Nantes | Hamburg | Helsinki

THIS DELIVERABLE HAS NOT YET BEEN APPROVED BY THE EC

Deliverable due date: M51 – February 2021

D8.9 Report on business models of selected use cases

WP8, Subtask 8.3.2

Transition of EU cities towards a new concept of Smart Life and Economy

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Project Acronym	mySMARTLife
Project Title	**Transition of EU cities towards a new concept of Smart Life and Economy**
Project Duration	1st December 2016 – 30th November 2021 (60 Months)
Deliverable	D8.9 Report on business models of selected use cases
Diss. Level	PU
Status	☐ Working ☐ Verified by other WPs ■ Final version
Due date	28/02/2021
Work Package	WP8
Lead beneficiary	Steinbeis-Europa-Zentrum
Contributing beneficiary(ies)	CAR, ENG, ENH, ESA, FOU, HEN, NBK, SAL, SEZ, TEC, TSY, VTT
Task description	Task 8.3: Business cases and business models [ESA] (CAR, SEZ, ENG, ARM, HCU, HAW, VTT, HMU, TEC, NBK) all partners, especially RTD and industry partners that are owners of the selected commercial, exploitable results. Subtask 8.3.2: Business plan: Identification and evaluation of business opportunities and initial business model(s). The objective of this task is to transfer the results from the Exploitation Roadmap of Results into economic feasible business models. ESA will guide this activity. The data collected and determined in task 8.3 will lead to identification of business models and the definition of subsequent business plans, which will be evaluated taking various factors and aspects into account: project plan with timeline, gate reviews (Gantt chart) and budget; value chain and stakeholders, problem solution and customer value proposition, customer segment/ relations, channels for communication, distribution and sales, envisaged key activities and respective partners, key resources, financial investment, cost-benefit analysis, pricing and expected revenue for company provided through value proposition; risk analysis and mitigation plan, SWOT analysis and respecting regulatory issues from the energy market (EU legislation and member states legislations), addressing respective barriers for market uptake. Business models will aim at providing solutions for communities and end-users and be confirmed by a benefit analysis through commonly accepted KPIs. The developed business plans proposing initial business cases for the project's products, services and processes will be the outcome of this task and lead to the respective deliverable D8.9 Report on business models of selected use cases.

Date	Version	Author	Comment
12.11.2020	0.1	ENG, ENH, ESA, FOU, HEN, NBK, SAL, SEZ, TEC, TSY, VTT	1st draft of the document incorporating the different part prepared by the partners
16.12.2020	0.2	ENH	2nd version of the document considering inputs to the existing parts from the different partners
14.01.2021	0.3	ENG, ENH, HEN, SEZ, TSY	3rd version of the document considering modifications and addition from the different partners
02.02.2021	0.4	ESA	4th version with further inputs and corrections from ESADE
09.02.2021	0.5	ENG, ENH, HEN, SEZ, TSY, ESA	5th and final version before intern review of the document considering the last modifications and additions suggested by the partners
24.02.2021	0.6	SEZ, ESA	6th version taking into consideration some comments of the reviewers
26.02.2021	0.7	CAR	7th and final version for submission to the EC

THIS DELIVERABLE HAS NOT YET BEEN APPROVED BY THE EC

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Table of Content

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Table of Figures

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Table of Tables

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Abbreviations and Acronyms

Acronym	Description
APIs	Application Programming Interfaces
CHP	Combined Heat and Power
CO_2	Carbon dioxide
DT/DTAG	Deutsche Telekom
DY.Z	Z^{th} deliverable of the Y^{th} Work Package
EEG	Erneuerbare Energien Gesetz, in English: renewable energy law
ERs	Exploitable Results
EU	European Union
GUI	Graphical User Interface
ICT	Information Communication Technologies
IoT	Internet of Things
IRR	Internal rate of return
IVC	Internal Value Chain
LED	Light Emitting Diode
M2M	Machine to Machine
MXX	XX^{th} project month after the beginning of mySMARTLife project in December 2016
mySMARTLife	Transition of EU cities towards a new concept of Smart Life and Economy
NPV	Net Present Value
OEM	Original Equipment Manufacturers
OGC	Open Geospatial Consortium
PbP	Pay-back Period
PPP	Public Private Partnership
PV	Photo-Voltaic
RES	Renewable Energy Sources
RoA	Return on Assets
RoI	Return on Investment
STY.Z.V	V^{th} sub-task of the Z^{th} task of Y^{th} Work-Package
SUP	Smart Urban Platform
SWOT	Strengths Weaknesses Opportunities Threats
UDC	Universal Document Converter
UI	User Interface
VCE	Value Creation Ecosystem
WP	Work Package

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Executive Summary

Within the Work Package 8 on Communication, Dissemination and Exploitation of the project mySMARTLife, the deliverable 8.9 (D8.9) has been dedicated for the identification, development, and validation of business models, as well as the identification of potential ERs from each pilot intervention.

First, this study is a product of work and inputs of several consortium partners and is connected to several activities as well as deliverables provided within the mySMARTLife project. The main purpose of this project was to develop an Urban Transformation Strategy supporting the cities in the definition of transition models, addressing the main city challenges, and progressing towards assumptions of the concepts such as smart people and smart economy. The development of this strategy includes the implementation of different innovative solutions in the fields of building and districts, city infrastructure, smart mobility, non-technical actions as well as urban platforms and Information Communication Technologies (ICT). This strategy developed in cooperation with the three Lighthouse Cities and replicated by the three Follower Cities aims at supporting European municipalities in becoming smarter.

