating costs in comparison to conventional heating [30]. Furthermore, cost-effective construction and sharing of risks among the stakeholders during the development process ensured the feasibility of this social housing concept [28]. Finally, the replicability of the concept of Hunziker Areal may be demonstrated by the planned development of another similar participatory project in Oberwinterthur (Switzerland) [37]. Figure 3-4 shows the core factors of the Hunziker Areal business model.

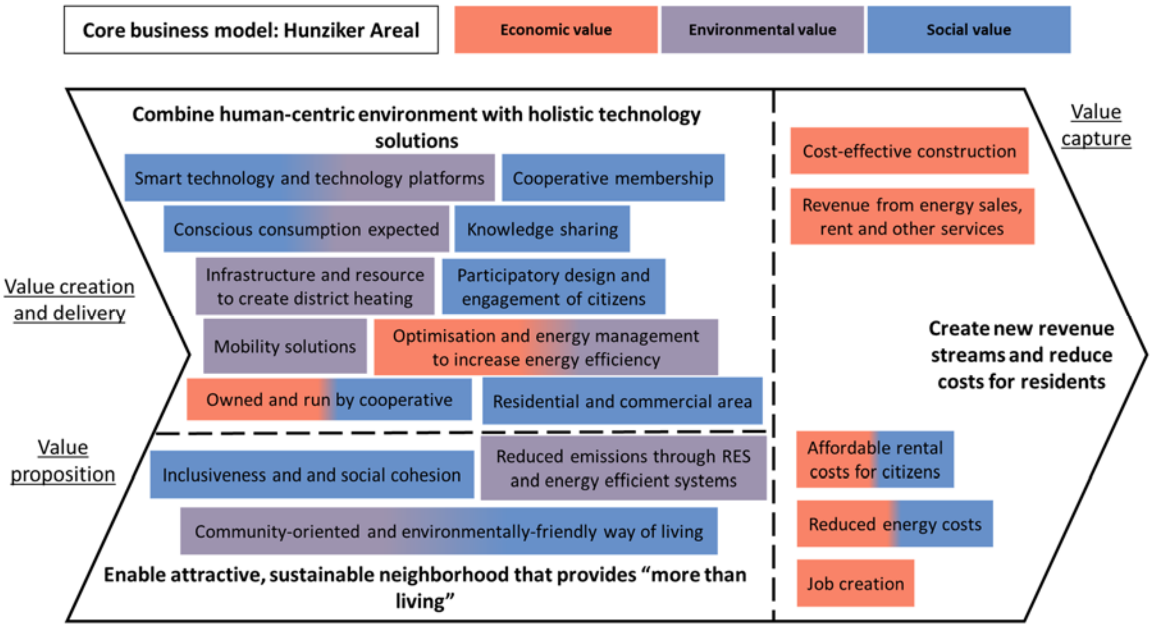

Figure 3-4. Hunziker Areal business model through the lenses of the conceptual framework representing value and sustainability dimensions

3.2.1 District of Vauban, Germany

The district of Vauban (Freiburg, Germany) demonstrates similarity in key features to Hunziker Areal, also focusing on creating value in the socio-environmental dimension. The construction of the Vauban urban district was initiated by citizens and supported by the city of Freiburg. The citizens founded the cooperative "Forum Vauban" in 1993, with which the participatory construction and development process started. Vauban also aims to provide an environmentally-friendly living and working environment to its residents [38]. The vision includes a holistic mobility concept to keep the district largely car-free, to apply renewable technologies such as solar rooftop PV and district heating solutions, and to construct passive houses (low-energy construction) [39]. The district does not focus on social housing like Hunziker Areal but appreciates and recognises the different social groups and mix of residential and commercial spaces that ensure the liveliness of the district [40].

3.2.2 La Fleuriaye (Carquefou), France

La Fleuriaye (Carquefou) in France is a newly built district like Vauban and Hunziker Areal. Construction was initiated by the city of Carquefou (part of Nantes Métropole) and implemented by a public engineering agency (Loire-Atlantique Développement - SELA) together with a total of 18 partners, including the municipality and an energy company. This project was developed in two phases focused on two sub-districts: West (residential area) and East (business area). La Fleuriaye West strives to provide a comfortable living environment. The district combines different technological approaches including solar PV and biomass for energy production, passive houses, smart technology, and soft mobility for energy efficiency and management. Through this approach, the district aims at energy self-sufficiency and efficiency. Similar to Hunziker Areal and Vauban, La Fleuriaye prioritises the social aspect of sustainability [41].

3.3 Samsø Island, Denmark: achieving energy self-sufficiency

Samsø Island was chosen as a representative case study to showcase its rapid transition to self-sufficiency with relatively little government intervention, active involvement of the local community, and innovative technologies. The three accompanying cases, Schoonschip, Aardehuizen, and the Orkney Islands, demonstrate other ways in which citizen-led self-sufficiency is being achieved across a number of environmental dimensions (e.g. waste and water management), despite varying scale and physical boundaries.

Denmark's island of Samsø became the world's first 100% renewable island, powered mainly by wind energy [42] (Figure 3-5). By 2007, the island had achieved its ten-year masterplan of becoming a model renewable energy community [43]. The island of Samsø serves as an example for others in achieving self-sufficiency based on renewable energy, thus demonstrating the positive energy concept in its business model.

Figure 3-5. Impression of the Samsø island's wind turbines. [44]

The island of Samsø is 114 square km in area and located in the Kattegat Strait, between the mainland of Jutland and the island of Zealand in Denmark. The island has a population of 3,724 people (as of 2017). In 1997, the island was entirely dependent on fossil fuels imported from the mainland; growing unemployment and emigration caused increasing depopulation [45]. That year, Samsø won a government competition to become an energy self-sufficient island based on 100% renewable energy sources. The island municipality and its population saw the potential of the renewables to secure energy independence, build up the local economy, and provide jobs [43]. The main drivers for the islanders to become energy self-sufficient were high electricity costs, operational cost savings that could result from self-sufficiency, reliability and stability of the energy supply, and independence from the traditional energy system [46]. The energy, environmental, and socio-economic challenges influenced the goals of the islanders to become energy independent and CO_2 neutral based on renewable sources.

With these drivers in mind, Samsø's main value proposition was environmentally, socially, and economically motivated. The **products and services** offered to achieve this value proposition would need to ensure that sufficient energy was produced to meet local energy demand, foster a carbon-free environment and energy independence, and promote sustainable mobility.

As Samsø shifted away from fossil fuels, it replaced its energy production with offshore and onshore wind turbines, with some additional contribution from solar PV. Value was created and delivered through the combination of innovative **technologies** such as wind turbines, biomass district heating plants, and improvements in transportation and energy conservation. The electricity on the island is supplied by 21 wind turbines (10 offshore and 11 onshore) installed between 1998 and 2001 and which covered the island's energy needs by 2002 [43]. To provide heating to the islanders, three district heating plants were built by 2005. Heat production based on renewable energy such as biomass and solar energy rose from 25% in 1997 to 65% in 2005 [43]. These technologies are used and owned mainly by the citizens, which promotes their strong engagement and cooperation with other **stakeholders** including the local energy agency, the municipality of Samsø, the local development office, and the municipally-owned energy company.

The renewable energy produced on the island has brought many environmental benefits, offsetting the CO_2 emissions caused by traffic and other sources on the island. Nowadays, the islanders have an average annual CO_2 footprint of negative 12 tonnes per person, compared with the Danish average of 6.2 tonnes [47]. Samsø benefits from recycling all resources with minimal waste. A biogas plant was built that converts food waste, vegetation waste, and grass into biogas for use as fuel for the ferries. At the same time, residual products serve as fertiliser on farms [43]. Sustainable mobility is promoted by replacing all transport, including ferries, cars, and other fossil fuel-powered vehicles with electric or biofuel vehicles. Samsø's inhabitants own the highest number of electric cars per capita in Denmark. Electric cars constitute 90% of all vehicles on the island, while the ferry runs on biogas. These efforts have made Samsø CO_2-neutral.

The value creation process also produced social benefit by focusing on the inclusion of Samsø's residents. Local communities' engagement and acceptance of renewable energy was considered a 'natural' process as the entrepreneurial spirit of the local citizens and partnerships with local stakeholders increased the likelihood of community benefits and support [45]. External support through funding programmes and expert assistance also played a crucial role in developing 'shared visions' for achieving the common energy goal. Additionally, flexible energy policies allowed renewable energy projects to be adapted to the needs and motivations of the citizens.

The favourable funding possibilities that were available at the time of implementation made the project possible. This constitutes the <u>value capture</u> of the business model of Samsø. The total **cost** of the project was 57 million euros from 1998 to 2007, while 70% of the **investments** came from local investors and islanders [43]. The government offered financial support for technological solutions, such as subsidies and tax incentives, to local communities to launch the project and secure its financial viability45. Samsø's inhabitants benefited economically as well: the local homeowners were granted subsidies of up to 30% of the cost of converting to solar thermal, biomass or heat pump installations, and energy efficient refurbishments. To create more value on the island, the installation work was carried out only by local tradesmen, thus meeting the goal of building up the local economy and creating jobs. Nowadays, the ownership of the technology creates **revenues** from energy sales, boosting the local economy since the money remains on the island. The surplus energy is exported to neighbouring Jutland, which also contributes to the financial returns (Figure 3-6).

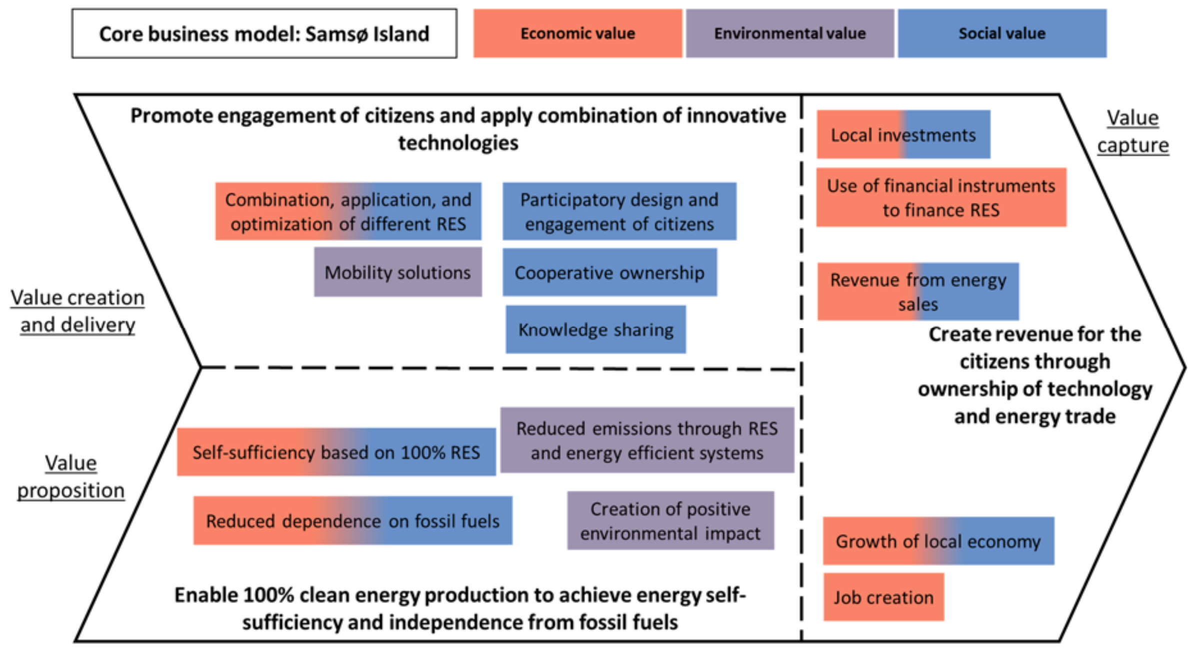

Figure 3-6. Samsø island's business model through the lenses of the conceptual framework representing value and sustainability dimensions

3.3.1 The Orkney Islands, the UK

The Orkney Islands are an archipelago off the north coast of Scotland that have depended on renewable energy technologies based in wind, wave, and tidal resources for over 30 years [48]. The Orkney Islands energy transition is economically driven [49] and initiated and enabled by the local community [50]. The citizens achieved energy self-sufficiency [51] by investing in over 500 small and medium-sized wind turbines for their farms or gardens [52]. The local supply chain helped to decrease the negative impact on the local environment or community and created significant benefits to the local economy through revenue from energy sales, creation of jobs, and affordable prices for consumers [53]. The aims and objectives [54] for transforming Orkney islands into sustainable islands have evolved during the island's energy journey to address different challenges (e.g. curtailments of wind turbines) and to reduce dependency on economic benefits [52]. Diversification of activities and partnerships [49][50] in this community-driven energy transition has led the Orkney Islands to address energy efficiency and fuel poverty, to decarbonise electricity[48], to establish a marine energy test site [55], and to introduce a smart-grid [56], innovative heating, energy storage, and energy management solutions [57].

3.3.2 Schoonschip, the Netherlands

Schoonschip is a Dutch floating residential area with a total of 46 newly-built households in the Johan van Hasselt canal, Amsterdam. The project was initiated by the citizens (over 100 future residents) in 2012 and is being implemented in partnership with the municipality and numerous other partners. It is still under development but is planned to be functional in 2020 [58]. Similar to Samsø's value proposition, Schoonschip aims to become energy self-sufficient through renewable energy and to achieve climate neutrality, albeit on a smaller scale. The project generates its own electricity and heat with solar panels and heat pumps, while effective insulation reduces energy consumption and losses. Connection to the smart grid enables the residents to exchange electricity among each other to achieve an energy balance. Aiming at climate neutrality, Schoonschip intends to apply environmentally-friendly solutions such as energy generation based on exclusively RES, sustainable waste and water management, disconnection from the natural gas network, and promotion of e-mobility. Efforts of citizens contribute a great deal to the implementation of these solutions, while the economic benefits are secondary.

3.3.3 Aardehuizen, the Netherlands

Aardehuizen is a community of 23 homes located in the municipality of Olst in the Netherlands. Like the project on Samsø, the development of this self-sufficient community was driven by the engagement of citizens: it was built in cooperation between Transition Deventer (a citizen-led organisation focused on energy transition), the municipality, and regional experts to create a way of living "in harmony with nature" [59][60]. Aardehuizen's goal is to enable a self-sufficient lifestyle that encompasses all aspects of sustainability [60]. All of the homes were built with the help of the residents and over 1,000 volunteers. Most of the materials for the construction were sourced within 50 km and all energy needs are met through installed PV [59]. Although operating on a smaller scale compared to Samsø, Aardehuizen aims to be fully energy self-sufficient, relying on its inhabitants for energy production and management through PV. The project contributes to environmental, social, and economic dimensions by aiming to optimise use and re-use of materials, ensuring that the community is self-sufficient in terms of energy, water, and sanitation, and strengthening mutual social efforts toward this goal. Since its inception, the project has created different values for the community: it has opened its bulk buying of solar panels to the citizens of Olst, created construction jobs, supported the formation of a collective of eco-carpenters, and organised many informational and skills-building events.

3.4 IssyGrid, France: developing smart grid/technology test platforms

The case of IssyGrid was chosen as a representative case study as it best illustrates how success of a project can be achieved through the coming together of stakeholders with different technical skill sets and knowledge bases (e.g. stakeholders from the municipality, private companies, and research organisations). The Smart Energy Åland project, presented alongside IssyGrid, also demonstrates how a complex set of energy services is delivered through partnerships, though at a different scale and within the boundary of an island.

In 2012, Bouygues Immobilier, a private property developer in France, initiated the development of IssyGrid, with the goal of creating France's first smart grid network with district-level optimised energy production and management. The project was supported by the mayor of Issy-les-Moulineaux and nine additional companies joined the project. Located in the Seine Ouest business district and Fort d'Issy in Issy-les-Moulineaux, IssyGrid services 1,600 homes (10,000 people in total) and an area of 160,000 m^2 [61].

The development of IssyGrid was environmentally and economically motivated. While the main <u>value proposition</u> was to create France's first smart grid, appealing to new business, this was achieved through **products and services** that promised to introduce a way to "consume better and less", integrate renewables into the grid, and optimise energy management across a diversity of uses (e.g. office, home, shopping) [61]. In the end, the project was able to create social value as well, expanding from the Seine Ouest business district to include the residential area of Fort d'Issy.

Figure 3-7. The IssyGrid business district [62](left) and Fort d'Issy [63].

IssyGrid was able to <u>create and deliver</u> its mission through the power of **stakeholder partnerships**. Ten partners from the municipality and a range of sectors came together to help develop IssyGrid (real estate, telecommunications, energy and technology consulting, energy utility, and software sectors)[1] [64]. Through this partnership, a number of **technologies** and technical strengths were made available to make the project a reality. For example, EMBIX, a company that was born out of IssyGrid, manages the information system and the analysis and optimisation of the smart grid's energy flows across the district [65][66]. Microsoft provides cloud services development, hosting, and management for the large amount of energy data that needs to be stored and processed [67]. On the energy management and optimisation side, a number of the partners have worked together to create the 14 interconnected information systems that balance supply and demand [68]. In addition to analysing the energy use data generated through connected sensors in the neighbourhoods, energy batteries make it possible to

[1] Partners involved: Bouygues Energies & Services, Bouygues Immobilier, Bouygues Telecom, EDF, EMBIX, Enedis, Microsoft, Schneider Electric, Sopra Steria, Total

absorb and store energy during production peaks. Bouygues contracted Renault to help bring recycled batteries to the grid in order to store excess energy. Meanwhile, Enedis played a critical role in IssyGrid's aim of allowing users to track their energy use by installing 1,700 Linky meters in the buildings. These smart meters allow users to check their energy use in real time and change their behaviour to be more efficient energy users [69]. The oil and gas company, Total, which launched its solar PV arm in 2011 [70] was responsible for the installation of the PV panels in IssyGrid. Bouygues Energies and Services provided public lighting to the district, introducing dimming adjusted to the hour of the day and traffic in order to save energy at night [64]. Finally, SoMobility, which was launched in 2015, has also joined the project to provide mobility solutions in the district [66].

Stakeholder engagement also led to the resolution of anticipated issues of data privacy that come along with the monitoring of energy usage data. IssyGrid is notable as the first time that a procedure for data use in smart grids was defined in agreement with the Commission Nationale de l'Informatique et des Libertés (CNIL) [71], an organization that protects individuals in line with the French Data Protection Act, thus paving the way for future smart grid development.

The technologies these companies implemented in IssyGrid helped achieve the goal of optimising energy management, thereby creating environmental value for the neighbourhood and greater area. Additionally, the development created economic value, making the neighbourhood appealing to new businesses and residents who could also benefit from reduced long-term energy costs [64]. This is important as the commune of Issy-les-Moulineaux is a hub for information and communication technologies (ICT) companies [72].

Value capture in the IssyGrid development was also achieved through the partnerships between the ten consortium companies. The partnering companies were able to share the initial **investment** of 2 million euros equally. As the partners are private companies, they accrue **costs** and **revenues** for the products and services they offer, but economic benefit is also transferred to IssyGrid's users who have reduced energy costs through optimised energy management [73].

An added benefit captured in the IssyGrid development has been reputation-building and the opening of new opportunities for start-ups involved in the consortium. At least two new companies, Embix and SoMobility, were born out of work done at IssyGrid. Additionally, IssyGrid was able to expand into Fort d'Issy, an adjoining residental neighbourhood that offers further economic, environmental, and social value. Fort d'Issy aims to be an eco-neighbourhood. The residential area holds 1,600 homes, around 20% of which is social housing, and boasts many shops, restaurants, and green spaces [74]. 60% of the neighbourhood's energy needs are met through renewables [75] and two geothermal wells cover 75% of the neighbourhood's heating needs[76][77]. The main priorities and key factors of the Issygrid business model are summarised in Figure 3-8.

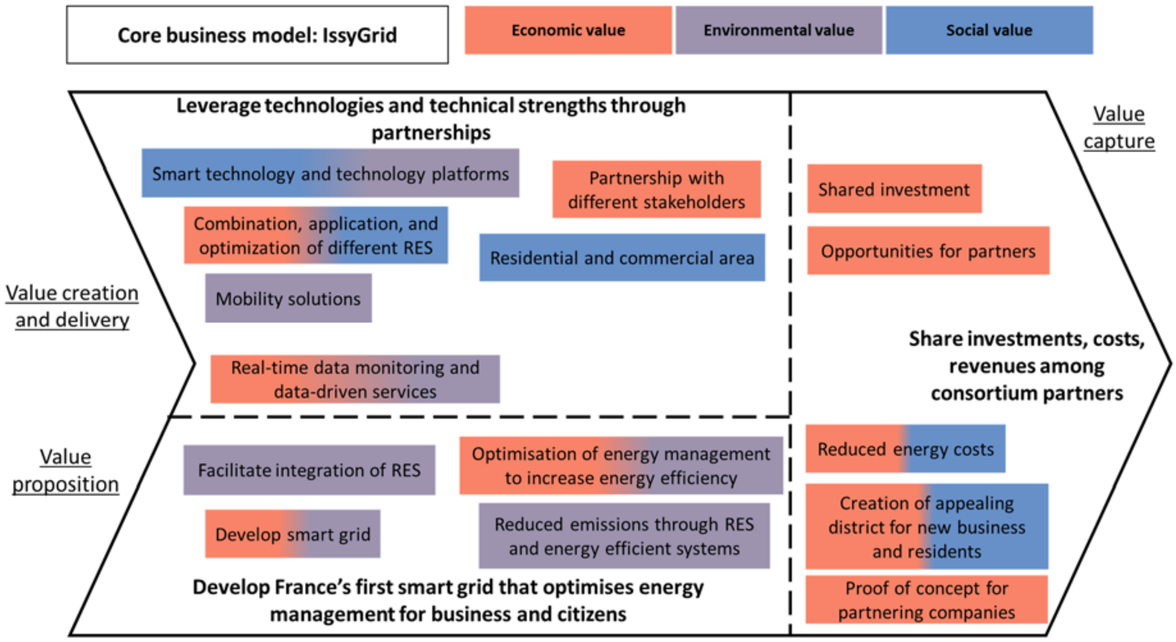

Figure 3-8. IssyGrid business model through the lenses of the conceptual framework representing value and sustainability dimensions

3.4.1 Smart Energy Åland, Finland

Like IssyGrid, Smart Energy Åland is a smart grid project powered by stakeholder partnerships. Åland, an autonomous island region belonging to Finland, has become a test bed for innovative renewable energy technologies. The government of Åland initiated the project in 2014 as a way to reduce CO_2 emissions and increase the share of renewable energy [78]. A variety of products and services have been developed through this project to capture solar energy, wind energy, wave energy, and geothermal energy. The project also includes solutions for e-mobility, energy storage, and heat [79]. Similar to IssyGrid, Smart Energy Åland has been able to deliver innovative technologies due to the varying expertise of a number of private stakeholders that have partnered with the municipality of Åland and a number of research organisations [80]. Together, these partners have created the joint venture Flexens, 50% owned by Clic innovation (a consortium of 46 Finnish companies, universities, and research institutions) and 50% owned by the municipality of Åland and local energy operators [81][82][83] . The autonomous nature of the islands has also led to the project's success as new policies facilitating the smart grid development can be enacted easily and quickly [84]. Unlike IssyGrid, Smart Energy Åland is highly dependent on citizens as stakeholders, both in awareness and prosumption. Thus, solutions for flexibility management and storage are of great importance on Åland [85][86].

3.5 Händelö Industrial Park, Sweden: developing district heating through a symbiotic, eco-cycle network

Händelö is presented as a representative case study to showcase how a district heating network can be created though a circular economy, the development of a symbiotic network that leverages partnerships and maximises the reuse of existing resources and by-products. Projects in Pozo Barredo and Drammen are presented for comparison to showcase other, relatively less complex approaches to creating environmentally-friendly district heating.

The Händelö bioenergy complex is located on an island belonging to Norrköping Kommune (Figure 3-9) in eastern Sweden. It is made up of industrial symbiotic activities comprising an ethanol plant, a biogas plant, and an energy provider (E.ON) [87]. A combined heat and power (CHP) plant lies at the heart of the complex, providing electricity, district heating, and other services to the residents of Norrköping [88]. Within the symbiotic network, heat is delivered to the district heating network, electricity to the grid, and steam to the nearby ethanol production plant which produces pure ethanol that is then used as biogas to heavy duty vehicles and alternative fertilisers for the local agricultural activities. In turn, the municipality of Norrköping provides household waste to be used as waste in the CHP plant.

Figure 3-9. Händelö Industrial Park, Norrköping Kommune. [89]

The network's dominant process is the utilisation and processing of waste and by-products from municipalities and the forest industry. Hence, Händelö's value proposition is to enable eco-cycle thinking [90] and an effective use of resources in an environmentally and economically efficient way. The industrial symbiosis network is a showcase of synergies between industrial, urban, and agricultural activities for improving regional sustainability. This minimises dependence on fossil-fuel resources and contributes to the development of a bio-based economy that tackles the challenges that often relate to bio-energy production (e.g. land-use issues, transportation problems, and seasonality).

Value is created and delivered through a proactive collaboration of several **stakeholders**[90]. The energy company, bio fuel production companies, companies from the agriculture, forestry, and logistic sectors, recycling companies of various materials, and the Norrköping municipality are the major partners involved. Together, they create a network that makes effective use of resource linkages and applications of clean technologies, while being sensitive to the environmental characteristics of their exchanges.

Economic and environmental value is captured through the reduction of operational **costs**. By using the outputs of one process as input for another, Händelö has become a hub of industrial symbiosis and environmental technology that stimulates a circular economy in the area [91]. The CHP plant also receives a fee for the domestic waste it receives. Additionally, substantial investments and operational costs are minimised from the steam generation. As a result, the complex attracts interest from business developers and local authorities. Figure 3-10 illustrates the key features of the Händelö business model.

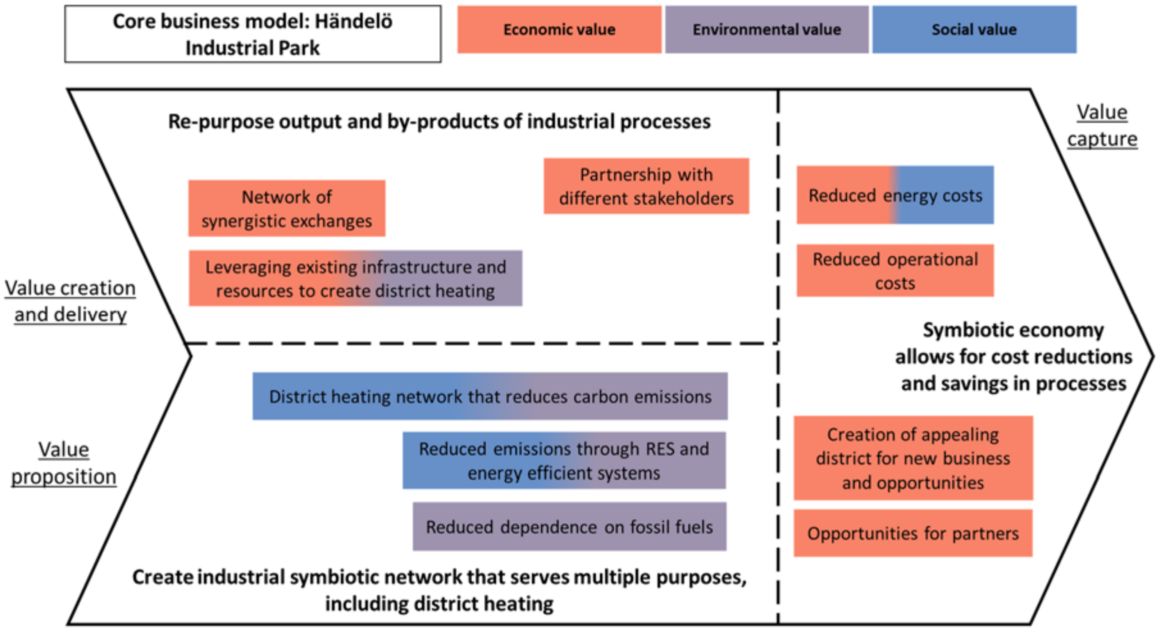

Figure 3-10. Händelö business model through the lenses of the conceptual framework representing value and sustainability dimensions

3.5.1 Pozo Barredo, Spain

Pozo Barredo is based in the region of Asturias in Northwestern Spain. It is led by Hunosa, a company which specialises in geothermal and biomass projects [92]. Its value proposition is to use geothermal facilities to transform mine water into heat for the municipality's public buildings such as hospitals, universities, and schools. As in Händelö, the project is able to deliver district heating in a way that leverages existing resources (e.g. geothermal, mine water). However, the project covers a smaller area (1 km^2) than the Händelö complex and given its site-specific availability of both geothermal and mine water, has geographical restrictions of replicability [93]. Nevertheless, it showcases the possibilities for sustainable means to generate heat and has achieved a reduction on emissions of 636.85 tCO_2/year [92].

3.5.2 Drammen Kommune, Norway

The Drammen Kommune [94] in Norway also integrates renewable resources into the district heating system. The project is currently in the process of upgrading the existing heating system that uses electricity, bio-mass, and gas to utilise seawater as a heat source for the industrial heat pump, moving away from fossil and combustion fuels. Ambient water provides the ability to provide a high debit of water, thus enabling the heat pumps to extract more heat [95]. The system is owned and operated by a Drammen Fjernvarme, a company which is 50% owned by the municipal energy company and 50% by a commercial energy company [96].

3.6 Egni Co-op, the UK: expanding the deployment of PV

The case of Egni Co-op was chosen as a representative case study to showcase how deployment of PV can be done through a cooperative structure that engages citizens in its environmental and economic value proposition. The cases of Partagélec and Coopem also present approaches that deliver financial value to citizens while creating environmental value through PV installation.

Egni cooperative (Co-op) is a non-profit, community-owned energy cooperative situated in Wales [97]. The cooperative was founded in 2014 by Awel Aman Tawe with the support of Renew Wales to tackle climate change on a local level [98]. For this purpose, Egni Co-op aims to help increase the share of renewable energy in Wales while engaging citizens in the development of rooftop solar PV. The cooperative achieves this through the development of PV on public buildings and simultaneously creating public awareness, acceptance, and inspiration for future generations [97]. Egni Co-op raises funds for these PV installations, plans, installs, and manages them with support of local partners [97].

The *value proposition* of Egni Co-op's business model is to deploy rooftop PV installations on public buildings. At the same time, central to the business model are the cooperative share offers which allow anyone with a similar mind-set – but without the possibility of building their own rooftop PV – to become a member and to invest into this technology, while receiving economic benefits through a "fair rate of return" [98]. Through this approach they bring benefits to people and engage them in reducing CO_2 emissions to tackle climate change [99]. Thus, the core of Egni Co-op's business model delivers social, environmental, and economic value to the citizens (Figure 3-11) [100].

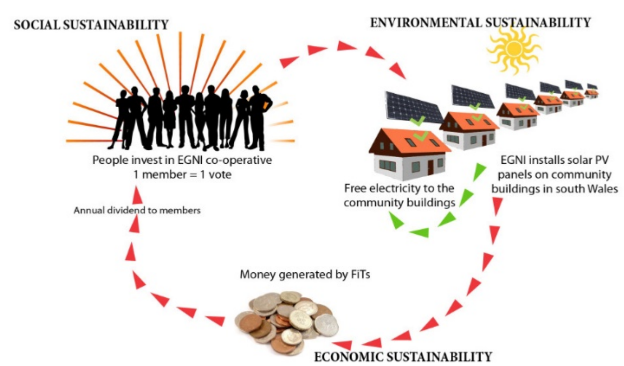

Figure 3-11. Egni Co-op provides environmental, economic, and social sustainability to all participants (left) [100]. This concept provides solar PV on community buildings like the primary school "Ysgol y Bedol" (right). [101]

Egni Co-op's value proposition uses its **products and services** to engage citizens, educate them, and raise awareness of the benefits from the energy transition through the deployment of rooftop solar PV. For example, it offers energy monitoring screens for each building equipped with PVs [102] to inform the communities about their energy consumption and the energy and CO_2 emissions savings [103]. Schools such as "Ysgol y Bedol" are also able to benefit from this by teaching the students how conscious energy consumption and renewable energy can be used to mitigate climate change.

These value propositions demonstrate that *value is created and delivered* through involvement of different **stakeholders** and established **technology** (solar PV). In the first place, Egni Co-op is membership-based, where anyone can become a member by buying shares. The "one member one vote" principle of the cooperative allows members to get involved in the planning and decision-making process of developing the rooftop solar installations [104]. In addition, Egni Co-op seeks partnerships with local enterprises and communities for installation and maintenance. In short, Egni Co-op delivers value through funding, managing, and developing solar PV in cooperation with local stakeholders.

This leads to the *value capture* of Egni Co-op [97], which describes the economic value that it generates from its PV installations. The initial capital **investment** for these is funded through share offers. A share **costs** £1, but the minimum investment is £50, and the maximum is £100.000. As the installation has a life expectancy of 20 years, this investment is a long-term investment, and the invested money cannot be easily withdrawn [104]. During its first share offer in 2014, Egni Co-op raised £230.000, which they used to finance the installation of seven rooftop solar PV projects. These installations have saved more than 63t of CO2 and reduced the energy bills of the communities in these buildings by £13.000 in 2018 [97], creating environmental and economic value for them. The communities can directly use their locally produced green electricity at a cost which is 20% lower than that offered by a traditional supplier. In fact, small member sites even get the electricity for free [97]. The majority of the electricity is fed to the main power grid, from which the cooperative receives revenue from feed in tariffs (FITs). This results in economic benefits for the shareholders as Egni Co-op uses it to provide its members with an average annual 4% rate of return on investment. The revenue is also used to cover various costs (e.g. maintenance costs[1]) [104].

Figure 3-12 shows how the analysed sustainability and value dimensions come together and form the business model of Egni Co-op. Since 2014 Egni Co-op has successfully deployed rooftop solar on various sites all over Wales [105] and even received awards for its engagement [106]. One of the latest projects in Newport (Geraint Thomas National Velodrome in Newport[2]) exemplifies how an energy cooperative business model can be used for the development of PV in PEDs, focusing on the inclusion of citizens. In addition, Egni Co-op aims to expand its outreach through projects that address fuel poverty [97].

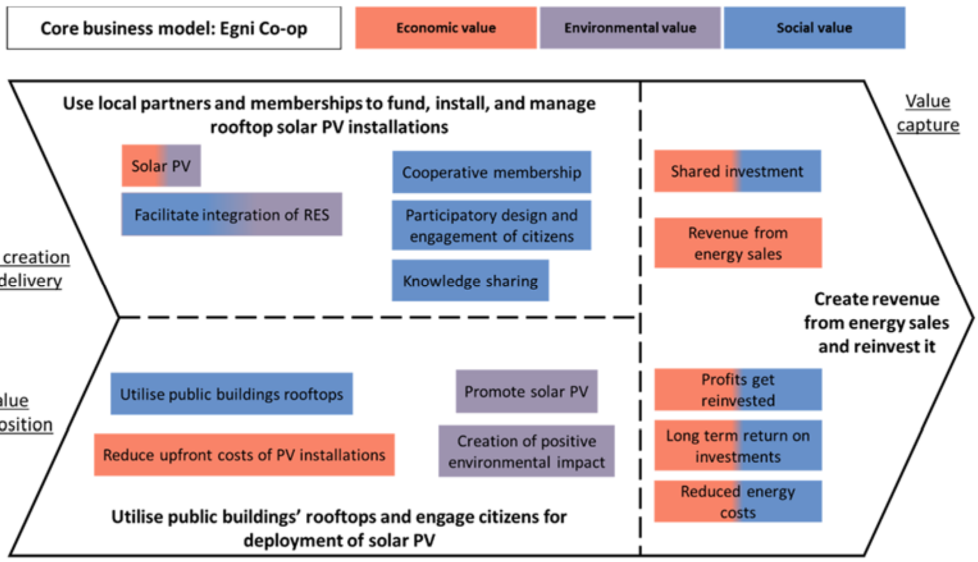

Figure 3-12. Egni Cooperative (Co-op) business model through the lenses of the conceptual framework representing value and sustainability dimensions.

[1] Egni Co-op uses this money to fund: ˣ
- maintenance & repairs required for the panels and associated equipment,
- running costs of Egni,
- a sinking fund for replacement of the inverters,
- annual interest payments to investors and capital repayments,
- an educational and awareness raising program.

[2] Funded by a loan from the Development Bank of Wales and the co-op's shares offering. It will be is the largest installation of the kind in Wales, helping the city council to become carbon neutral through a 2000 PV installation.

3.6.1 Partagélec, France

The Partagélec project in France aims to promote the deployment of PV and the possible collective self-consumption of the locally produced green energy. This was initiated in 2016 and led by the city of Pénestin while run and financially supported by an assembly of 15 adjacent municipalities (known as Cap Atlantique). The project is driven by a partnership between municipalities, implementers, sponsors, and the local community. It is a pilot project as part of the process of developing municipal and inter-municipal energy production and collective self-consumption. Hence, the main objective of the project is to promote and demonstrate the feasibility of PV electricity production and consumption by local businesses and residents of the Closo business park, while leading to energy cost reductions for the citizens [107].

3.6.2 Coopem, Belgium

While Partagélec and Egni Co-op have a strong emphasis on sharing knowledge that results in increased social value, Coopem is more enviro-economically driven. Coopem (Cooperative Energy of Mouscron), founded in 2017, is a cooperative created out of the desire to reduce the area's carbon emissions and promote the installation of more solar PV at accessible prices in Mouscron, a city located in the Walloon region in Belgium. It is a joint venture between the city, the citizens of Mouscron, and two other partners that assist in the technical part of PV installation (Energiris and Aralia) [108]. This marks a main difference with the Egni Co-Op, which owns the PV installations and takes over the finances of the system. Coopem facilitates the purchase of solar PV by reducing upfront costs and providing technical and administrative help in the process [108]. The cooperative offers PV at a reduced price to citizens and leases it to businesses in exchange for green certificates. Coopem has managed to complete around 100 installations since its inception, accounting for 1,145 PV solar panels (producing around 292 MWh) [109].

3.6.3 Legendre Energie, France

Legendre Energie is a French private limited company based in Rennes, Bretagne [110], that we refer as a representative case of enterprises that work with public authorities and companies to deploy PV and provide efficiency services. Unlike the above co-ops cases, Legendre deploys renewable energy generation for profit demonstrating the commercial viability of such a proposition. The company installs solar PV cells to commercial or public buildings which self-consume their power or connect directly to the electric grid. More than 70MW of solar has been installed between 2007 and 2020 across 500 facilities, including roofs and car park shelters.