According to the objective of D8.9, data and information have been identified by each partner according to a business, validation and financial methodological approach using different types of tools. The data and information provided for business models identification and validation, as well as their financial viability, corresponds to the following pilot interventions:

- Smart Lighting
- Open Urban Platform
- Electric Power Tenant Supply
- Heat Demand Response Service

The D8.9 is a logic extension of the work presented in deliverable 8.3 (D8.3), where partners explore the existing market conditions for these interventions to select exploitable results (ERs) developed during the project.

The business models analysis and validation offer the possibility to highlight key aspects from each intervention, as well as to identify potential ERs from each one, which could be of great value for companies in terms of market entrance and consolidation of solutions. Furthermore, the analysis of each intervention provides economic and financial indicators to underline their economic viability.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

1. Introduction

1.1 Purpose and target group

The main purpose of this deliverable (within subtask 8.3.2 Business plan: identification of business opportunities and initial business model(s) of the task 8.3 Business Cases and Business models in Work Package (WP) 8 Communication, Dissemination & Exploitation) is to present the Business models and related information of these ERs selected in the framework of the mySMARTLife project:

- Smart Lighting
- Open Urban Platform
- Electric Power Tenant Supply
- Heat Demand Response Service

One of the main objectives of WP8 is to ensure the replicability of some pilot solutions beyond the framework of the mySMARTLife project. Industrial partners participating in this project play a key role in offering their products and services in new cities around Europe. To guarantee the long-term viability, it is essential to understand how the business models and cases of promising exploitable results work. If, and only if, there is a clear vision that one service could be sustainable from an economic point of view, companies will be eager to introduce it on the new markets.

This report on business models of selected use cases studies the business related to the selected promising exploitable results presented earlier ensuring their sound exploitation. These studies and their related methodology can serve as useful examples for the effective exploitation of other solutions, products, processes, services, and business models inside or outside mySMARTLife. The multitude and variety of the selected Exploitable Results and the structure of the consortium concentrating many heterogeneous members is the first opportunity. Partners often happen to be potential customers/suppliers for each other. Hence, all entities related to the fields of these selected solutions show a great interest in the common development of the ERs and this market analysis which is confidential to external organisation to the consortium:

- Lighthouse and Follower Cities: which could implement these solutions
- Academic and Research and Development Organisations: interested in developing new high-education curricula or extand their field of research
- Industrial partners: developing these solutions or services related
- Policy decision makers could learn about the hurdles of energy effiency solutions

1.2 Contribution of partners

The following table depicts the main contributions from the partners in the development of this deliverable:

Participant short name	Contributions
CAR	Guiding industrial partners when necessary, final submission of the deliverable (D8.9)
ENG	Business model and related information for the solution: Smart Lighting and intern review
ENH	Business model and related information for: Electric Power Tenant Supply
ESA	Methodology, guidelines, review.
FOU	Intern review
HAM	Interim review of the Roadmap
HEN	Business model and related information for: Heat Demand Response Service

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

SEZ	Collect of the inputs in the present deliverable, review, correction and editing
TSY	Business model and related information for: Open Urban Platform

Table 1: Contribution of partners

1.3 Relation to other activities in the project

The following table depicts the main relationship of this deliverable to other activities (or deliverables) developed within the mySMARTLife project, which should be considered along with this document for further understanding of its contents:

Deliverable Number	Contributions
D8.1 Exploitation & Market Deployment Plan	This deliverable provides a plan for the exploitation during the project mySMARTLife
D8.3 Market Analysis	This deliverable provides a common framework for a systematic analysis that should be conducted before entering new markets
D8.6 Roadmap	Report on the action plan and steps towards market uptake and efficient exploitation of results
D8.11 Technology and Market Watch Report	Technology & Market Watch Report: Report on the technology & market watch activities, including information about the annual patent search and the market watch catalogue.
D6.14 Cities Network replication activities planning	This deliverable is a report on the mySMARTLife Cities Network strategic plan.

Table 2: Relation to other activities in the project

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

2. Overall methodological approach for the preparation of the business models

The methodology for the analysis and validation of BMs and related information of ERs for selected interventions has used different business tools, open questionnaires, and financial indicators. These methodological tools have been grouped in three parts according to their nature and logic temporality in the gathering of the information. The first part use business tools to define and analyse the busines models of interventions; the second part focuses on intervention validation; and the third part on the financial viability of these interventions.

2.1 Part 1: Business models

2.1.1 Value Creation Ecosystem (VCE)

Companies (public and private) must work with other companies, establishing solid value chains, to produce products and/or services because they are not capable of carrying out all the needed activities by themselves (Pfeffer and Salancik, 1978; Johanson and Matsson, 1992; and Cristopher, 2016). Each actor increases the value of the product and/or services along the value chain, and just for that, each actor can capture part of that value, which in many cases, goes beyond economic value (Lepak *et al*. 2007; Agandoña, 2011). The relationship established by the actors participating in the value chain is based on coopetition, which is the combination of cooperation and competition (Urzmetzer *et al*. 2016).