3.7 Enedis, France: transitioning to data-driven grid management

The case of Enedis' Linky smart meter was chosen as a representative case study to illustrate how the energy transition requires new technologies in the fields of smart grids and how new services emerge through energy data-driven platforms. Furthermore, the opportunities that emerge through data management systems, decentralised energy management systems, and new services at localised level are demonstrated through Spectral's products and engagement in local energy community projects.

Enedis is a major public distribution system operator that manages the distribution grid throughout France, the largest in Europe (13% of the European network) [111]. One of its objectives is to facilitate the French energy transition by providing to the stakeholders in the electric power system with innovative grid connection solutions and automations for facilitating the integration of distributed renewable energy sources [112]. In December 2015, Enedis initiated the deployment of Linky [113], a smart metering system (Figure 3-13) that enables remote operations, shorter intervention times, and more detailed monitoring of electricity consumption. Linky allows for the development of energy efficiency services based on home automation [114], key to the transition to smart-grid technologies. Overall, Enedis aims at the development of new solutions that are based in the application of large volumes of data in a large-scale rollout112.

Figure 3-13. A Linky smart meter. [115]

The development of the Linky smart meters was environmentally and economically motivated. The value proposition of Enedis is to use new **technologies** in the fields of smart grids and data-driven systems. In particular, the Linky smart meter improves communication of energy usage between end consumers, electricity suppliers, electricity producers, network managers, and local authorities. Additionally, it allows network operations to become more dynamic due effective use of data, improves response rate regarding the state of the network (e.g. localised level data profiles regarding flow of voltage and ability to launch real-time alarms at the data centre), maintenance (e.g. condition of equipment, triggering preventive maintenance), and understanding of the consumers (e.g. change of consumption patterns) [116].

Real-time data monitoring through the Linky meter, combined with intensive data-driven models, is the key value creation instrument that helps optimise maintenance operations and energy system management. Access to real time information on the field through the smart metering technology allows the network to operate more effectively. Additionally, it allows the introduction of progressive tariffs for different time periods with higher or lower tariffs for peak or low-peak periods for users [113]. Furthermore, the use of the smart meter technology allows effective decentralised management at the community level by managing energy generation and self-consumption (balancing the local loop) among the different stakeholders (e.g. local councils, cooperatives, commercial or low scale industrial users, home owners) [116], and supporting local authorities in the development, optimisation, and assessment of energy resources in the region [114]. Finally, smart metering technology can support the deployment of small-scale PVs in the energy mix by making remote energy management possible at the household-level.

Value is captured for Enedis through smart grid deployment, by improving its brand recognition as a sustainable energy provider, generating **revenues** from the energy distribution network that become transparent for its users, and at the same time reducing costs by creating more efficient network management [114][117] Additionally, data collected and provided by Linky are the backbone of new services, allowing for major changes in the decentralised distribution network management. Figure 3-14 shows the core factors of the described business model.

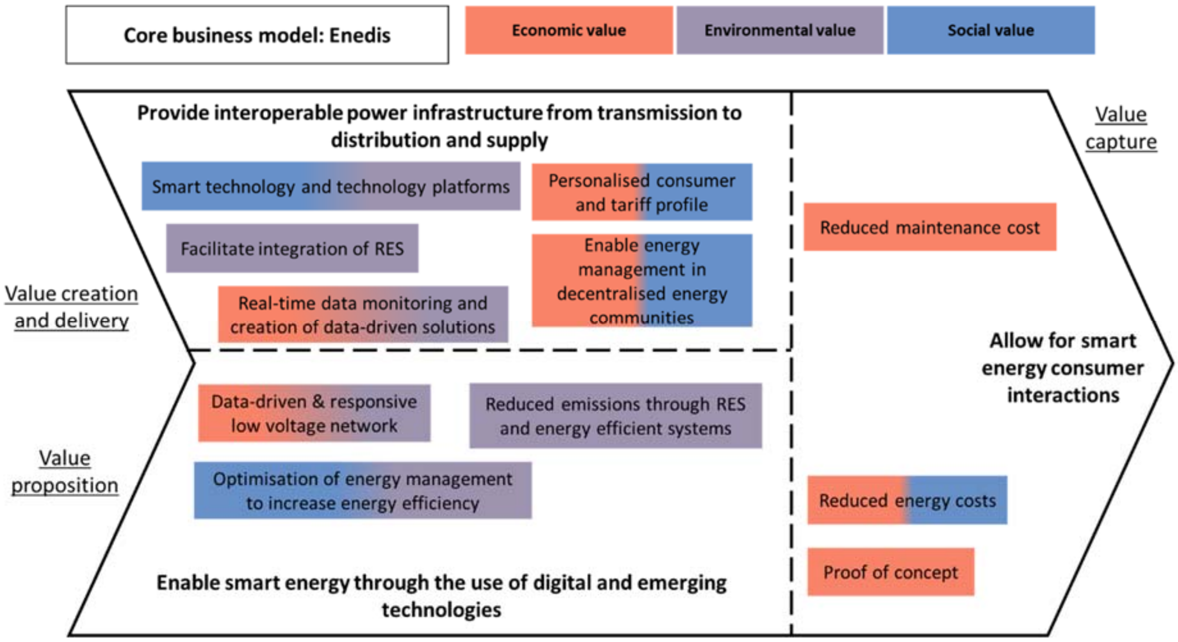

Figure 3-14. Enedis Smart grid deployment business model through the lenses of the conceptual framework representing value and sustainability dimensions

3.7.1 Spectral, the Netherlands

Spectral's value proposition is to create solutions for the current challenges faced by energy grids: a fluctuating renewable energy stream, limitations in the amount of renewable energy supported by the grid, and a need to better balance energy supply and demand [118]. Like Enedis' Linky smart meter, Spectral uses data-driven solutions to create real-time, predictive optimization of energy use in buildings. Testing their products and services at Café de Ceuvel, a "clean-tech playground", and working on community projects like Schoonschip in Amsterdam, Spectral enables the quick deployment of smart grids and allows real-estate owners to have a better view of their energy efficiency performance [119] . Recently, Spectral has joined as the technical lead on the ATELIER project, a consortium of partners that build PEDs across Europe [120]. Taking on new, ambitious projects showcases Spectral's technical strengths, builds the company's reputation, and allows them to improve their own products and services.

4 Business model archetypes

The analysis and grouping of the selected case studies according to the business model value dimensions led to the identification of three main archetypes and seven sub-archetypes (Figure 4-1). These showcase the diversity of opportunities that are available in designing a business model that creates social, environmental, and economic value in PEDs or PED-like projects. The detailed summary of key value features of the case studies that have led to the archetypes and their description can be found in Appendix B.

The names of the archetypes are generalised to allow for a diversity of methods in achieving their broad value propositions. At the same time, the sub-archetypes reveal more specific key features of the selected case studies that allow them to create the promised value. Figure 4-1 summarises the three archetypes and their sub-archetypes. The business models falling under these archetypes create economic, environmental, and social value for citizens and the community in different ways and to varying extents.

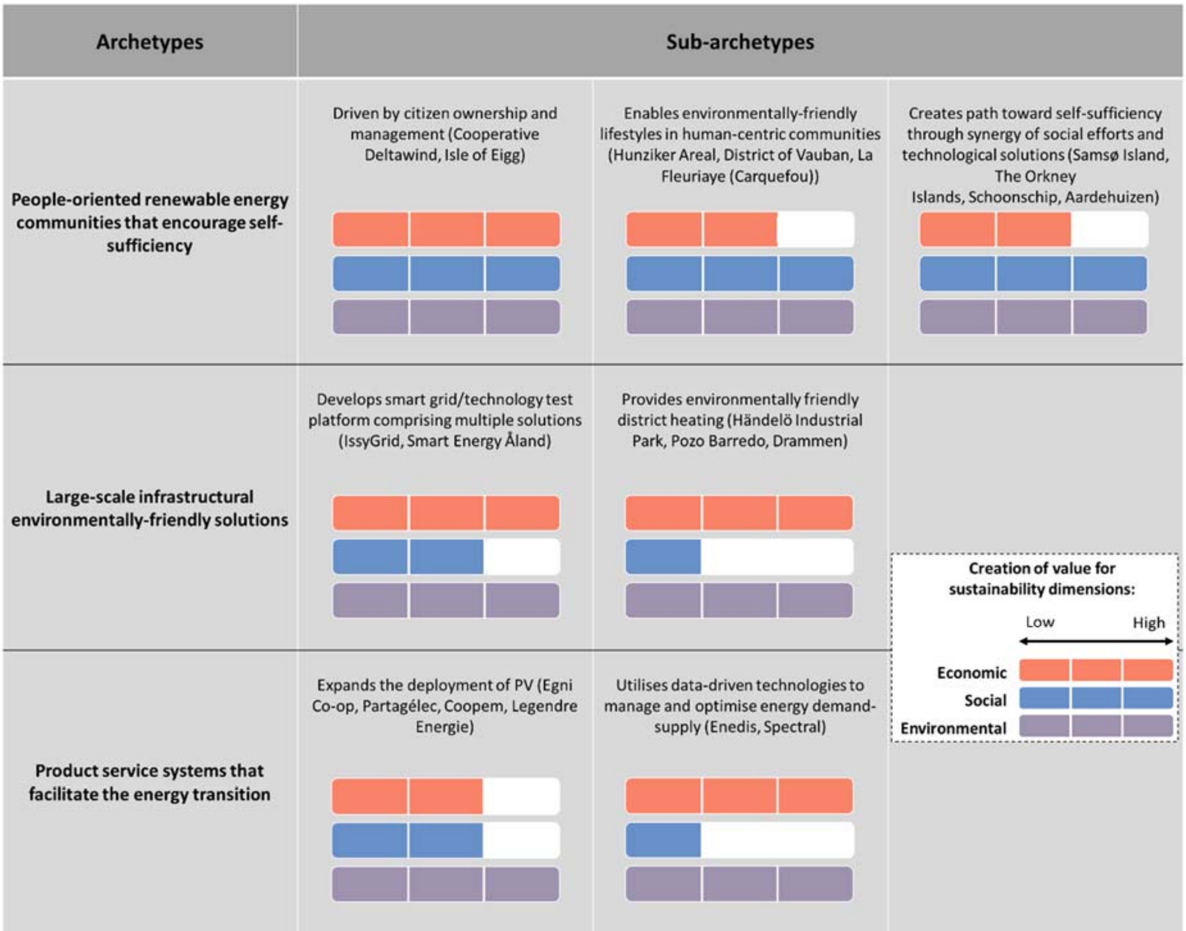

Figure 4-1. Business model archetypes and sub-archetypes as well as the sustainability value they create for their projects.

The archetypes demonstrate that a variety of initiatives and projects have been addressing the path to a renewable energy transition for some time, independent of the concept of PEDs. The value created by the studied business models enables movement in the direction of integrating renewable energy technologies while, often, also creating a socially-inclusive environment. The EU's definition of PEDs offers a chance to systematize these efforts and highlights the aims of energy decentralisation and social integration in energy communities. Furthermore, the PED concept guides the energy transition with useful principles and functions which must be achieved in a modern energy system that prioritises social, environmental, and economic values [1].

The pathways of these projects evolve over time and are dependent on contextual conditions. The examples of PEDs or PED-like projects reveal that implementation is dependent on a facilitative environment that is made up of: policies and regulations that foster development of energy communities and allow adoption of renewable energy technologies; maturity of conversations among stakeholders and the community; awareness of and readiness for adoption of new technologies; engagement on the part of different stakeholders, including citizens; and availability of financial resources and investment. These aspects highlight the path dependence of the projects which are only able to flourish because past social, economic, and regulatory aspects motivated this development. While motivation can result from an encouraging environment, motivation can also be reactionary, as when island communities initiate a transition to self-sufficiency to reduce dependence on fossil fuels.

Ultimately, environmental, economic, and social value is achieved through the deployment of technologies, access to financing, and support from stakeholders. The use and combination of different innovative technologies can be one step towards finding solutions for achieving energy goals. However, access to financing should not be underestimated, as renewable energy projects are often dependent on great capital investments and different financing streams.

4.1 People-oriented renewable energy communities that encourage self-sufficiency

The first archetype, "People-oriented renewable energy communities that encourage self-sufficiency", describes ways that business models have created value by putting challenges that people and communities face (e.g. equitable participation in benefits of new developments or engagement in decision-making processes) at the centre of renewable energy generation projects. In their value propositions, these projects attempt to jointly create social, economic, and environmental value through a combination of social initiatives and technologies that mitigate negative environmental impact. The value proposition of this sub-archetype includes fostering a sense of ownership and stewardship of renewable energy technologies and services in a community. Citizens are given the ability to actively manage the technology and to work collectively toward greater energy efficiency and even energy self-sufficiency.

This archetype concerns newly-built districts just as it describes projects that evolve and continuously develop in the direction of the PED vision. Among the three archetypes, this archetype represents case studies with holistic drivers and goals closest to the PED vision. Consequently, this archetype has a strong focus on all sustainability dimensions with a strong tendency towards socially inclusive propositions. A key feature of this archetype is the critical position of the citizens and community in delivering the value proposition (through citizen engagement and environmentally friendly lifestyles), thereby creating environmental and economic value for themselves. Business models under this sub-archetype can also attempt to address energy injustice and affordability issues by increasing access to (green) energy across different socio-economic groups.

Sub-archetypes of business models:

- *Driven by citizen ownership and management* (Cooperative Deltawind and Isle of Eigg): Projects under this sub-archetype have been able to promote renewable energy technologies and self-sufficiency through strong citizen initiatives. Both the Isle of Eigg and Deltawind demonstrate the power of citizens to come together to create strong environmental, social, and economic value for themselves. They achieve this through ownership and self-management of the system of renewable energy technologies.

- *Enables environmentally-friendly lifestyles in human-centric communities* (Hunziker Areal, Vauban, La Fleuriaye): This sub-archetype describes projects of newly-built districts that empower their citizens to adopt lifestyles that reduce negative environmental impact, grow the local economy, and engage in their community. This holistic goal is achieved through a system of solutions that addresses energy, mobility, and social needs. These communities aim at being socially inclusive and integrating people of various economic and social backgrounds. For these human-centric districts the social and environmental dimension is in the foreground, while economic benefits for the initiators play a secondary role. In fact, incentives and economic benefits to the citizens are created for them to fully enjoy an affordable environmentally-friendly lifestyle.
- *Creates path toward self-sufficiency through synergy of social efforts and technological solutions* (Samsø Island, The Orkney Islands, Schoonschip, Aardehuizen): The key feature of the projects under this sub-archetype is their all-inclusive goal of self-sufficiency. For some cases, like Samsø or Orkney, the need for self-sufficiency may be tied to their island setting, which makes dependence on traditional fossil fuels expensive. For other cases, like Schoonschip and Aardehuizen, the wish for complete self-sufficiency is driven by the wishes of the residents who wish to create a climate-neutral community. The path toward self-sufficiency goes beyond energy to include other sustainability efforts, such as waste and water reuse. All of these projects rely on a combination of different renewable energy technologies and a strong foundation of community and social cohesiveness. Enabling energy self-sufficiency provides strong environmental and social value for the citizens. The scale and complexity of the projects can vary but involves several financing streams and needs strong partnerships. The initiators may focus on creating value in the social and environmental dimensions, but ultimately create positive impact in the economic dimension as well.

4.2 Large-scale infrastructural environmentally-friendly solutions

The second archetype, "Large-scale infrastructural environmentally-friendly solutions", captures ways in which large-scale infrastructural solutions can drive larger areas on the path to climate neutrality. Infrastructural changes depend on systems thinking and partnerships between stakeholders that leverage different technical capabilities, resources, and knowledge. Environmental value is created through innovative technologies that reduce carbon emissions and maximise resource recycling, while economic value is created through reduced costs for the service provider. Large infrastructural projects can also help build the stakeholders' experience and technical capabilities, while create knowledge that can be shared with other project developers.

This archetype largely creates value in the economic dimension with less consideration for the social inclusiveness than seen in the first archetype. This archetype presents rather complex project approaches with innovative technologies at a large scale (IssyGrid, Smart Åland Islands, Händelö Industrial Park), but can also focus on the roll-out of one technological solution for district heating (Pozo Barredo, Drammen). The key feature of this archetype is the leveraging of partnerships and shared resources, thereby creating new opportunities and environmental and economic benefits for the stakeholders. Sub-archetypes within this category describe smart grid projects and district heating projects that create a complex set of solutions for integrating renewable energy technologies to existing districts.

Sub-archetypes of business models:

- *Develops smart grid/technology test platform comprising multiple solutions* (IssyGrid, Smart Energy Åland): Cases under this sub-archetype include smart grid and technology test bed projects that require the collaboration of stakeholders with a diversity of technical capabilities. In both IssyGrid and Smart Energy Åland, partnerships between private companies, the municipality, and research organisations create solutions for energy generation, management, and consumption. Projects under this sub-archetype can evolve with time, creating opportunities for testing and integrating innovative technologies and leading to long-term economic and environmental win-win situation for business partners and society. However, the described technological approaches involve local communities that live in the districts and have to use the technology effectively and efficiently. Therefore, the projects also need to focus on social dimensions to enable benefits to the community while delivering their technological value.

- *Provides environmentally-friendly district heating* (Händelö Industrial Park, Pozo Barredo, Drammen): Projects under this sub-archetype are focused on creating sustainable solutions for heat generation at a district-level. The three cases under this sub-archetype optimise renewable resources in different ways to achieve this goal. This is done through involvement of different stakeholders, the circular economy approach, and other innovations in system design that make effective use of waste and resources. Thus, these projects heavily focus on reducing the strain on natural resources and optimising processes, while improving cost-effectiveness for service providers and industry partners. These sub-archetypes create low social value, as citizens are not actively involved in these projects, but benefit from having environmentally-friendly district heating.

4.3 Product service systems that facilitate the energy transition

The third archetype, "Product service systems that facilitate the energy transition", describes business models that provide technological solutions for the energy transition. Products and services in this archetype create environmental value through renewable energy technologies, smart metering, and data systems that can match energy demand with supply, eliminating any inefficiencies in energy distribution. Business models in this archetype create solutions and work in partnership with stakeholders such as energy service providers and citizens to provide the full value of energy efficiency and carbon emissions reductions. They can also reduce costs throughout the value chain by optimising energy supply and demand or leveraging cooperative financing models.

Business models that fall under the other two archetypes can be seen as the technological facilitators in the first archetype. This archetype represents products and services that aid in the deployment of renewable energy technologies and smart grid development. This third archetype's value propositions revolve around new technologies that can create environmental and economic value, with less focus on the social dimension. Value creation in this archetype heavily depends on new technological possibilities and the opportunities that are conceived through partnerships. These partnerships can involve citizens and the community (e.g. through cooperatives), though to a lesser extent than in the first archetype. The sub-archetypes within this category showcase different ways in which economic value can be created for the product or service provider while at the same time providing solutions for climate change mitigation.

Sub-archetypes of business models:

- *Expands the deployment of PV* (Egni Co-op, Partagélec, Coopem, Legendre Energie): Business models in this sub-archetype focus on facilitating the deployment of solar PV energy technologies alongside financially beneficial consumption models. They deliver their value proposition in a number of ways: cooperative structures that leverage financial incentives; companies that deploy renewable energy technology for profit; strong partnerships with the local municipality, technology providers, and citizens; and utilisation of public building spaces (e.g. public building rooftops). Value is created in the environmental dimension through the deployment of solar PV and energy management technologies with the goal of mitigating climate change. The case studies demonstrate that value can be captured through different finance structures based on cooperative or commercial approaches and can create economic value for different stakeholders (e.g. the reduction of upfront costs for solar PV installations delivering socio-economic value to citizens). For companies deploying PV for profit, it can demonstrate the commercial viability of the product. However, this archetype may be implemented at the community level to provide direct social and economic benefits back to the citizens and the community. Hence, the social dimension is equally important to the economic dimension in this sub-archetype.

- *Utilises data-driven technologies to manage and optimise energy demand-supply* (Enedis, Spectral): Business models in this sub-archetype create environmental value through their technological solutions that leverage data in order to optimise energy supply and demand and allow the network operations to become more dynamic. For example, Enedis' Linky smart meter can support deployment of large-scale renewable energy infrastructure by enabling remote operations and facilitating decentralised energy management in the local community. Technologies in this archetype assist in the development of smart grids, provide support for decentralised energy management systems, and are integral to emerging local renewable energy communities (e.g. Spectral providing solutions for projects like Schoonschip in energy supply-demand optimisation). Businesses representing this archetype can be energy utilities that provide new products and services as part of their business model innovation, start-ups, or research organisations. They develop data-driven innovative technologies to provide services to customers. Hence, the social dimension is less important than the economic dimension.

4.4 Business model archetypes coming together

These case studies and the developed business model archetypes demonstrate potential approaches that PED developers can take based on the value they wish to generate in PEDs. While the resulting archetypes are distinct in their key value propositions, the case studies show that multiple benefits can be offered simultaneously and across the sustainability dimensions (even when the initial priority was to create environmental value). The sub-archetypes also show that similar value propositions can be created through different approaches to value creation and value capture. The approach taken can depend on the scale of the project, stakeholders involved, and even the physical boundary (e.g. an island community).

Goals and pathways of the project can also change – the Samsø and the Orkney Islands cases illustrate how citizen-initiated project can evolve over time to include different concepts and projects. In other words, to reach their energy goals, the initiators need to overcome obstacles as they come evolving with their goals. Hunziker Areal and Vauban also demonstrate this attitude throughout their participatory development through their approach of "learning while building" following their vision of social inclusiveness and environmentally friendly living solutions.

All case studies prioritise climate-neutral solutions throughout their value chain and thus contribute to one of the EU goals to achieve net zero CO_2 emissions. Importantly, the case studies demonstrate that strong engagement of citizens, partnerships, and skill and knowledge-sharing are critical to successful PED implementation. The analysis of the case studies revealed that these characteristics stand out and helped initiate and drive projects. Citizen ownership and management, and the enthusiasm it fosters, can help sustain an ambitious project. In particular, this can be seen in the cases of islands such as Samsø Island, the Orkney Islands, the Isle of Eigg, as well as cooperatives that these island communities initiate such as Deltawind. In these projects, citizen engagement was integral in reaching the goal of reduced dependence on expensive fossil fuels.

The analysed cases demonstrated the various configurations in which investment for PED projects can be acquired. The approaches can vary from social inclusive cooperative funding models to other financial instruments or a combination of various financing options. The financing model of Egni Co-op, by engaging the citizens to invest, exemplifies how social and economic values can be combined to fund renewable energy technologies. Partnerships can significantly contribute to making projects financially possible. The case studies demonstrate that citizens and municipalities can raise initial capital investments for PED and PED-like projects and that joint projects between citizens, municipalities, cooperatives, and/or private companies are most effective. IssyGrid and Smart Energy Åland demonstrate how a consortium of private companies and research organizations can make a project technically and financially viable. While Egni Co-op's model (and other cooperative and citizen-initiated models) relies on citizens as a financial stream, IssyGrid and Smart Energy Åland Island show how external investments can be acquired by offering a technology testbed for various partners to implement their technologies and benefit from the revenue streams. Thus, the prospect of technological innovation and reputation-building for the technology providers can be a way for garnering new investment for PED and PED-like projects.

5 Conclusion

In this study, the authors developed an understanding of the business model archetypes involved in energy generation, distribution, and management in PEDs based on an evidence-based case study analysis. The study reveals that the identified business models create value beyond the environmental dimension and generate benefits for the social and economic dimensions as well.

The PED business model archetypes identified summarise the contextual conditions needed for implementation of PEDs and the potential for synergy in sustainability value creation and business processes. Based on 20 case studies with different contexts and complexities, the authors identified three business model archetypes:

- People-oriented renewable energy communities that encourage self-sufficiency
- Large-scale infrastructural environmentally-friendly solutions
- Product service systems that facilitate the energy transition

These archetypes are generalised to allow for a diversity of applications but generate a common understanding of the key features. Some possible applications are represented by the sub-archetypes that present specific key value features of the selected case studies that enable them to create value across sustainability dimensions.

The conceptual framework used in this study helped guide the analysis of the business model cases, and resulting archetypes, according to the sustainable value they create. The analysis showed that there is a diversity of priorities around the sustainability dimension that is addressed through the value proposition, value creation and delivery, and value capture. Further, the identified business model archetypes show that value – economic, social, and environmental – can be accrued to varying extents and goes beyond the product or service provider to other beneficiaries and involved actors, be it an energy company or a local energy community. Stakeholders (e.g. end-users, policymakers, investors, implementers) are encouraged to examine archetypes depending on the value they aim to create, though it is likely that created value will be cross-dimensional.

The cases that comprise the archetypes demonstrate how business models in energy generation, distribution, and management are moving in the direction of decentralisation. Decentralisation of energy services is enabled by engagement of local stakeholders and citizens, while also fostering this participatory environment. The archetype *Product service systems that facilitate the energy transition* showcases technologies that enable decentralised energy generation and management – which can also be implemented in the projects described by the other two archetypes.

To a varying extent, all case studies highlight the importance of delivering value in the social dimension by creating benefits for citizens and the community. The social dimension is important to consider as the outcomes of renewable energy projects need to go beyond creating environmental and economic benefits and attend to the needs of citizens and society. This is in line with the EU's definition of PEDs as providing a socially inclusive environment that aims to address energy poverty. While not an explicit goal of the analysed case studies, creating affordability in renewable energy technology installations or reduced energy prices can begin to create a path toward alleviating energy poverty.

In other words, the case studies represent current examples of the paradigm shift [121] from a centralised, provider-consumer energy system, to a decentralized, human-centric energy system. In a such decentralised system, consumers are seen as active citizens with possibilities to participate in the energy market or in decision-making processes. Ambitions of sharing knowledge and success stories and awareness raising initiatives of several of the presented case studies help to spread the word to make the citizens aware of the new role that they can take in mitigating climate change, and in future living environments like PEDs.

Figure 5-1 summarises the key messages for future stakeholders that have been identified from the analysis of case studies and final archetypes with regard to the conceptual framework of analysis.

Value dimensions / Sustainability dimensions	Value proposition	Value creation & delivery	Value capture
Economic Environmental Social	The **products, services, and technological platforms** offered in a project depend on the economic, environmental, and social aspects to be addressed. Additionally, the maturity of thinking of the stakeholders determines the complexity of the resulting project and value delivered to the citizens. Nevertheless, different approaches enable holistic possibilities with a focus on mitigating climate change.	Projects are path-dependant, which means that contextual factors and previous and future actions affect the resources available for project development. Alignment of **stakeholders** and new partnerships are crucial to opening new pathways. Citizens' engagement and their awareness are key to a successful energy transition. Impact can be created through different innovative **technologies** and their combinations.	Variability in project determines the amount of capital **investments** needed. Stakeholders need to be prepared for the high investment costs that are needed for holistic, large infrastructure PED-like projects. A key aim is to reduce energy **costs** for citizens. Sales of "green" energy or energy management provide **revenue** streams to technology owners and communities.

Figure 5-1. Key messages derived from case studies and archetypes based on conceptual framework of PED business models categorisation.

A limitation of the identified archetypes can be the extent of their replicability. PEDs are evolving through different approaches and in different locations such as city districts or islands. Nevertheless, since the concept has not yet been developed completely, this study analysed cases with business models considered as PED-like or useful to be part of a future PED. In fact, this study focused on a limited number of cases, many of which had technological innovation at their heart. The identified archetypes from these case studies cannot necessarily ensure exactly the same result in different locations and at different times.

Future studies should focus on analysis of a larger number of PED cases in order to gain more clarity around the archetypes. In particular, PED examples from different parts of continental Europe will help to identify other business model archetypes applicable for diverse locations, which can ensure replicability. Hence, the archetypes need to be regularly updated to reflect the latest state of the art in PED implementation. The importance of the study lies in the undebatable need for the development of innovative business models to facilitate the energy transition.

The future deliverable of this work package will use these business model archetypes to build an open source web-based tool to initiate discussion among citizens, municipalities, investors, and other stakeholders and validate the developed business model archetypes.

Definitions of key terms

Term	Definition
Archetype	This study identifies business model archetypes. A business model archetype refers to a distinctive set of elements that represent a group of business models (i.e. a categorization of business models by their distinctive, comparable elements)
Business model	The way in which an organisation creates, delivers, and captures value. Often described through business model components: key partners, key/activities, key resources, value propositions, customer relationships, channels, customer segments, cost structure, and revenue streams [2]
Positive Energy District (PED)	The EU SET-Plan defines PEDs as: districts with annual net-zero energy import and net zero CO_2 emissions, working towards an annual local surplus production of renewable energy [1]
Prosumers	New entities in the energy value chain, such as citizens, that produce, consume, store, and share energy with other users in the grid or the main power grid [122]
Renewable energy sources (RES)	Renewable energy sources (RES) refer to renewable energy technologies used to produce electricity and heat. These innovative technologies harness the power of different renewable sources e.g. wind, solar, hydroelectricity, biomass, geothermal resources [123]
Sustainability dimensions	This study refers to the economic, environmental, and social dimensions as sustainability dimensions. The authors recognise that literature includes other categories such as technological or organisational [8][9]
Stakeholders	Stakeholders and their relationships are important elements of a business model. A stakeholder is a person or organisation that is involved in or affected by the business structure. Key stakeholders vary depending on the business model and may play different roles in different business models. Depending on the stakeholder perspective taken, the creation and capture of value, as well as key features and drivers of the business model, can be perceived in different ways (e.g. creator of products and services vs. users of products and services)
Value capture	Cost structure, investments, and revenue streams that result from the products and services [8][9]
Value creation and delivery	The central process by which the value proposition is implemented in a business model, made up of key value chain elements such as: resources, technologies, channels, partners, key competencies and key capabilities [8][9]. The way in which value is created and delivered can be perceived in different ways depending on the stakeholder perspective taken (e.g. economic

	benefit from the perspective of the company vs. the perspective of the consumer)
Value dimensions	Value dimensions represent value proposition, value creation and delivery, and value capture, that together describe a business model from the value perspective
Value proposition	Products and services provided in the business model to generate economic return [9]

Abbreviations

Abbreviation	Definition
Co-op	Cooperative
DH	District Heating
EU	European Union
EV	Electric Vehicle
GHG	Greenhouse gas
ICT	Information and communication technology
MW	Megawatt
PED	Positive Energy District
PV	Photovoltaic
RES	Renewable Energy Sources
SET	Strategic Energy Technology
UK	United Kingdom

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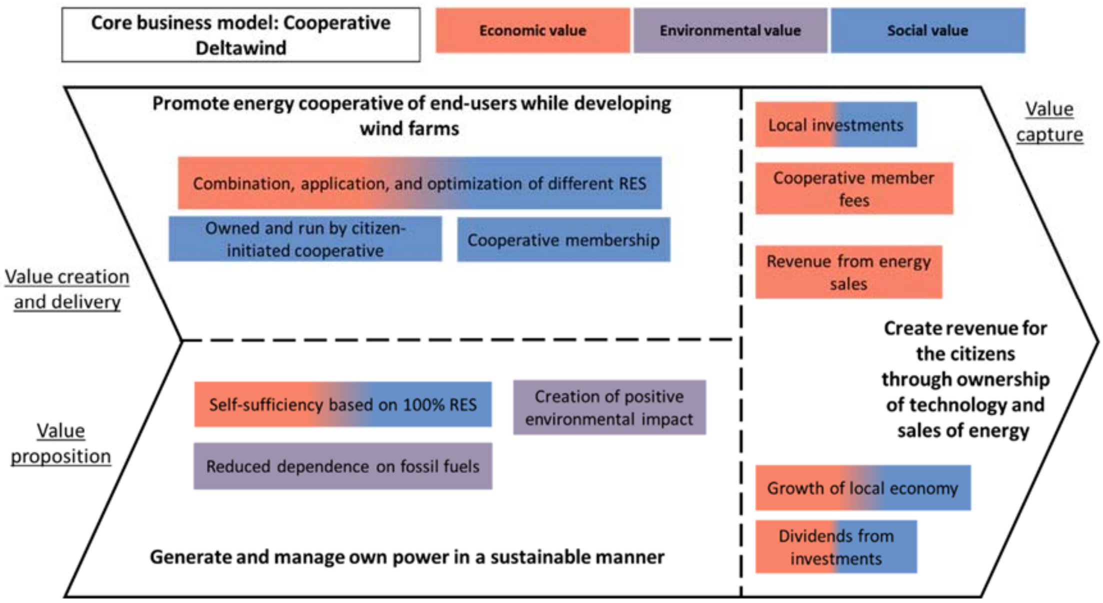
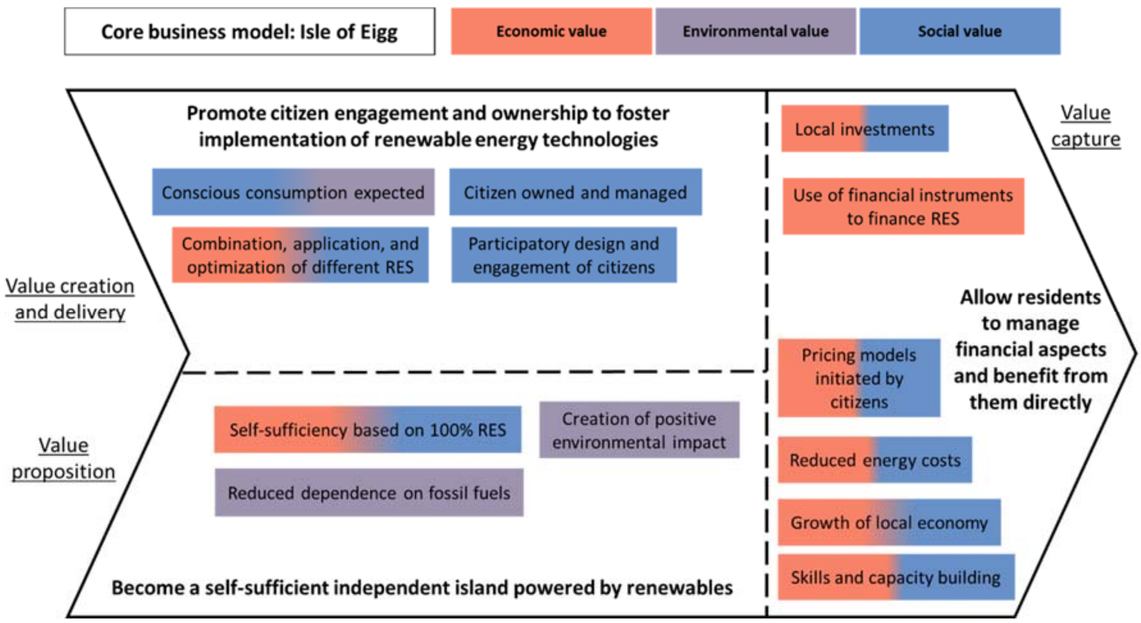
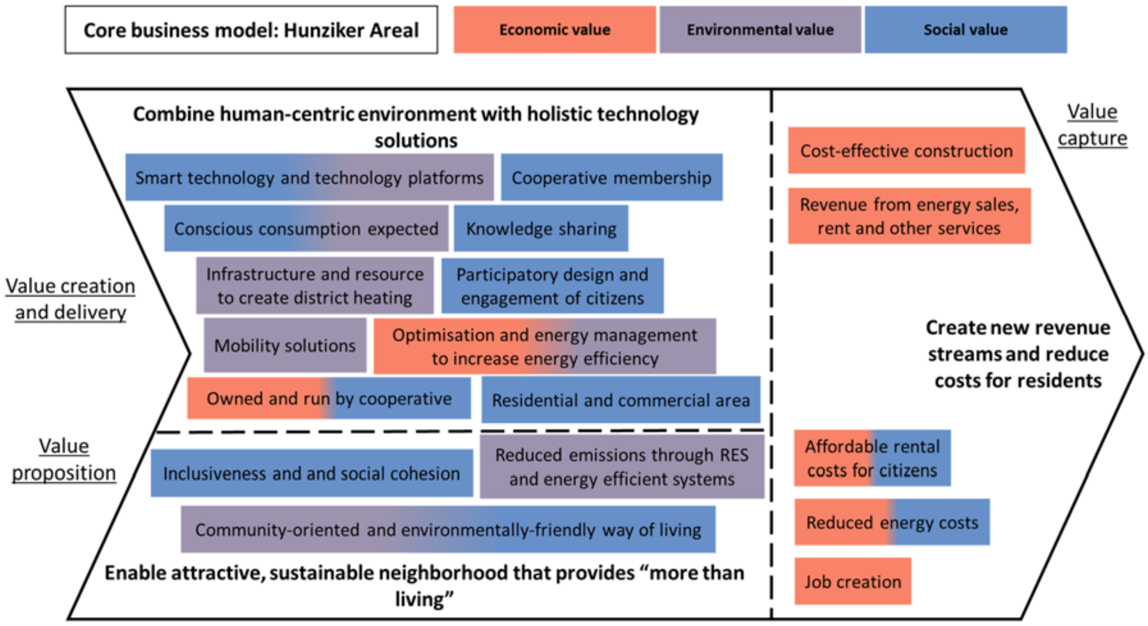
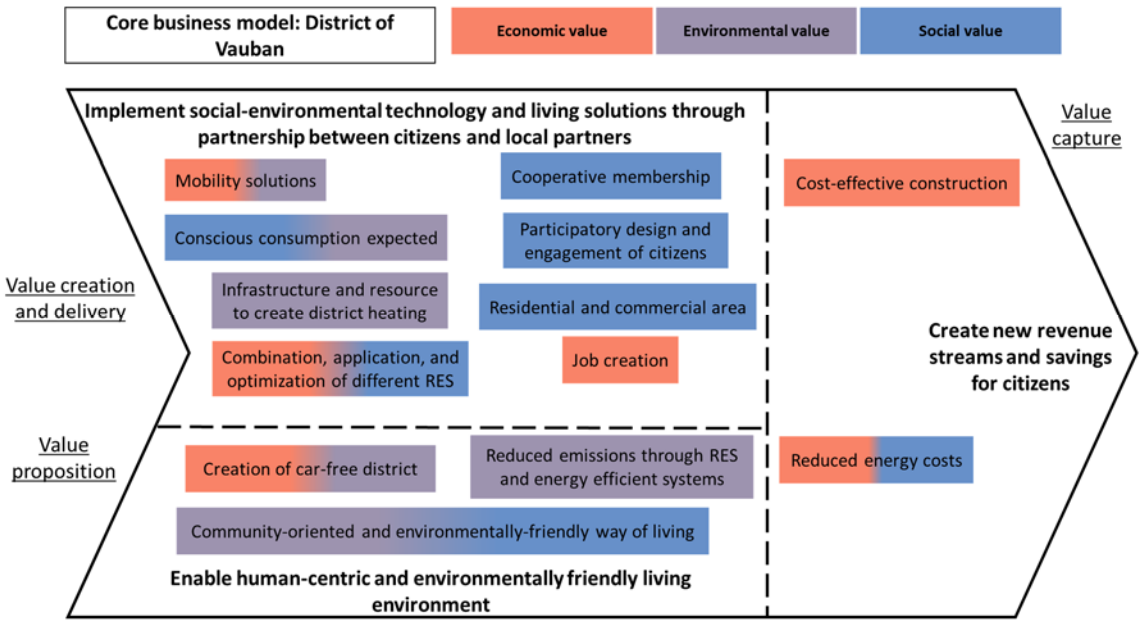
Appendix A. Business model schematics of case studies