To build up the ecosystems that develop smart city services, the proposed tool is called Value Creation Ecosystem (figure 1). This tool is based on the theory presented in Shapiro (2001), where nodes (actors) are connected to a network. Each actor can be connected to as many nodes as necessary. For each relation of a node A (actor A) with a node B (actor B), two links are generated. One from actor A to actor B (in blue in figure 1) which indicates the value that actor A creates for actor B, and another one from actor B to actor A (in red in figure 1) that shows the value that A captures from its relationship with B (this would represent the payback). Drawing the value chain is a key activity for explaining the following ideas:

- The actors needed along the value chain
- The value delivered and captured by each actor and its impact on the whole ecosystem of value creation
- The interdependences created among actors
- The actor (final user) that receives the whole value at the end of the chain

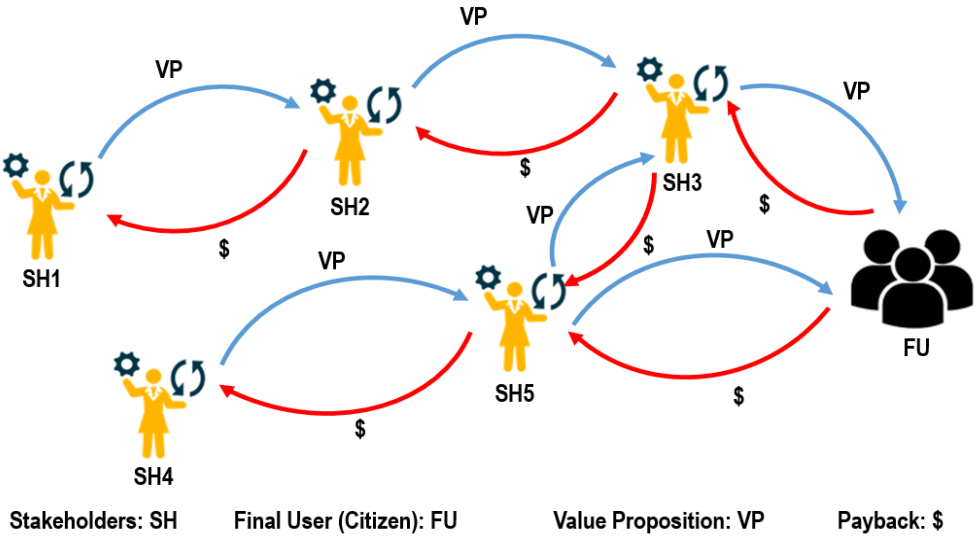

Figure 1: Value Creation Ecosystem

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

2.1.2 Internal Value Chain (IVC)

The value chain identifies and describes the activities carried out by a company to generate value for the customer and the company itself. The objective is to see how the company creates its competitive advantage. Furthermore, understanding how a company creates value allows a company to understand the cost of generating it and, therefore, generating a profit margin when it sells a product or service.
Originated in the 1980s by Michael Porter, the model suggests that a company is split into primary activities and support activities (see Figure 2).

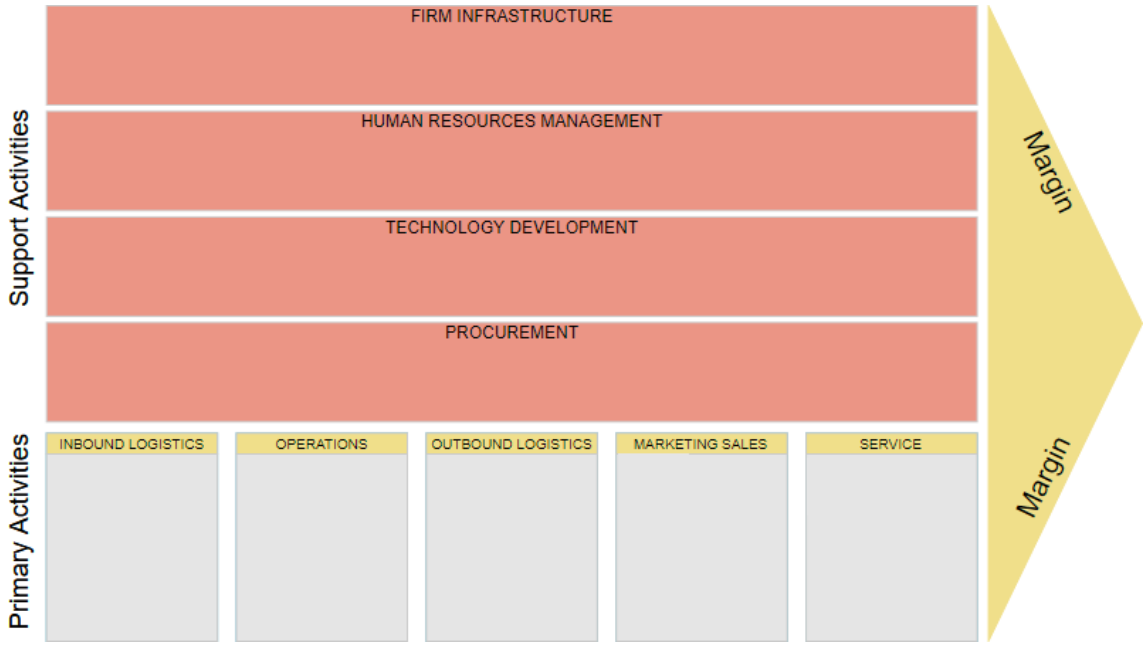

Figure 2: Internal Value Chain[1]

The value chain displays the total value. It is constructed by value and margin activities. The margin is the difference between the total value and the cost of developing value activities. And the value activities are those activities that does a company.