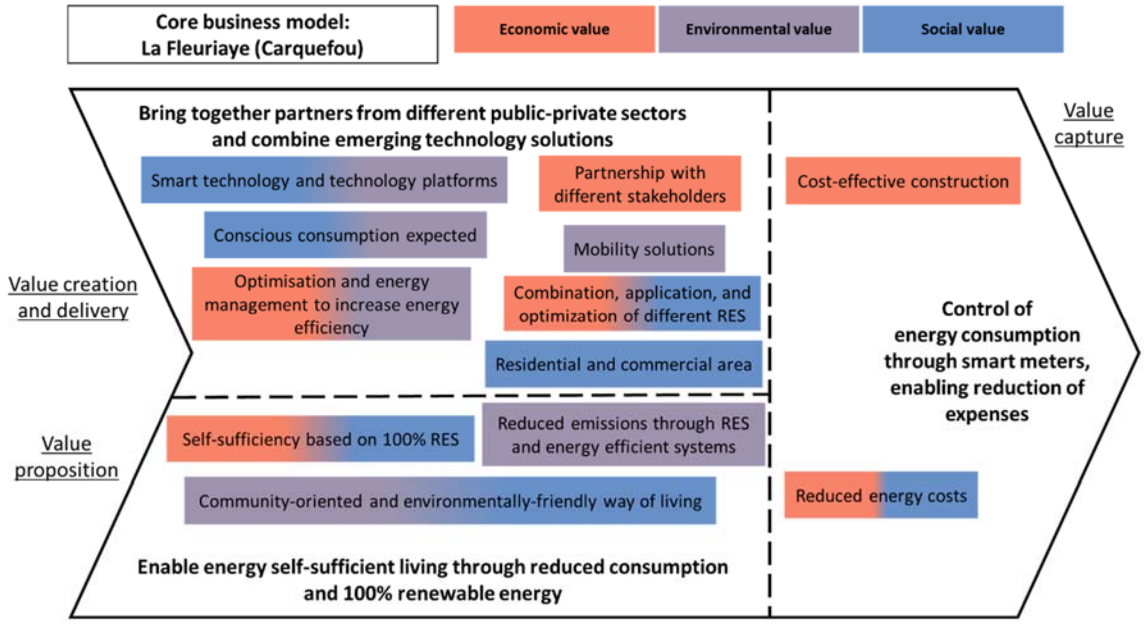
These business model schematics showcase the core business model features of each case study that make each case a best-practice example on how sustainable values can be spread over the value chain. The features are generalised to allow for easy comparison among the cases and, hence, do not take the scale and complexity of the business model into consideration.

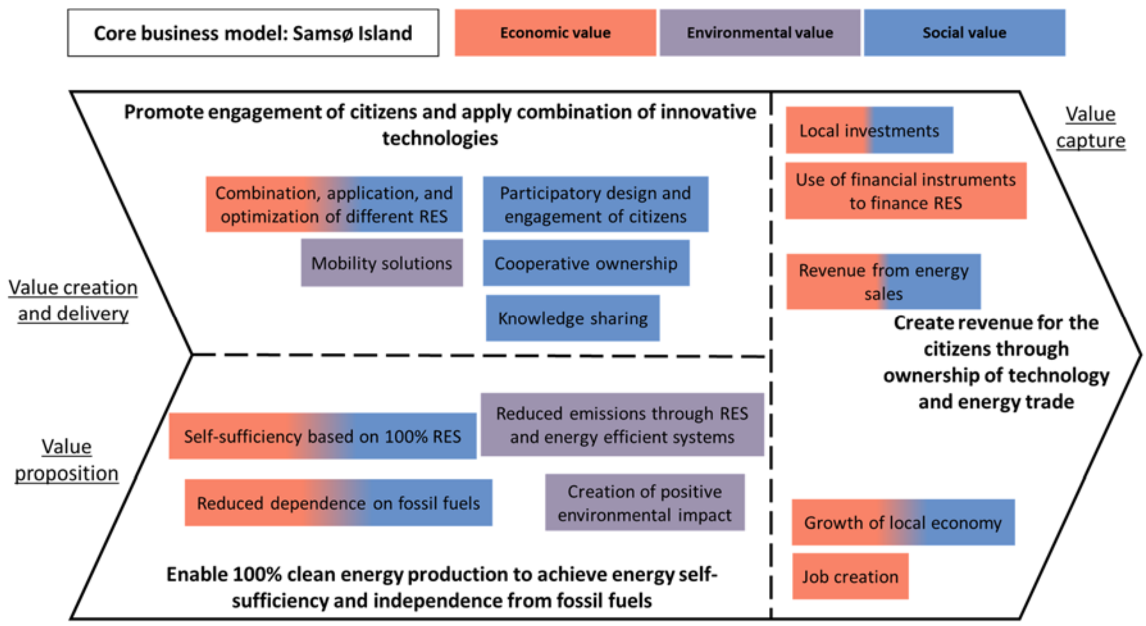


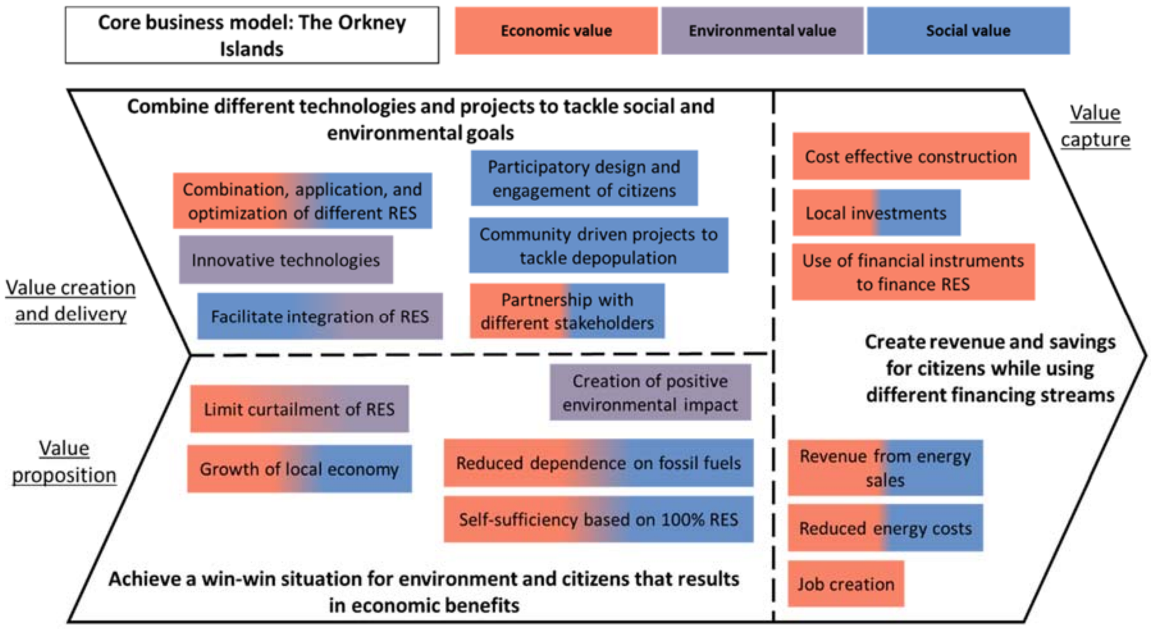


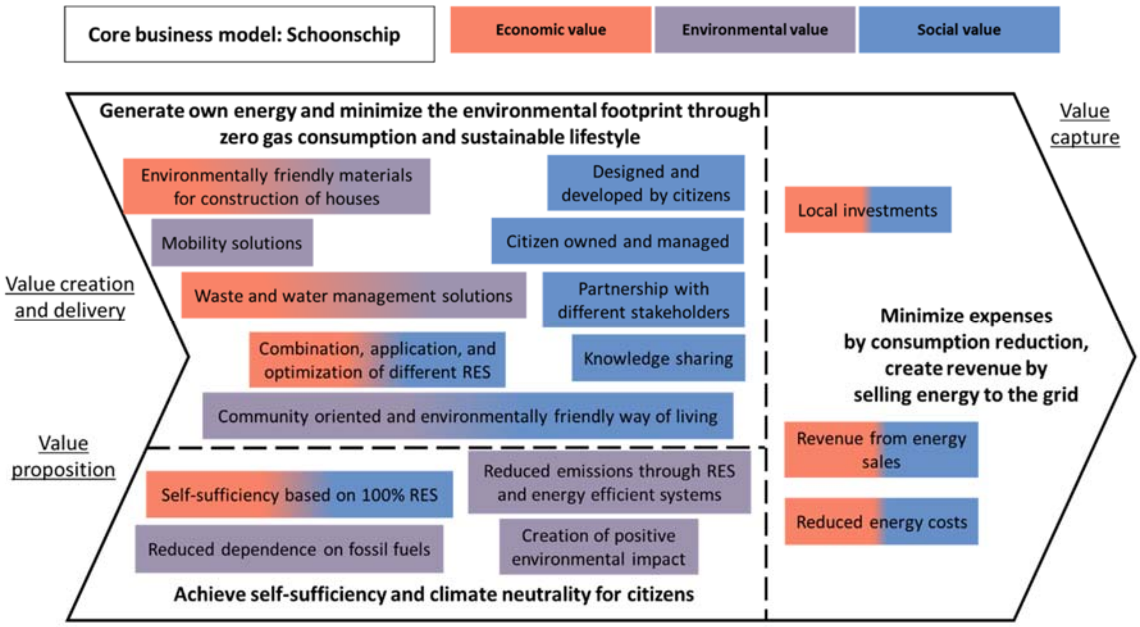

Core business model: Hunziker Areal
Economic value
Environmental value
Social value
Combine human-centric environment with holistic technology solutions
Smart technology and technology platforms
Cooperative membership
Conscious consumption expected
Knowledge sharing
Infrastructure and resource to create district heating
Participatory design and engagement of citizens
Mobility solutions
Optimisation and energy management to increase energy efficiency
Owned and run by cooperative
Residential and commercial area
Inclusiveness and and social cohesion
Reduced emissions through RES and energy efficient systems
Community-oriented and environmentally-friendly way of living
Enable attractive, sustainable neighborhood that provides "more than living"
Value creation and delivery
Value proposition
Value capture
Cost-effective construction
Revenue from energy sales, rent and other services
Create new revenue streams and reduce costs for residents
Affordable rental costs for citizens
Reduced energy costs
Job creation

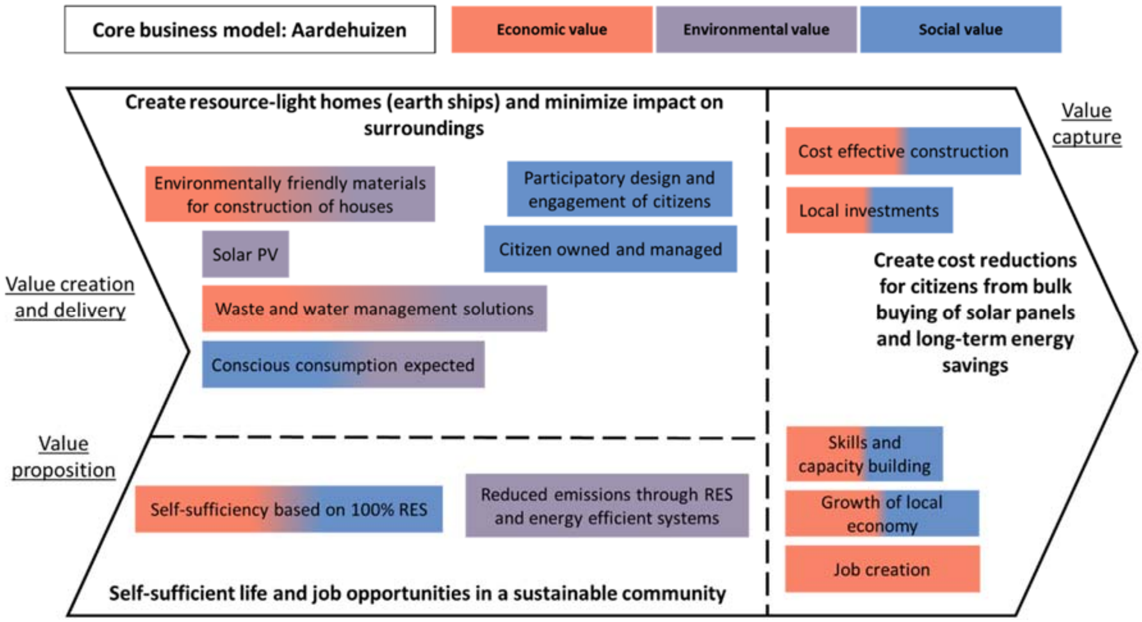

Core business model: District of Vauban
Economic value
Environmental value
Social value
Implement social-environmental technology and living solutions through partnership between citizens and local partners
Mobility solutions
Cooperative membership
Conscious consumption expected
Participatory design and engagement of citizens
Infrastructure and resource to create district heating
Residential and commercial area
Combination, application, and optimization of different RES
Job creation
Creation of car-free district
Reduced emissions through RES and energy efficient systems
Community-oriented and environmentally-friendly way of living
Enable human-centric and environmentally friendly living environment
Value creation and delivery
Value proposition
Value capture
Cost-effective construction
Create new revenue streams and savings for citizens
Reduced energy costs

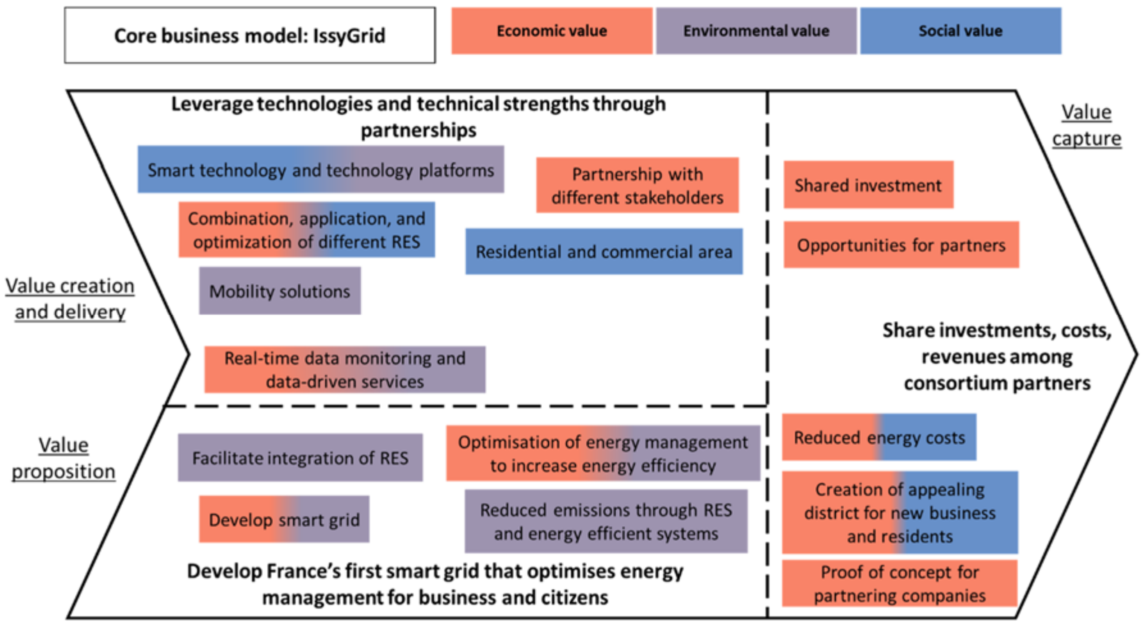

Core business model:
La Fleuriaye (Carquefou)
Economic value
Environmental value
Social value
Bring together partners from different public-private sectors and combine emerging technology solutions
Smart technology and technology platforms
Partnership with different stakeholders
Conscious consumption expected
Mobility solutions
Optimisation and energy management to increase energy efficiency
Combination, application, and optimization of different RES
Residential and commercial area
Value creation and delivery
Value proposition
Self-sufficiency based on 100% RES
Reduced emissions through RES and energy efficient systems
Community-oriented and environmentally-friendly way of living
Enable energy self-sufficient living through reduced consumption and 100% renewable energy
Value capture
Cost-effective construction
Control of energy consumption through smart meters, enabling reduction of expenses
Reduced energy costs

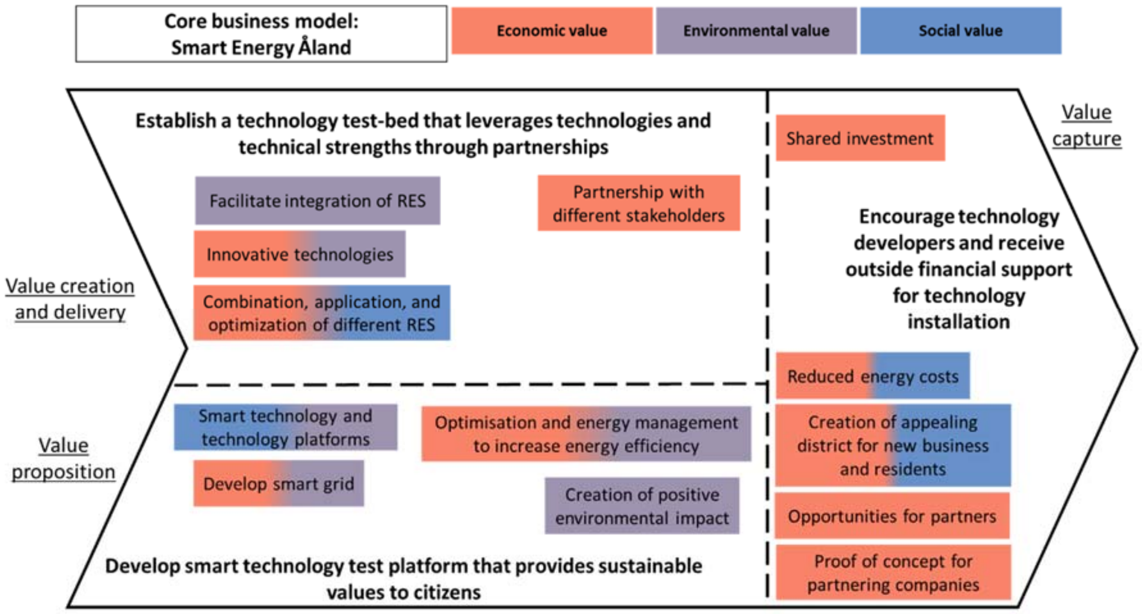

Core business model: Samsø Island
Economic value
Environmental value
Social value
Promote engagement of citizens and apply combination of innovative technologies
Combination, application, and optimization of different RES
Participatory design and engagement of citizens
Mobility solutions
Cooperative ownership
Knowledge sharing
Value creation and delivery
Value proposition
Self-sufficiency based on 100% RES
Reduced emissions through RES and energy efficient systems
Reduced dependence on fossil fuels
Creation of positive environmental impact
Enable 100% clean energy production to achieve energy self-sufficiency and independence from fossil fuels
Value capture
Local investments
Use of financial instruments to finance RES
Revenue from energy sales
Create revenue for the citizens through ownership of technology and energy trade
Growth of local economy
Job creation

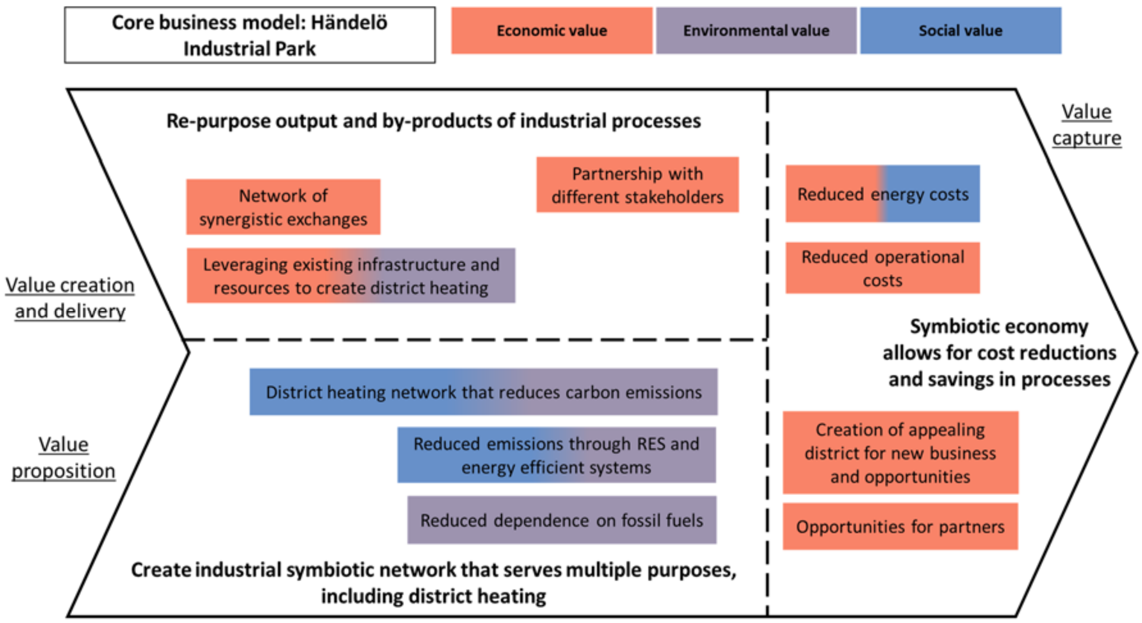

Core business model: The Orkney Islands
Economic value
Environmental value
Social value
Combine different technologies and projects to tackle social and environmental goals
Combination, application, and optimization of different RES
Participatory design and engagement of citizens
Community driven projects to tackle depopulation
Innovative technologies
Facilitate integration of RES
Partnership with different stakeholders
Value creation and delivery
Value proposition
Limit curtailment of RES
Creation of positive environmental impact
Growth of local economy
Reduced dependence on fossil fuels
Self-sufficiency based on 100% RES
Achieve a win-win situation for environment and citizens that results in economic benefits
Value capture
Cost effective construction
Local investments
Use of financial instruments to finance RES
Create revenue and savings for citizens while using different financing streams
Revenue from energy sales
Reduced energy costs
Job creation

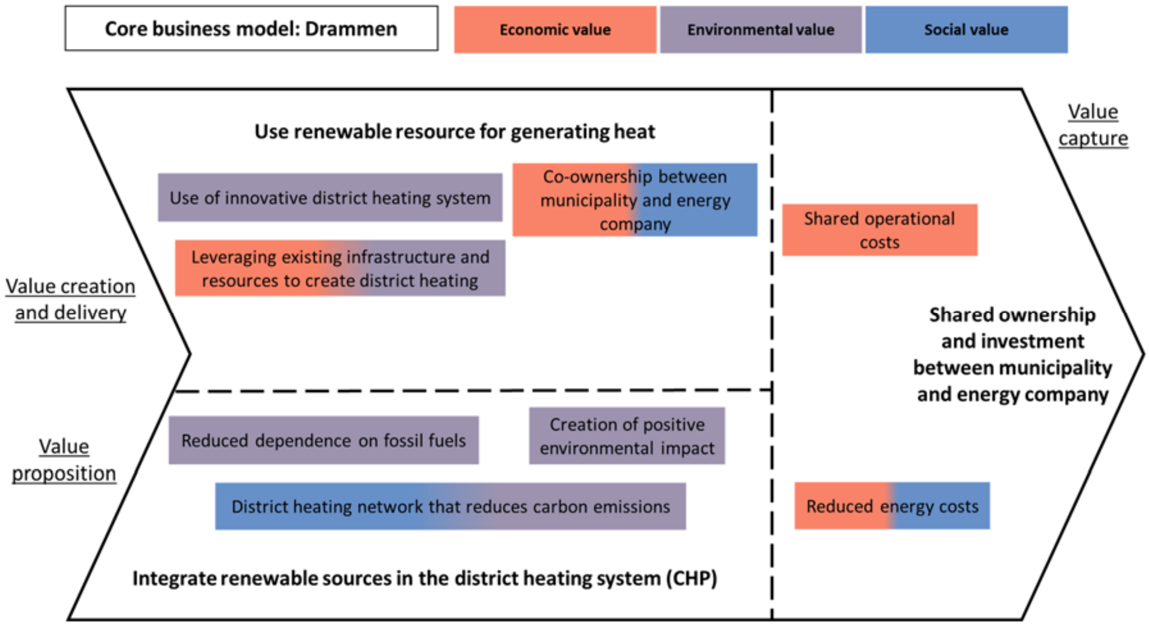

Core business model: Schoonschip
Economic value
Environmental value
Social value
Generate own energy and minimize the environmental footprint through zero gas consumption and sustainable lifestyle
Environmentally friendly materials for construction of houses
Designed and developed by citizens
Mobility solutions
Citizen owned and managed
Waste and water management solutions
Partnership with different stakeholders
Combination, application, and optimization of different RES
Knowledge sharing
Community oriented and environmentally friendly way of living
Value creation and delivery
Value proposition
Self-sufficiency based on 100% RES
Reduced emissions through RES and energy efficient systems
Reduced dependence on fossil fuels
Creation of positive environmental impact
Achieve self-sufficiency and climate neutrality for citizens
Value capture
Local investments
Minimize expenses by consumption reduction, create revenue by selling energy to the grid
Revenue from energy sales
Reduced energy costs

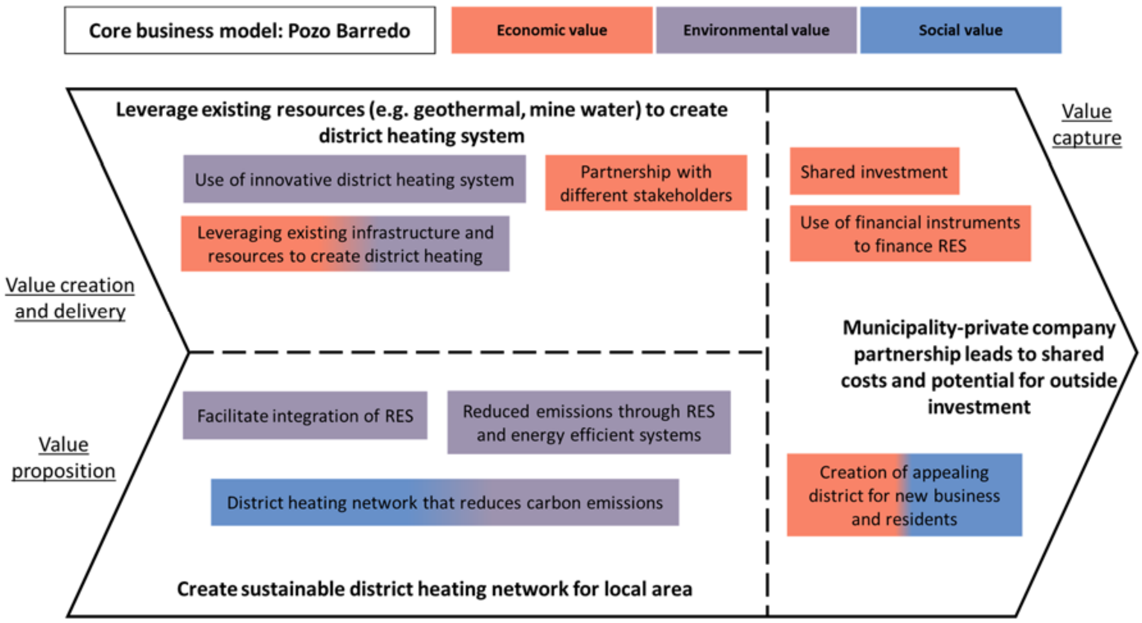

Core business model: Aardehuizen
Economic value
Environmental value
Social value
Create resource-light homes (earth ships) and minimize impact on surroundings
Environmentally friendly materials for construction of houses
Participatory design and engagement of citizens
Solar PV
Citizen owned and managed
Waste and water management solutions
Conscious consumption expected
Value creation and delivery
Value proposition
Self-sufficiency based on 100% RES
Reduced emissions through RES and energy efficient systems
Self-sufficient life and job opportunities in a sustainable community
Value capture
Cost effective construction
Local investments
Create cost reductions for citizens from bulk buying of solar panels and long-term energy savings
Skills and capacity building
Growth of local economy
Job creation

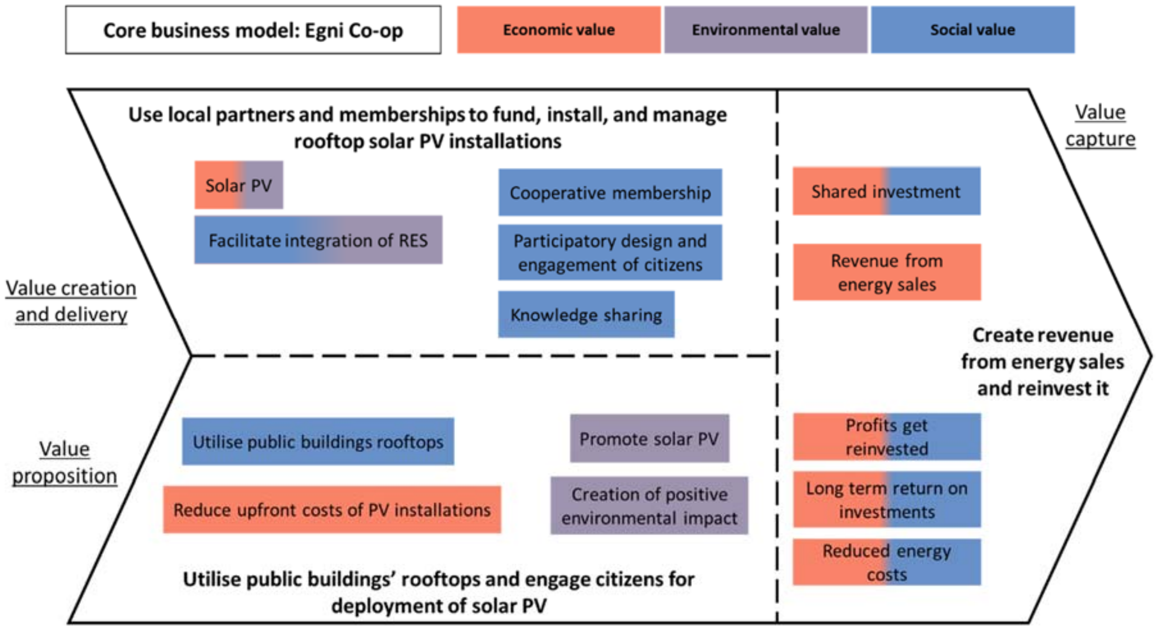

Core business model: IssyGrid
Economic value
Environmental value
Social value
Leverage technologies and technical strengths through partnerships
Smart technology and technology platforms
Partnership with different stakeholders
Combination, application, and optimization of different RES
Residential and commercial area
Mobility solutions
Real-time data monitoring and data-driven services
Value creation and delivery
Value proposition
Facilitate integration of RES
Optimisation of energy management to increase energy efficiency
Develop smart grid
Reduced emissions through RES and energy efficient systems
Develop France's first smart grid that optimises energy management for business and citizens
Value capture
Shared investment
Opportunities for partners
Share investments, costs, revenues among consortium partners
Reduced energy costs
Creation of appealing district for new business and residents
Proof of concept for partnering companies

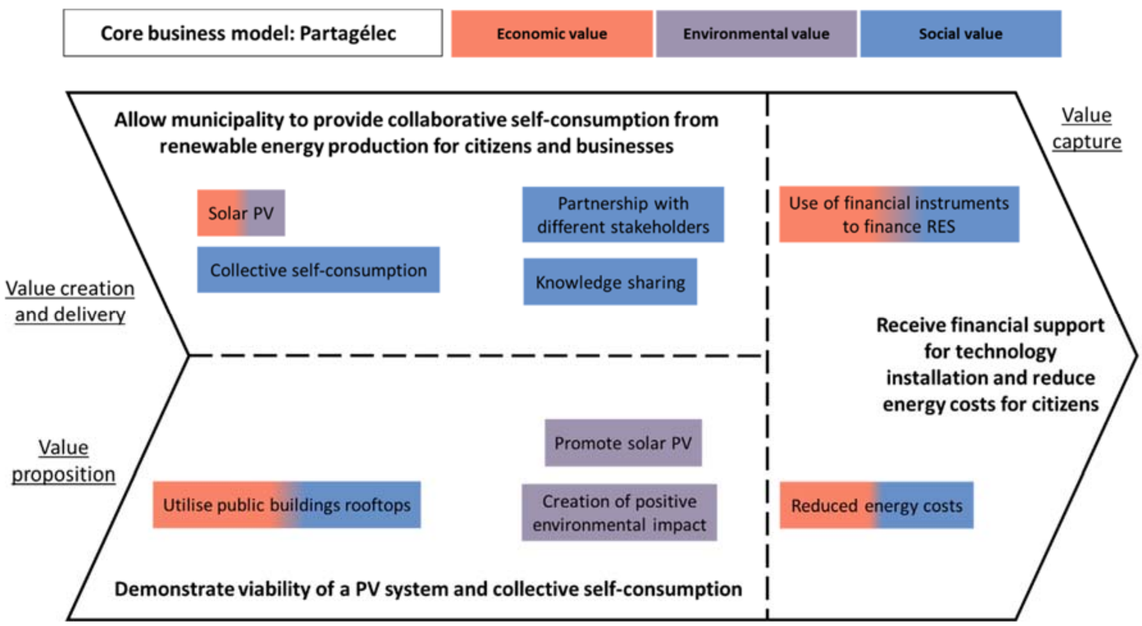

Core business model: Smart Energy Åland
Economic value
Environmental value
Social value
Value creation and delivery
Value proposition
Value capture
Establish a technology test-bed that leverages technologies and technical strengths through partnerships
Facilitate integration of RES
Partnership with different stakeholders
Innovative technologies
Combination, application, and optimization of different RES
Smart technology and technology platforms
Optimisation and energy management to increase energy efficiency
Develop smart grid
Creation of positive environmental impact
Develop smart technology test platform that provides sustainable values to citizens
Shared investment
Encourage technology developers and receive outside financial support for technology installation
Reduced energy costs
Creation of appealing district for new business and residents
Opportunities for partners
Proof of concept for partnering companies

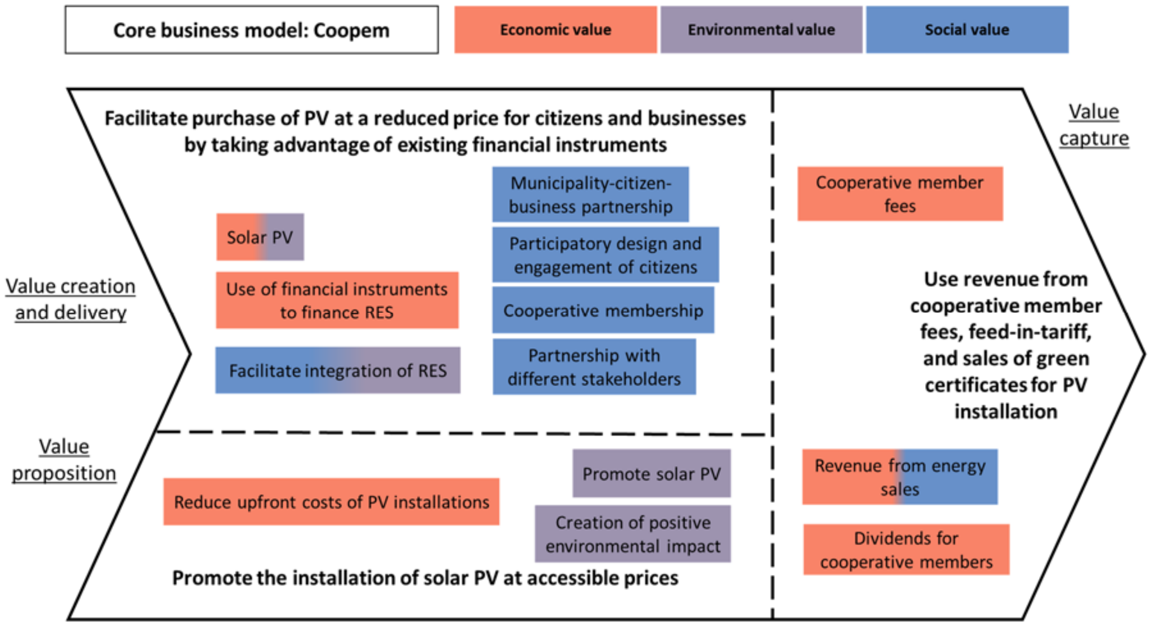

Core business model: Händelö Industrial Park
Economic value
Environmental value
Social value
Value creation and delivery
Value proposition
Value capture
Re-purpose output and by-products of industrial processes
Network of synergistic exchanges
Partnership with different stakeholders
Leveraging existing infrastructure and resources to create district heating
District heating network that reduces carbon emissions
Reduced emissions through RES and energy efficient systems
Reduced dependence on fossil fuels
Create industrial symbiotic network that serves multiple purposes, including district heating
Reduced energy costs
Reduced operational costs
Symbiotic economy allows for cost reductions and savings in processes
Creation of appealing district for new business and opportunities
Opportunities for partners