Basic concepts:

Primary Activities

Primary activities are directly concerned with creating and delivering a product. They can be grouped into five main areas: inbound logistics, operations, outbound logistics, marketing and sales, and service. Each of these primary activities is linked to support activities which help to improve their effectiveness or efficiency; according to Porter (1985), the primary activities are:

Inbound logistics

Refers to goods being obtained from the organisation's suppliers and to be used for producing the end product.

Operations

Raw materials and goods are manufactured into the final product. Value is added to the product at this stage as it moves through the production line.

Outbound logistics

Once the products have been manufactured, they are ready to be send to distribution centres, wholesalers, retailers, or customers. Distribution of finished goods is known as outbound logistics.

[1] Source: https://www.visual-paradigm.com/guide/strategic-analysis/what-is-value-chain-analysis/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Marketing and Sales
Marketing must make sure that the product is targeted towards the correct customer group. The marketing mix is used to establish an effective strategy, any competitive advantage is clearly communicated to the target group through the promotional mix.

Services
After the product/service has been sold: What support services does the organisation offers customers? This may come in the form of after sales training, guarantees and warranties.
With the above activities, any, or a combination of them are essential if the firm wants to develop the "competitive advantage" which Porter presented.

Support Activities
Support activities assist the primary activities in helping the organisation achieve its competitive advantage. There are four main areas of support activities: procurement, technology development (including R&D), human resource management, and infrastructure (systems for planning, finance, quality, information management etc.). They include:

Firm infrastructure
Every organisation needs to ensure that their finances, legal structure, and management structure work efficiently and help to drive the organisation forward. Waste resources of Inefficient infrastructures could affect the firm's reputation and even leave it open to fines and sanctions.

Human resource management
The organisation will have to recruit, train, and develop the correct people for the organisation to be successful. The staff will have to be motivated and paid the 'market rate' if they are to stay with the organisation and to add value. Within the service sector such as the airline industry, employees are the competitive advantage as customers are purchasing a service, which is provided by employees.

Technology development
The use of technology to obtain a competitive advantage is very important in today's technological driven environment.

Procurement
This department must source raw materials for the business and obtain the best price for doing so. The challenge for procurement is to obtain the best possible quality available (on the market) for their budget.

2.1.3 Business Model Canvas (BMC)

During the last 20 years, the business model concept has gained prominence until its consolidation as an essential element in the development of a product or service by a private company. But what really is a business model? According to Osterwalder et al. (2009) a business model is a rationality that explains how a company creates, delivers, and captures value.
Business models are for managers the equivalent of the scientific method for researchers, declaring that both begin with a hypothesis that must be validated with a test, and that can be revised if necessary. In that sense, the implementation of common frameworks helps in explaining what works and what does not work to create value in each specific business.
Considering that business models are based on hypotheses, another key aspect is testing the solutions before their scale-up. This increases considerably the chances of success because organizations are capable of fixing problems that they could not imagine they would have to face (Wynn et al., 2009). Sometimes companies do not have the capacity to learn through the validation process, and they remain stuck in a business model that is not able to mature or reach the market successfully.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Nowadays, according to De Reuver, Bouwman and Haaker (2013), the most prominent and popular tool for practitioners to design business models is the Business Model Canvas (Osterwalder et al., 2009). Business Model Canvas (BMC) is based on nine building blocks (figure 3) that covers according to its developers the four main areas of a business: customers, offer, infrastructure and financial viability. Planellas and Muni (2015) state that the BMC allows to analyse the equilibrium between the nine blocks, giving a holistic business idea. A new business could be the result of introducing a single innovation in any of the nine blocks, such as a new revenue model, introducing a new partner or a new type of customer relationship.
In general terms, most business models focus their attention on just one firm. However, it is also important to draw the attention to the whole set of activities performed by the third parties (partners, suppliers, customers). Without these actors, the focal firm would not be capable to run its business (Zott and Amit, 2010). Any business model should define the entire ecosystem of activities creating, delivering, and capturing value. It means that it is necessary to describe accurately the actors needed, the activities carried out by each of them, the connection among actors (the sequence of activities), and finally the type of value captured by each actor. It is necessary to keep in mind that everything happening within the value chain of a business model will affect the rest of the firms although it is not under their control.