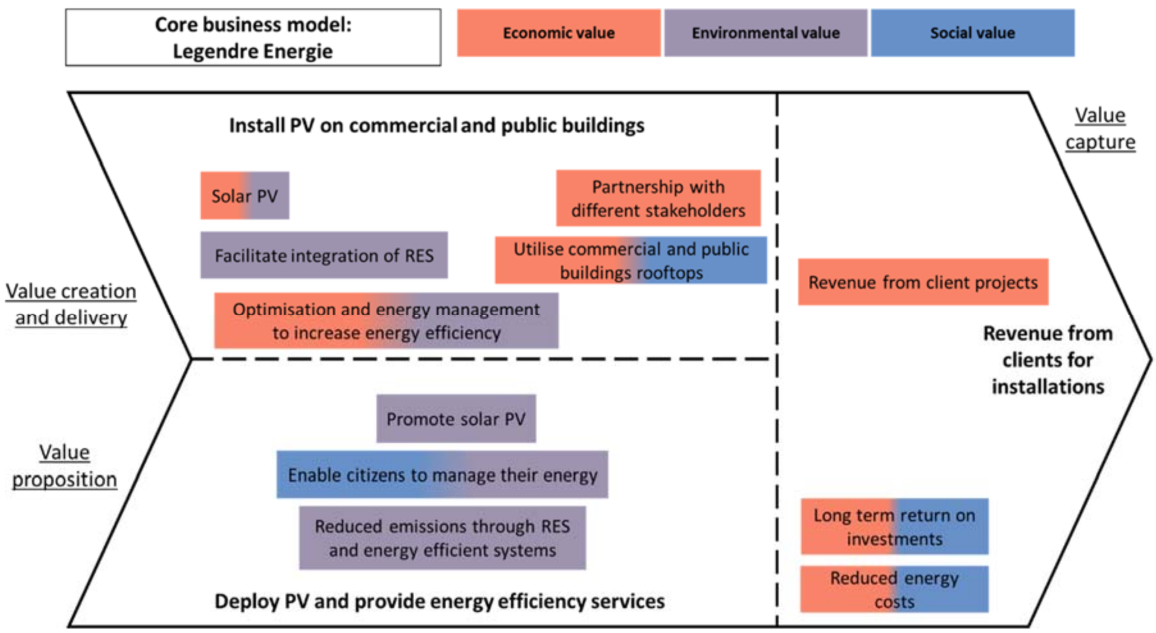

Core business model: Drammen
Economic value
Environmental value
Social value
Use renewable resource for generating heat
Use of innovative district heating system
Co-ownership between municipality and energy company
Leveraging existing infrastructure and resources to create district heating
Value creation and delivery
Value capture
Shared operational costs
Shared ownership and investment between municipality and energy company
Value proposition
Reduced dependence on fossil fuels
Creation of positive environmental impact
District heating network that reduces carbon emissions
Reduced energy costs
Integrate renewable sources in the district heating system (CHP)

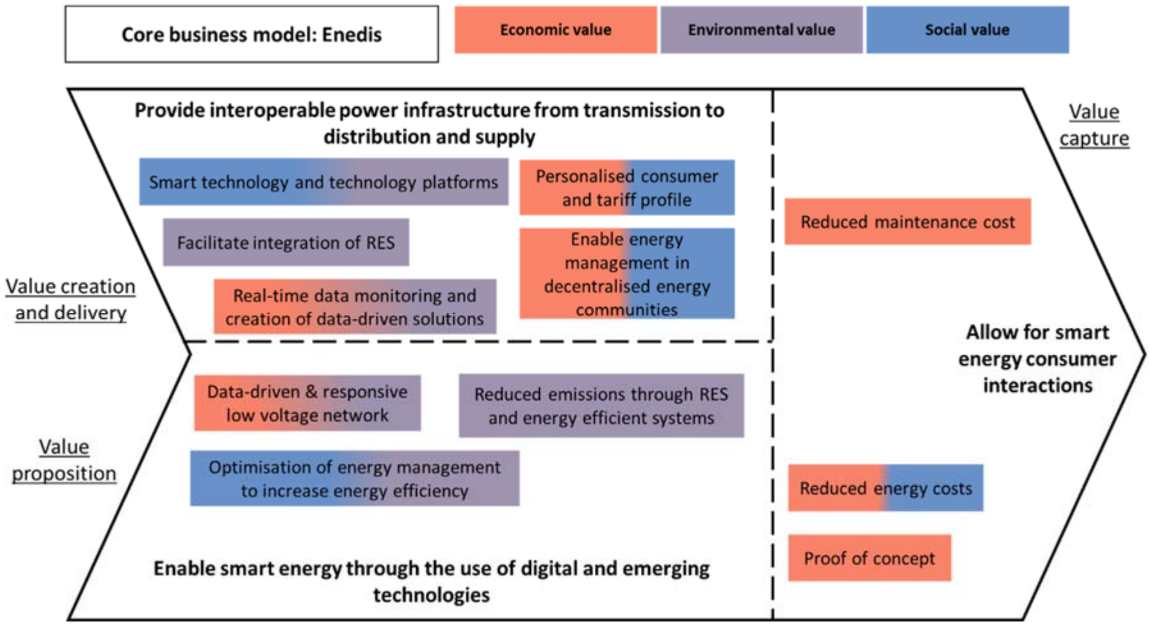

Core business model: Pozo Barredo
Economic value
Environmental value
Social value
Leverage existing resources (e.g. geothermal, mine water) to create district heating system
Use of innovative district heating system
Partnership with different stakeholders
Leveraging existing infrastructure and resources to create district heating
Value creation and delivery
Value capture
Shared investment
Use of financial instruments to finance RES
Municipality-private company partnership leads to shared costs and potential for outside investment
Value proposition
Facilitate integration of RES
Reduced emissions through RES and energy efficient systems
District heating network that reduces carbon emissions
Creation of appealing district for new business and residents
Create sustainable district heating network for local area

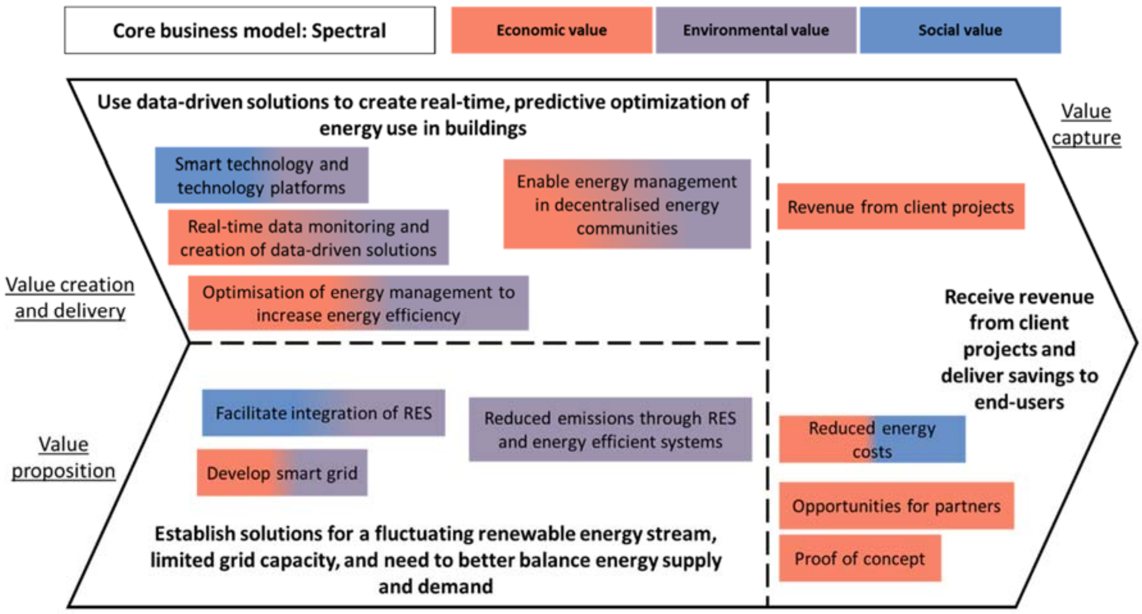

Core business model: Egni Co-op
Economic value
Environmental value
Social value
Use local partners and memberships to fund, install, and manage rooftop solar PV installations
Solar PV
Facilitate integration of RES
Cooperative membership
Participatory design and engagement of citizens
Knowledge sharing
Value creation and delivery
Value capture
Shared investment
Revenue from energy sales
Create revenue from energy sales and reinvest it
Value proposition
Utilise public buildings rooftops
Reduce upfront costs of PV installations
Promote solar PV
Creation of positive environmental impact
Profits get reinvested
Long term return on investments
Reduced energy costs
Utilise public buildings' rooftops and engage citizens for deployment of solar PV


Core business model: Partagélec
Economic value
Environmental value
Social value
Allow municipality to provide collaborative self-consumption from renewable energy production for citizens and businesses
Solar PV
Collective self-consumption
Partnership with different stakeholders
Knowledge sharing
Value creation and delivery
Value capture
Use of financial instruments to finance RES
Receive financial support for technology installation and reduce energy costs for citizens
Value proposition
Promote solar PV
Utilise public buildings rooftops
Creation of positive environmental impact
Reduced energy costs
Demonstrate viability of a PV system and collective self-consumption


Core business model: Coopem
Economic value
Environmental value
Social value
Value creation and delivery
Value proposition
Value capture
Facilitate purchase of PV at a reduced price for citizens and businesses by taking advantage of existing financial instruments
Solar PV
Use of financial instruments to finance RES
Facilitate integration of RES
Municipality-citizen-business partnership
Participatory design and engagement of citizens
Cooperative membership
Partnership with different stakeholders
Reduce upfront costs of PV installations
Promote solar PV
Creation of positive environmental impact
Promote the installation of solar PV at accessible prices
Cooperative member fees
Use revenue from cooperative member fees, feed-in-tariff, and sales of green certificates for PV installation
Revenue from energy sales
Dividends for cooperative members

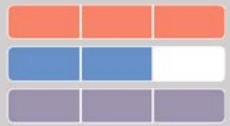
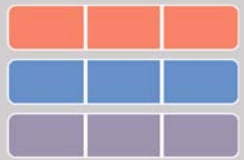

Core business model: Legendre Energie
Economic value
Environmental value
Social value
Value creation and delivery
Value proposition
Value capture
Install PV on commercial and public buildings
Solar PV
Partnership with different stakeholders
Facilitate integration of RES
Utilise commercial and public buildings rooftops
Optimisation and energy management to increase energy efficiency
Promote solar PV
Enable citizens to manage their energy
Reduced emissions through RES and energy efficient systems
Deploy PV and provide energy efficiency services
Revenue from client projects
Revenue from clients for installations
Long term return on investments
Reduced energy costs

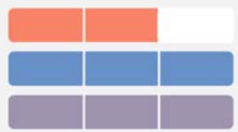

Core business model: Enedis
Economic value
Environmental value
Social value
Provide interoperable power infrastructure from transmission to distribution and supply
Smart technology and technology platforms
Personalised consumer and tariff profile
Facilitate integration of RES
Enable energy management in decentralised energy communities
Real-time data monitoring and creation of data-driven solutions
Value creation and delivery
Value capture
Reduced maintenance cost
Allow for smart energy consumer interactions
Data-driven & responsive low voltage network
Reduced emissions through RES and energy efficient systems
Value proposition
Optimisation of energy management to increase energy efficiency
Reduced energy costs
Proof of concept
Enable smart energy through the use of digital and emerging technologies


Core business model: Spectral
Economic value
Environmental value
Social value
Use data-driven solutions to create real-time, predictive optimization of energy use in buildings
Smart technology and technology platforms
Enable energy management in decentralised energy communities
Real-time data monitoring and creation of data-driven solutions
Optimisation of energy management to increase energy efficiency
Value creation and delivery
Value capture
Revenue from client projects
Receive revenue from client projects and deliver savings to end-users
Facilitate integration of RES
Reduced emissions through RES and energy efficient systems
Develop smart grid
Value proposition
Reduced energy costs
Opportunities for partners
Proof of concept
Establish solutions for a fluctuating renewable energy stream, limited grid capacity, and need to better balance energy supply and demand

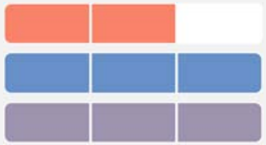
Appendix B. Case study matrix for archetype identification

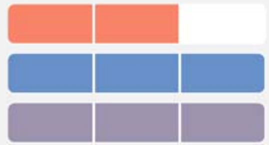
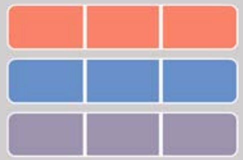
This matrix presents the grouping of case studies and a summary of their value and sustainability dimensions that have been identified through the lens of the conceptual framework, using the business model schematic. The sustainability dimensions showcase the priorities of the projects, and their impact and scale, within each archetype group. The sustainability dimensions of the case studies have been generalised and averaged to represent the sub-archetypes.

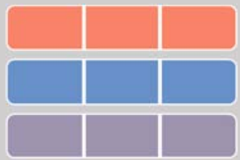
Case study	Value proposition	Value creation and delivery	Value capture	Key feature	How	Sustainability dimensions
Cooperative Deltawind, the Netherlands	Motivated to protect the environment, the cooperative seeks RES solutions to generate and manage energy, fostering **self-sufficiency** and a **fossil fuel independent and a carbon-free** environment.	The technologies that Deltawind cooperative funds comprise a combination of **wind turbines and solar PV.** Deltawind has already enabled the deployment of e.g. 2960 solar PV installations. These installations are **owned and managed by the cooperative**. Local people can become members of the cooperative. In fact, the whole cooperative was **initiated by the citizens**. Deltawind **partners with different stakeholders** to reach its goals and enable RES installations of different sizes.	Local people can join the cooperative by paying **membership fees**. The renewable energy technologies are funded through **local investments**, from which the people can expect a yearly **dividend of 6%**. This revenue is a result of the energy sales. 3.9 million Euros have been already invested through these loans. An additional positive side effect of these direct economic benefits is the **growth of the local economy**.	achieve energy self-sufficiency	Initiation of citizen ownership and management	
Isle of Eigg, UK	Because the Scottish island has no grid connection to the mainland, it has historically been highly dependent on expensive fossil fuels. The islanders'	The small size of the island, with only 96 residents, unites the islanders and fosters a strong social and environmental sense. Hence, the islanders	The Isle of Eigg community used different sources to fund their capital investments. They received **funding from the EU and UK**, utilised **local**	achieve energy self-sufficiency	Initiation of citizen ownership and management	

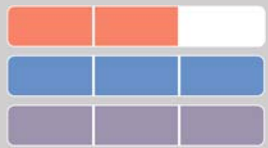
Case study	Value proposition	Value creation and delivery	Value capture	Key feature	How	Sustainability dimensions
	wish to be financially and environmentally sustainable has led them to install a **RES capacity** that allows them to be **totally self-sufficient** (with two back up diesel generators). This **addresses the environmental concerns** of the islanders and **decreases the strong dependence on fossil fuels.**	initiated their energy transition towards a self-sufficient island based on a **microgrid system** that combines **several technologies: solar PV, hydroelectric plants, wind turbines, and batteries for storage.** The island's energy infrastructure and the whole island itself is **owned and managed by the islanders** themselves, which **facilitates decision-making processes**. For instance, the islanders decide together on energy pricing and management regulations. Conscious energy consumption is expected on the part of the inhabitants as the generated electricity is limited.	**investments** and a **bank loan** to cover the costs. As a result of the enhanced fossil-fuel free energy system, the islanders benefit from **long-term reduced energy costs**. At the same time, the journey has helped the island **grow its local economy** and **build direct capacities** among the islanders.			
Hunziker Areal, Switzerland	Hunziker Areal is a sustainable neighborhood that has been constructed by a social housing cooperative. **Social cohesion, inclusiveness, and affordability** of these services is a key value proposition that the cooperative wants to provide to its residents. Through technological innovations, the residents benefit from sustainable energy and thermal	With the help of **different partners** "mehr als wohnen" **housing cooperative** designed and developed a district that combines **residential and commercial areas**. A key opportunity was found in **transforming a former wasteland into an attractive urban zone,** thus allowing for developers to implement innovative design from the beginning. To allow for environmental sustainability, the district	The **cost effective construction** of the district and sharing of risks among the different stakeholders allowed for the feasibility of the project. The land is leased from the city of Zürich, but the infrastructure is owned by the cooperative. The social dimension of the project is represented through **affordable rental costs** for the residents, social housing, and **reduced**	provide a social and environmentally friendly place for living and working	Combination of citizen engagement and community-oriented living and environmentally friendly solutions	

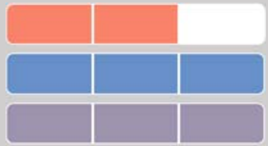
Case study	Value proposition	Value creation and delivery	Value capture	Key feature	How	Sustainability dimensions
	solutions that **reduce greenhouse gas emissions**. Hunziker's cooperative structure, the built environment of the neighborhood, and various community initiatives foster a **community-oriented and environmentally friendly way of living and working**.	incorporates **different technological approaches: smart technology and technology platforms, collective self-consumption (solar PV), leveraging of existing infrastructure and resources (waste heat from data center) to create DH, concepts for conscious energy consumption, and mobility solutions** such as electric vehicles and limiting regulations for cars for the residents. The infrastructure is owned by the cooperative. All residents are required to become members of the cooperative which allows for **participatory design and engagement**. The human-centric "lighthouse" project encourages the residents to engage in the district, **share knowledge** within and among other social housing cooperatives, and promote replication.	**electricity and heating costs**. In comparison to common energy supply rates, the residents benefit from up to 30% less heating costs annually, and reduced costs for "green" electricity from local rooftop solar PV. The cooperative also benefits from these cost reductions, and receives direct **revenue from energy sales** to the grid and to the residents. By creating a commercial space within the district, the cooperative is able to **create jobs** in the neighbourhood.			

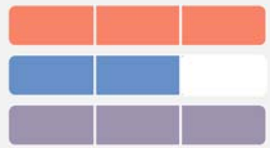
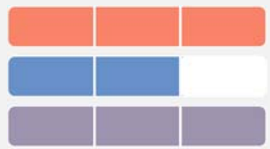
Case study	Value proposition	Value creation and delivery	Value capture	Key feature	How	Sustainability dimensions
District of Vauban, Germany	Vauban is a district that combines working and living for different social groups. The **environmental dimension of the district's approach focuses on energy-efficiency approaches for heating and housing,** and creation of a **car-free environment**. In other words, it enables human- centric, **community-oriented and environmentally friendly ways of living**.	**Initiated by citizens**, a former barrack site of the French army was transformed into an urban zone with emphasis on short distances to the city center and public transport, combining **residential and commercia**l needs (incl. **job creation**). To **roll out and design this project, the citizens** founded a cooperative and formed **partnerships with different stakeholders** such as the city of Freiburg. The district's environmental goals were established from the beginning. The buildings **combine technologies such as solar PVs and DH (wood chips), and energy efficient construction (passive housing) and consumption.** The district is mostly car-free enabled through a special **mobility concept**. All processes and initiatives seek to involve citizens for a **participatory design**. Citizens can become **members** and volunteer in the Vauban cooperative.	The **cost-effective construction** was enabled through sharing of capital investments among private and public builders. Residents with no car can actually **save money through the mobility concept** while the ones that want a car will need to pay fees for it. The energy measures for the buildings allows for **energy savings for the residents** in comparison to traditional energy supply. The cooperative receives small amounts of revenue from **energy sales** from their solar PV installation and other services.	provide a social and environmentally sustainable place for living and working	Combination of citizen engagement and community-oriented living and environmentally friendly solutions	

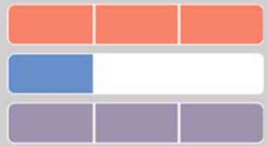
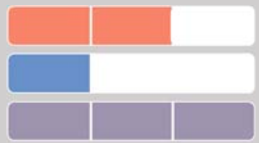
Case study	Value proposition	Value creation and delivery	Value capture	Key feature	How	Sustainability dimensions
La Fleuriaye (Carquefou), France	This newly built district aims to provide **community-oriented and environmentally friendly way of living** in its residential area (West). Through this innovative combination it enables **self-sufficiency based on 100% RES** and **reduced emissions and energy consumption.**	La Fleuriaye combines **residential and commercial area**. The East district provides a commercial area for residents and other citizens. Both districts are equipped with **smart technology and technology platforms**, and **combine solar PV, biomass energy, passive houses to optimise energy and increase energy efficiency**. Additionally, they provide environmentally-friendly **soft mobility solutions**. The project was initiated by the city that **partnered with different public-private stakeholders** to finance, implement, and develop the district.	A key aspect of the value capture are the **reduced energy costs** to both residential and commercial users of the district. Additionally, the **municipality covered the costs for the passive house construction**.	achieve energy self-sufficiency	Reduction of energy consumption accompanied by RES	
Samsø Island, Denmark	Samsø Island became the world's first **self-sufficient island based on 100% RES**. The islanders benefit from carbon-free environment and energy production, and sustainable mobility solutions, **creating a positive environmental impact**. Nevertheless, similar to other islands, the **independence from fossil fuels** is a key benefit enabled by the self-sufficiency.	The island's energy transition to become a sustainable island was initiated by the deployment of **wind turbines**. Later the path included a **combination of other technologies and other projects such as solar PV, biomass, district heating, electric and biofuel mobility, and waste recycling**. The implementation of these technologies was enabled through **promotion of**	Up to 70% of the total initial **investments were covered by local islanders**. Additionally, they received **subsidies** and tax incentives. Now they use new financing streams such as **funding** through participation in research projects. The islanders benefit economically from the **revenues from energy sales, created jobs, and the overall growth of economy** on their island.	achieve energy self-sufficiency	Synergy of social efforts and combination of environmentally friendly solutions	

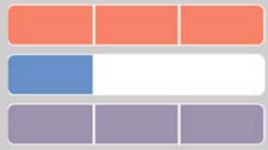
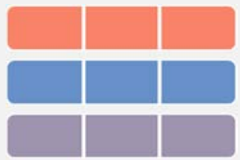
Case study	Value proposition	Value creation and delivery	Value capture	Key feature	How	Sustainability dimensions
		participatory design and engagement of citizens. This **cooperative and citizen owned** wind farms showcase this fact. **Partnership with various stakeholders**, experts from private businesses to research, made this pathway feasible. Also cooperation with government, flexible energy policies were crucial to the success. The island continuous its energy transition path and **shares its knowledge and experience**.				
The Orkney Islands, UK	The Orkney Islands PED-like energy system provides **self-sufficiency based on 100% RES**, that addresses the social, environmental, and economic concerns of the islanders. They now benefit from a **carbon-free environment, limited curtailment of their wind turbines, and growth of their economy**.	The first wind farms were deployed at the **initiation of the citizens to tackle depopulation of the islands** and mitigate fuel poverty. Now, the Orkney Islands **apply and optimise a range of renewable energy technologies to allow for their integration** into the limited electricity grid. The system includes e.g. 500 small and medium-sized wind turbines, innovative heating, smart grid, energy storage, and other **innovative technologies**. Through the diversification of projects (e.g. SMILE , ReFLEX) the islands	The finance for minor and larger capital investments was covered through l**ocal investments** based on cooperative structures of the local community, **financial instruments**, subsidies and funding such as through research projects. Also the network operator saved significant costs from the **cost-effective integration of the smart grid instead of an expensive grid-reinforcement**. At the same time, the islanders economically benefit directly or indirectly as all community turbines provide	achieve energy self-sufficiency	Synergy of social efforts and combination of environmentally friendly solutions	

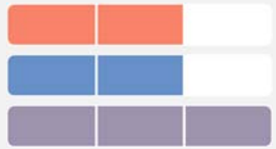
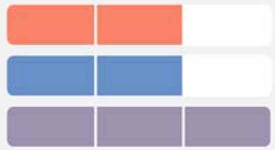
Case study	Value proposition	Value creation and delivery	Value capture	Key feature	How	Sustainability dimensions
		approach the energy transition holistically. The available resources make it possible for them to establish a marine energy test site. From this site and other initatives the island seeks to **share its knowledge** and raise awareness among the citizens. Even though the project path demonstrates **partnerships with different stakeholder**s, the focus is always on a **participatory design and engagement of citizens.**	**revenue from energy sales** that is reinvested into the local community. The activities in research and development and local energy production **provide jobs** and deliver the value of **secure, affordable, and sustainable energy** to the local community,			
Schoonship, the Netherlands	Schoonschip is floating settlement in a canal in Amsterdam of 46 newly built houses that are constructed and connected to be **self-sufficiency based on 100% RES**. The residents benefit from a totally **gas-free consumption and carbon-free environment mitigating climate change**.	The **citizen owned and managed** Schoonship project focuses on creating social and environmental value. The community achieves this through generating its own energy and minimising the carbon footprint through **various technologies** implemented in the houses but also **the construction of the houses themselves: combination of solar PV and heat pumps, environmentally friendly materials for construction of houses, house insulation, e-mobility, waste and water management solutions, overall conscious energy consumption, and a**	The houses were financed by the residents themselves (**local investments**) who individually had to find financing solutions such as selling their old houses and applying for funding. However, the design of the district aims to minimise expenses, reduce consumption, and make them prosumers to **sell energy to the grid** in order to **reduce the energy costs** of the citizens, while contributing positively to the environment.	achieve energy self-sufficiency	Synergy of social efforts and combination of environmentally friendly solutions	

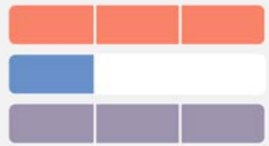
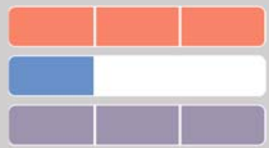
Case study	Value proposition	Value creation and delivery	Value capture	Key feature	How	Sustainability dimensions
		community-oriented way of living. The project was **initiated, designed and developed by citizens** that used public-private **partnerships with different stakeholders**. Schoonschip participates in the Atelier research project and **shares its experience to provide knowledge** for other communities.				
Aardehuizen, the Netherlands	The creation of Aardehuizen was motivated by the desire to contribute to the energy transition, developing a **self-sufficient, emission-free community** based on **100% RES**. The goal for the community was to also go beyond energy self-sufficiency and include solutions for sustainable water and waste management.	Aardehuizen's development was **initiated by citizens, in partnership** with the citizen-run organization Transition Deventer (focused on enabling the energy transition). The community is **owned and managed by citizens** who are able to achieve their energy goals through **installed PV and conscious energy consumption**. In addition, the community has **solutions for waste and water management**. As a community that aimed to be sustainable in all aspects, the homes were built from **environmentally friendly local materials**, some of which are "Earth Domes."	Aardehuizen has helped **grow the local economy**, both by **creating jobs** and volunteer opportunities and by providing residents and local citizens with **new skills and capacity-building**.	achieve energy self-sufficiency	Synergy of social efforts and combination of environmentally friendly solutions	

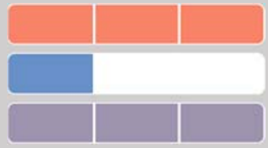
Case study	Value proposition	Value creation and delivery	Value capture	Key feature	How	Sustainability dimensions
IssyGrid, France	The IssyGrid project aimed to develop France's first **smart grid**. The IssyGrid district, located in a commercial area that houses many offices, would rely on the smart grid for **optimisation and energy management to increase energy efficiency** and **integrate RES** solutions. This approach will **reduce emissions** positively contributing to the environmental dimension.	IssyGrid produces environmental value through a combination of **energy service products and data-driven solutions**. These involve **smart meters, utilisation of energy data, mobility solutions, and a combination of solar PV, geothermal wells, and batteries for energy storage**. The grid was built through a **partnership of public and private stakeholders from different sectors**. IssyGrid has moved beyond the **commercial area** to include a **residential area** called Fort d'Issy.	IssyGrid is maintained by **shared investments** from the partnering companies; in return, the companies receive **new business opportunities** and are able to test new solutions for **proof of concept** (critical for start-ups). Residents and business owners within the district receive **reduced long-term energy costs**.	develop smart grid/technology test platform	Leveraging of partnerships to achieve technological, financial, and environmental goals	
Smart Energy Åland, Finland	Smart Energy Åland encompasses a wide variety of energy products and services at the centre of which is **smart grid development**. As a whole, it is able to provide a **test platform for innovative technologies**. The goal is to create solutions that **reduce carbon emissions** and **optimise energy management to increase energy efficiency**. Nevertheless, this development focuses on delivering sustainability values to the citizens and	Smart Energy Åland is able to achieve its goals through a **partnership with different private and public stakeholders (public-private-people partnership)**, as well as research organisations. These parties are able to a **test innovative technologies** and implement **solutions that utilise solar, wind, geothermal, and wave sources**. The platform also provides solutions for **e-mobility** and is dependent	Smart Energy Åland is financially maintained by **shared investment** from the municipality and partnering stakeholders. It provides a space for solutions providers to **test proof of concept, business opportunities,** and achieve credibility for technologies that can then be replicated elsewhere. Local residents and businesses benefits from **reduced energy costs and an appealing district**.	develop smart grid/technology test platform	Leveraging of partnerships to achieve technological, financial, and environmental goals	

Case study	Value proposition	Value creation and delivery	Value capture	Key feature	How	Sustainability dimensions
	creating a positive impact on the environment.	on **energy storage technologies**.				
Händelö, Sweden	The Händelö Industrial Park is a symbiotic network of companies that rely on the re-use of industrial outputs and by-products to achieve different goals, including the **creation and maintenance of a district heating network**. Due to resource symbiosis, that makes effective use of resources, utilising and processing of waste and by-products, and eco-cycle thinking, Händelö's district heating system **reduces carbon emissions** and **minimises dependence on fossil fuels**.	Händelö, achieves its goal through a symbiotic network based on a **partnership** between an ethanol plant, a biogas plant, and an energy provider. Different resources that derive from the **synergistic exchanges and reuse of industrial by-products** are combined and optimised. Through **utilisation and processing of waste**, multiple benefits are created across the network, including creating a sustainable district heating solution.	Partners in Händelö's symbiotic network experience **reduced operation and energy costs** and a guarantee steady demand for their industrial outputs and by-products. Additionally, **fees are collected** by the CHP plant for the domestic waste it receives. The industrial park captures value through the **creation of an appealing district** with innovative technological **opportunities**.	provide environmentally friendly district heating	Leveraging of existing infrastructure and resources to create DH	
Drammen, Norway	The Drammen Kommune in Norway integrates renewable resources into its district heating system to **reduce carbon emissions, promote integration of RES, and minimise dependence on fossil fuels**.	Drammen's district heating network is able to achieve its goal of sustainability by **utilising sea water as a heat source**. Additionally, **ammonia is used in place of HCFs** as the working fluid, thus further mitigating environmental impact. The network is **co-owned by municipality and the local energy company**, which ensures communication with the local citizens.	Drammen's district heating system is **co-owned by the municipality and a commercial energy company, thus leading to shared operating costs**. Citizens benefit from **reduced energy costs** due to the innovative leveraging of existing infrastructure and resources in their district.	provide environmentally friendly district heating	Leveraging of existing infrastructure and resources to create DH	

Case study	Value proposition	Value creation and delivery	Value capture	Key feature	How	Sustainability dimensions
Pozo Barredo, Spain	Pozo Barredo uses geothermal sources and mine water to create a **small district heating system** for the area. The project's **integration of RES optimises resource use and increases energy efficiency**.	Pozo Barredo creates environmental value by leveraging the company Hunosa's technical capabilities in **geothermal and biomass projects**. The project is enabled through a **partnership** between the municipality and the private company.	The partnership between the municipality and private companies leads to **shared investments** in implementation and helps garner additional **EU funding** for the innovative project. The creation of this innovative and **appealing district heating infrastructure and partnership** enables potential for outside investments.	provide environmentally friendly district heating	Leveraging of existing infrastructure and resources to create DH	
Egni Co-op, UK	Egni Cooperative (Co-op) uses public building rooftops to deploy and **promote solar PV** installations. Through their cooperative financing structure, they **reduced upfront costs of PV** for people and communities. In this way, they **increase the share of RES** in Wales, provide a **carbon-free environment**, **engage citizens, and raise awareness**. In short, they provide environmental, social and even economic benefits to people.	The cooperative funds, manages, and develops **rooftop solar PV systems**, adding monitoring systems to track the energy consumption. The core of their business model is that they use a cooperative membership structure to enable a participatory design and engagement of people anywhere (in Wales) **facilitating finance and development of the installations** in actual local communities. They **partner with local stakeholders** and provide several initiatives for awareness raising and **knowledge sharing** within the communities.	The cooperative funds installations through **share offers to cover upfont capital investment**. The produced **energy is then sold to the grid** to create revenue. Egni Co-op is a **non-profit** organisation. Hence, all **profits get reinvested** into e.g. the maintenance of the systems, social initiatives, and provision of **reduced energy costs** to the community buildings. Members receive an annual 4% 'fair rate of return' on their share of **long-term investment.**	expand the deployment of PV	Synergy of social efforts and combination of environmentally friendly solutions	

Case study	Value proposition	Value creation and delivery	Value capture	Key feature	How	Sustainability dimensions
Partagélec, France	Through the project of Partagélec, the municipality demonstrates and **promotes the viability the deployment of solar PV to mitigate climate change**. The project **utilise sbuilding rooftops** within the community to provide environmental, social, and economic benefits to the locals.	The **partnership with different municipal stakeholders** and especially the local community allows the municipality of Penestin to provide collective **self-consumption of solar PV** to its citizens. The pilot project is able to **share and expand technical knowledge** to later increase the scale of the collective self-consumption installation.	The project **uses financial instruments to support the finance of the installations**. The aim of collective self-consumption system is that the citizens can benefit from **reduced energy costs**, using their locally produced production.	expand the deployment of PV	Synergy of social efforts and combination of environmentally friendly solutions	
Coopem, Belgium	Coopem's main goal is to **reduce upfront costs of PV** installations, thus furthering the **deployment of solar PV** and facilitating **integration of RES**. Through this goal Coopem simultaneously **contributes to mitigating climate change.**	Coopem is organized as a **municipality-citizen-business partnership**, a cooperative that is co-owned by the city of Mouscron, cooperative members, and two technology companies that help install the PV. The cooperative fosters a **participatory design** and relies on **engagement of citizens**. Coopem is able to offer PV installations at a lower price by **taking advantage of financial incentives** such as feed-in-tariffs and the selling of green certificates.	Coopem is able to financially achieve its goals by generating revenue from **cooperative membership fees** and **leveraging existing financial instruments** (feed-in tariff, selling of green certificates). It pays dividends to its members and is able to offer PV **installations at a reduced price**.	expand the deployment of PV	Leveraging of partnerships to achieve technological, financial, and environmental goals	

Case study	Value proposition	Value creation and delivery	Value capture	Key feature	How	Sustainability dimensions
Legendre Energie, France	Legendre Energie deploys **solar PV**, enabling citizens to **manage their energy efficiently** and become prosumers.	Legendre develops **solar PV** installations for clients on **commercial and public buildings.** The installations include systems for **optimisation and energy management** to increase energy efficiency. Legendre is a **facilitator for RES integration**. **Partnerships with different stakeholders** form the resources of the commercially driven business model.	Legendre deploys solar PV for profit, getting **revenue from clients for the installations**. The clients benefit from **reduced energy costs** or energy sales, creating **long-term return on their investments.**	expand the deployment of PV	Deploy solar PV commercially	
Enedis, France	Enedis provides **data-driven solutions for real-time energy use monitoring**. It **enables decentralised energy management** and **balances the local energy loop** through products like the Linky **smart meter**. Hence, this technology enables **energy efficiency and helps to reduce emissions**, recognising the environmental dimension of the business model.	Through its products, Enedis facilitates **real-time monitoring of energy use data**. This leads to **optimised (and remote) maintenance operations and energy system management**. In addition, **tariffs are customised** by consumer profile according to the energy used through products like the Linky smart meter. Enedis' products and services can be used in projects like **smart grid development and/or management of energy in self-consumption communities**.	Through its products and services, Enedis creates **reduced energy costs** for it users and allows greater cost transparency for consumers. Additionally, remote monitoring of the grid allows for more **efficient management and lower maintenance costs of the network**. Enedis captures value by **proof of concept** by showcasing technology in new, ambitious projects.	provide product-service	Development of innovative technologies	

Case study	Value proposition	Value creation and delivery	Value capture	Key feature	How	Sustainability dimensions
Spectral, the Netherlands	Spectral aims to facilitate the energy transition by creating **data-driven solutions for optimisation and energy management**. These solutions are critical for **deployment of smart grids** and **can help decentralised renewable energy communities** in achieving energy efficiency.	Spectral's products and services create environmental value by using smart technology and technology platforms to **enable energy trading, optimise financial returns through flexible services, optimise energy use in buildings**. These **data-driven solutions** are implemented in p**artnership with other stakeholders** and in many new projects in Amsterdam and beyond.	Spectral receives **revenue from client projects** and is able to **test new technologies and gain credibility** by partnering with various projects that promote the renewable energy transition. Spectral captures value by **proof of concept** by showcasing technology in new, ambitious projects. The technology allows to optimise financial returns through data-driven energy services, **reducing energy costs** of the end-users.	provide product-service	Development of innovative technologies	

About the Smart-BEEjS Project

Energy transition is supported in the EU by legislative developments, such as the Strategic Energy Technology Plan that aims to transfer power to consumers by decentralising the energy eco-system at the local district-level. However, this transition occurs at a time of increasing wealth inequality, energy poverty, and gender difference. Thus, the long-term vision of the Smart-BEEjS project is **to design transformational pathways** that tackle **Energy Poverty and Justice**, providing evidence and using the decentralised nature of **'Positive Energy Districts'** and **'Networks of Districts'** as the central platform of transformation, whilst recognising the economic, social and environmental challenges faced. Tackling the issue of energy injustice and poverty is an essential pillar for contributing to the **decarbonisation of our economies** without leaving large parts of the population behind.

Behind any decision or intervention – whatever the field of expertise, technological, business or policy – are **people**. Therefore, **the overarching training aim of Smart-BEEjS** is to provide, through a multilevel, multidiscipline and interdisciplinary training platform, a programme to produce the technology, policy making or business oriented **transformative and influential champions of tomorrow**; educated in the personal, behavioural and societal concepts needed to deliver the success of any technological proposition or intervention under the human-centric perspective of energy justice.

The Smart-BEEjS project recognises that the new level of decentralisation in the energy system requires the **systemic synergy of different stakeholders**, who are **inseparable** and interrelate continuously to provide feasible and sustainable solutions in the area of **energy generation and energy efficiency**. They balance attention towards technological and policy-oriented drivers from a series of perspectives:

- **Citizens and Society**, as final users and beneficiaries of PEDs;
- **Decision Makers and Policy Frameworks**, in a multilevel governance setting, which need to balance different interests and context-specific facets;
- **Providers of Integrated Technologies, Infrastructure and Processes of Transition**, as innovative technologies and approaches available now or in the near future;
- **Value generation providers and Business Model Innovation (BMI)** for PEDs and networks of districts, namely businesses, institutional and community-initiated schemes that exploit business models (BMs) to provide and extract value from the system.

In order to introduce cooperation and shared thinking, Smart-BEEjS presents a balanced consortium of beneficiaries and partners from different knowledge disciplines and different agents of the energy eco-system, **to train at PhD level** an initial generation of **transformative and influential champions** in policy design, techno-economic planning and Business Model Innovation in the energy sector, **mindful of the individual and social dimensions,** as well as the **nexus of interrelation between stakeholders** in energy generation, technology transition, efficiency and management.

The overarching aim of the project is to boost knowledge sharing across stakeholders, exploiting a human-centric and systemic approach to design Positive Energy Districts (PEDs) for sustainable living for all.

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