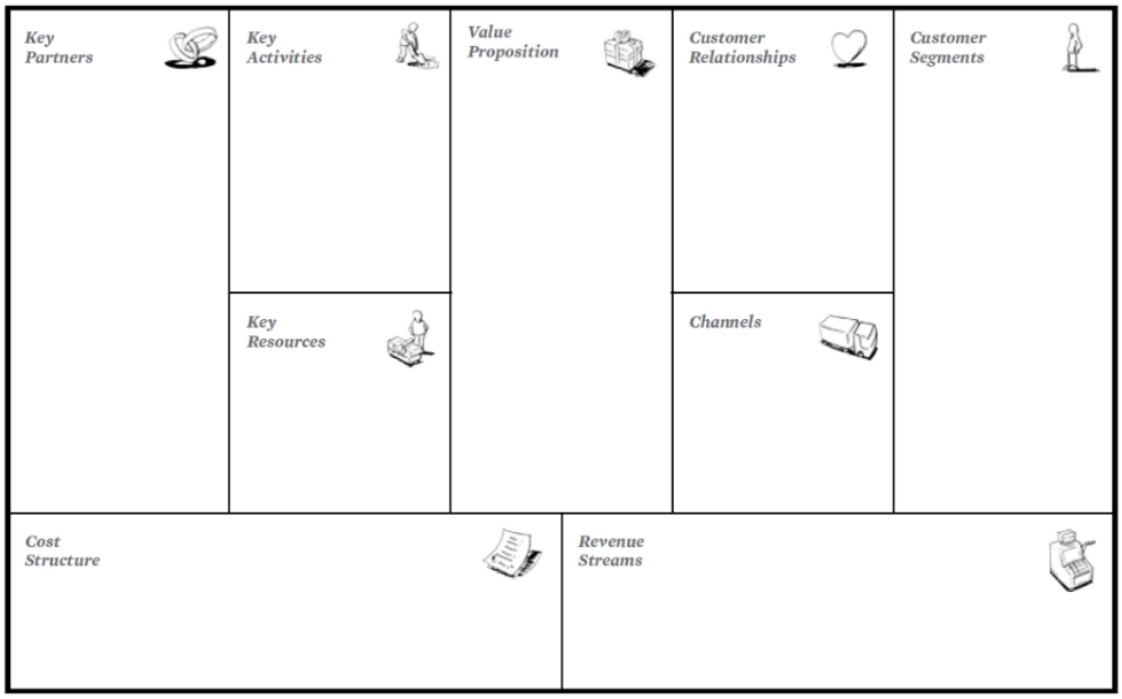

Figure 3: Business Model Canvas Structure (Osterwalder et al. 2009)

At this stage, it is important to highlight that a business model is not a business plan. Many times, these concepts create confusions among readers. In fact, a business plan tries to demonstrate the business model, estimating the financial viability of a business, paying special attention to the cash flow, profits or loses. It is also important not to confuse strategy and business models. Casadesus-Masanell and Ricard (2010) explain that strategy refers to the choice of how the company interacts with competitors in the marketplace, while the business model is the logic by which the company creates value for its customers and stakeholders. However, it is true that, business models lay at the intersection of strategy and entrepreneurship, reinforcing the connection between both fields, suggesting a more central place for customers, and emphasising the importance of the pilot implementations (Demil *et al*. 2015). The nine block and their definitions, according to Osterwalder et al. (2009), are:

1- Customers segments: It defines the different groups of people or organizations an enterprise aims to reach and serve. Every company must decide which segment to be served, because each of them has different needs or expectations.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

2- Value proposition: It describes the bundle of products and services that create value for a specific Customer Segment. It means which answers the needs or problems that customers have. Some new business models are articulated around new value propositions.

3- Channels: It describes how a company communicates with and reaches its customer segments to deliver a Value Proposition.

4- Customer relationships: It describes the types of relationships a company establishes with specific customer segments. The relation between a company and its customers can be personal or automated depending on the value proposition and the customer segment's characteristics.

5- Revenue streams: It represents the incomes a company generates from each customer segment. If the value proposition is attractive for customers, they will be willing to pay the acquisition price.

6- Key resources: It describes the most important assets required to make a business model work. It can be tangible (physical, human, financial…) or intangible (intellectual), but all of them are essential to create, deliver and capture value.

7- Key activities: It describes the most important actions that company must do to make its business model work.

8- Key partnerships: It describes the network of suppliers and partners that make the business model work. There are different types of partnerships, but usually, organizations try to create these alliances to reduces risks or acquire resources.

9- Cost structure: It describes all costs incurred to operate a business model.

2.2 Part 2: Pilot analysis (BM Validation)

Business models developed with the BMC, or with other methodologies, usually answer questions such as "What", "Who", "When", "How" or "How Much" (Mitchell *et al.*, 2004), but they always do it based on a series of hypotheses, so an important part of the study should consist in validating the correctness of hypotheses.
Lean start-up (figure 4), which is based on three different works: Blank (2005), Rise (2011) and Blank and Dorf (2012), is a methodology which was developed precisely to help organizations to perform this task. Its objective is to develop a product or services through an iterative process and continuous learning based on empirical data obtained from pilot interventions.

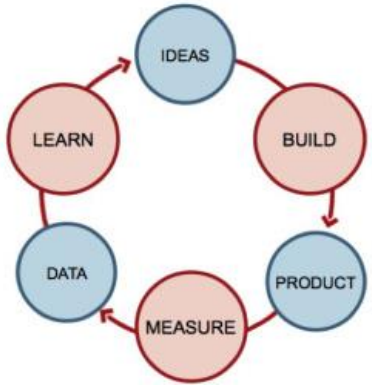

Figure 4: Build-Measure-Learn feedback loop (Rise, 2011)

The business model validation process starts with developing (build) the pilot intervention. The second activity to be carried out is to develop a set of indicators to assess the reliability of the hypotheses. Once the indicators are established the next stage is for the organization to analyse the data and extract conclusions that allow it to increase the knowledge of the product or services that they offer (learn). Based on what they learn through the Build-Measure-Learn loop, companies can introduce changes into their business model and, as a direct consequence, the result, the new business model is improved. Companies usually must go through this validation process several times until they reach an appropriate business model.
Considering that the products (interventions) are already build, in this section, companies should answer the following questions related to understand how the performance of each product/service is.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

1- What indicators did you define to assess the performance of your services/product? What kind of data did you take from them? What did you learn from these data? Are your forecasts met?

2- What improvements did you introduce in your product/service during its development/construction?

3- What are the major technical, design, adoption, or manufacturing hurdles to be solved?

4- The solution is well-defined and easily understood by the target customer?

5- What are the most complex barriers/difficulties/challenges that customers are facing when using your product or service?

6- Is your solution within the budget of the target market?

7- What are the most complex barriers/difficulties/challenges that the market presents to you?

8- Do you have clear ways to reach your target market? Did you have any problem with the channel through which you deliver your value proposition?

9- Did you have any problem with your key partners? How did you deal with it?

10- What are the main takeaways you get from pilot intervention?

2.3 Part 3: Financial viability

In this stage of the project, managers need an objective financial assessment, identifying what resources (costs) and benefits are required for implementations. This is a highly technical exercise, and according to Mersey Care (2011), it should ensure that all financial consequences of a proposal have been identified and accurately reflected, allowing the comparison between various options and various scenarios. It is not only a question of predicting the volume of sales, or the price of the products, but it is also a question of trying to predict workers' wages or the price of raw materials... However, the most important thing is to explain what assumptions have been made and why.

2.3.1 Scenarios for business evolution

A business scenario is a view of a possible future external environment based on a set of assumptions about important uncertainties which face the business, and which may affect organizational performance. When a company is planning for various financial scenarios, it will generate several probable future contexts for its business. In financial validation, this process is typically used to estimate changes in the value of a business through the re-evaluation of the most relevant concepts such as operating costs, product pricing, inflation, customer metrics or interest rates. In this deliverable, industrial partners describe three different scenarios: business-as-usual, best-case scenario and worst-case scenario.

2.3.1.1 Business-as-usual

This is a scenario for future patterns of activity which assumes that there will be no significant change in people's attitudes and priorities, or no major changes in technology, economics, or policies, so that normal circumstances can be expected to continue unchanged.

2.3.1.2 Best-case scenario

This is the ideal projected scenario and is almost always put into action by management to achieve their objectives. It will provide the best possible outcome. Although you are creating a best-case scenario, the data you use should still be realistic.

2.3.1.3 Worst-case scenario

This scenario considers the most serious or severe outcomes and prepares the company for potential problems. It can help you avoid issues or at least prepare for them by creating an action plan.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

2.3.2 Financial indicators

Considering the three scenarios described above and to develop an objective financial assessment, industrial partners calculated the following indicator: Net present value (NPV), Internal rate of return (IRR), Payback Period (PbP), Return on Investment (ROI) and Return on Assets (ROA); describing what they are considering in each scenario.

2.3.2.1 Net present value (NPV)

Net present value (NPV) is the difference between the present value of cash inflows and the present value of cash outflows over a period. NPV is used in capital budgeting and investment planning to analyse the profitability of a projected investment or project. The project is accepted if the NPV>0 at time n.

$$NPV = \sum_{t=1}^{n} \frac{V_t}{(1+k)^t} - I_0$$

Where
t= is the time of the cash flow
n= end of the exploitation period.
k= is the discount rate
V_t=is the net cash flow (cash inflow – cash outflow) at time t.
I_0=is the initial investment

2.3.2.2 Internal rate of return (IRR)

Internal rate of return (IRR) is the interest rate at which the net present value of all the cash flows from a project equal zero. IRR is used to evaluate the attractiveness of a project. The project is accepted if the IRR>MARR (minimum acceptable rate of return).

$$\sum_{t=1}^{n} \frac{V_t}{(1+IRR)^t} - I_0 = 0$$

where
t= is the time of the cash flow
n= end of the exploitation period.
V_t=is the net cash flow (cash inflow – cash outflow) at time t.
I_0=is the initial investment

2.3.2.3 Payback period (PbP)

Payback period (PbP) is the amount of time it takes to recover the cost of an investment, or in another words is the length of time an investment reaches a break-even point.

$$PbP = \frac{I_0}{V}$$

where
I_0=is the initial investment
V=is the net cash flow (cash inflow – cash outflow) per year, being this value a constant.

2.3.2.4 Return on Investment (ROI)

Return on Investment (ROI) is a performance measure used to evaluate the efficiency of an investment. ROI is calculated dividing the benefit (or return) of an investment by the cost of the investment. The result is expressed as a percentage.

$$ROI = \frac{NPV}{I_0}$$

where
NPV= is the net present value
I_0=is the initial investment

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

3. Open Urban Platform - TSY[2]

T-Systems, as one of the world's leading vendors of digitals services. To this end, the open urban platform (SUP) solution is of great value for the strategy of the company and provides many important impacts and benefits. The Exploitable Results identified in its solution contribute to extend its business in IoT solutions to support the digital transformation of companies and public services. In fact, the move towards connected cities is an evolutionary process, in which heterogeneous building blocks need to be integrated in a larger ecosystem of connected things and people. The step-by-step transformation of public infrastructures and services addresses the modern city challenges from energy supplies and traffic to economic and ecological sustainability.
From a commercial point of view, the solution is based on fundamental pillars of new approaches to the concept of urban platforms that the market demand, such as being more flexible and having open platforms for addressing new future applications, "standardized interfaces", open data policies and platform approaches. The urban platform approach has a renewed focus on cross-vertical and multi-point solutions, based on "standardized interfaces", open data policies and platform approaches.

3.1 Part 1: Business model description[3]

As part of the mySMARTLife project, the Telekom Innovation Laboratories (T-Labs) developed a connector between its oneM2M based data platform and Hamburg's OGC based Urban Data Platform. The Urban Data Platform is a non-commercial platform provided by the city that integrates and links city data and makes it accessible to users to analyse it.
T-Labs' data platform is called Smart Urban Platform (SUP). It provides a commercial platform that is designed for a similar purpose and can be understood as a harmonization layer within an IoT continuum. It is an offer for cities that do not have the technical expertise to develop their own system. The connector between the two platforms acts like a "translator" for the two standards oneM2M and OGC. Thus, it enables other potential customers (cities) who already have an OGC-based system in place to benefit from the services that the T-Labs SUP offers. The main purpose of the SUP is to bridge existing systems and sensors with others and new ones.

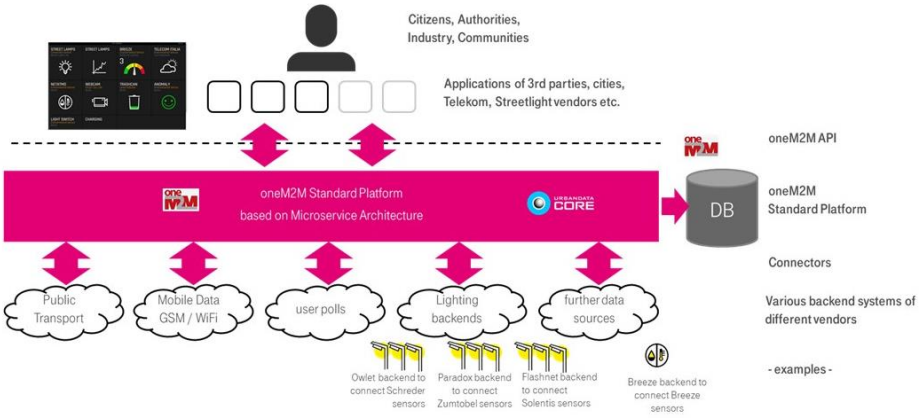

Figure 5: T-Labs Smart Urban Platform

[2] ESADE wanted to include a risk analysis and implementation plan in part 4, as it was presented in the action plan send last December, however, these two analyses were finally included in D8.6, so it does not make sense to repeat it in this deliverable.

[3] The tools to be used in part 1 (value creation ecosystem, internal value chain and business model canvas) were presented las December.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

The following passages represents only the commercial platform from T-Labs since the Hamburg Urban Data Platform is described non-commercial platform. The economical start of the T-Systems Smart Urban Platform is still not planned yet. So, the following section is based on first assumptions and estimations.

3.1.1 Value Creation Ecosystem

Extensive use of digital technologies in everyday life has become the new normal. The SUP platform allows multiple participants (owner of sensor data and processor/user of data) to connect to it, interact with each other, and create and exchange value.

Three typical types of value are provided:

- The SUP act as gateways, reducing friction as customers switch across related services. For example, different lightning systems (e.g., Paradox, Flashlight…), enable the technical department in cities responsible for the streetlights to switch and control the lights - all through a single interface. They do not need to switch between portals, manage separate logins, or spend mental energy maintaining multiple services.
- The SUP provides its customers with a monthly report card that illustrates their energy production.
- The SUP makes available data for a bunch of services. Therefore, the SUP collects data from different sensors or backend systems and makes them available by delivering them in a standardized way.

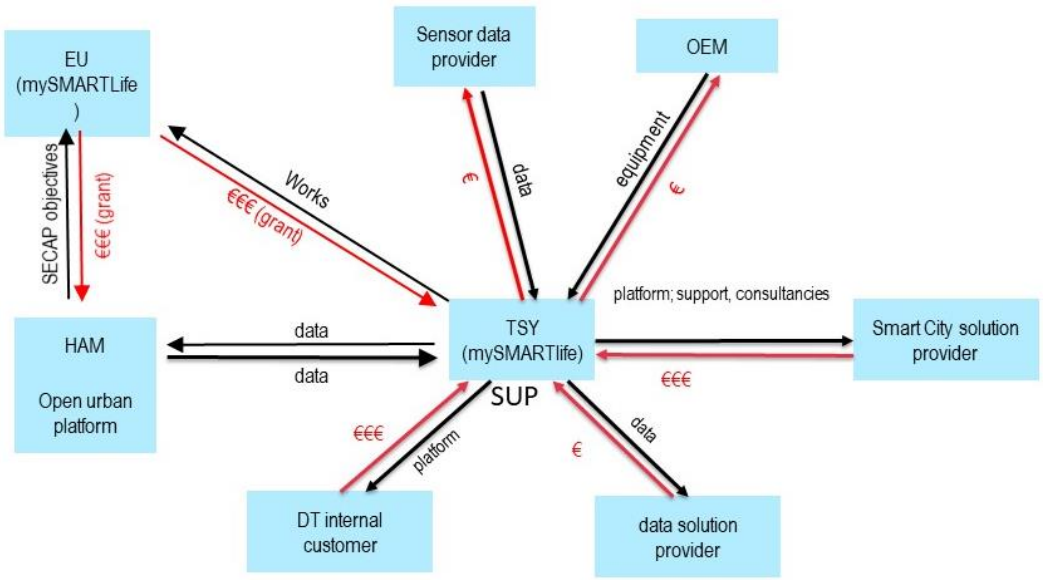

Figure 6: Value Creation Ecosystem of the Smart Urban Platform (SUP)

Building up the ecosystem of the T-Labs Smart Urban Platform will base on these aspects. The different players in the ecosystem are show in Figure 7.

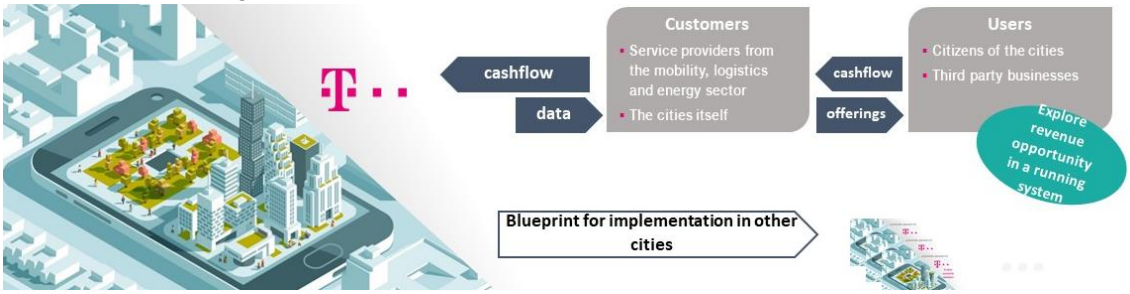

Figure 7: General view

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

3.1.2 Internal Value Chain

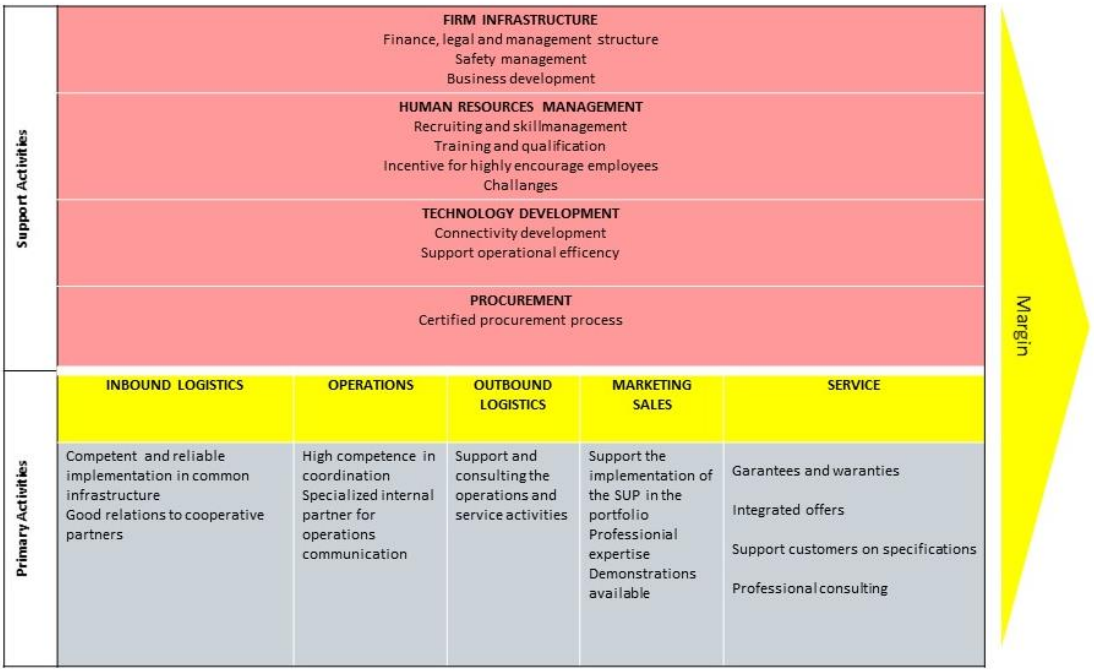

Figure 8: Internal Value Chain of the SUP

In this chapter, a look at the internal structure of TSY will be presented:
T-Systems supports more than 1,000 clients, including all DAX 30 companies in Germany and 100 of the Fortune 500 companies globally. The clients come from all regions and sectors, e.g., the automotive industry, retail trade, logistics and transport sector, and smart cities.
As a subsidiary of Deutsche Telekom, T-Systems provides all important building blocks for innovative information technology and digitalization. This includes development, implementation, integration, and sale of private and public IT infrastructures and applications, including strategic digitalization and the transformation solutions that accompany this. TSY also provides consultancy services, drawing from its deep knowledge of the industry and with the help of over 4,000 SAP experts around the world.
The Management Board includes the following positions, CEO, Finance & Controlling Director, Chief Commercial Officer and Human Resources Director.
Innovation management: Within industry, digitalization is increasingly turning established business models on their head. The focus of TSY, within Innovation Management is on the three major building blocks of digitalization – connectivity, cloud and infrastructure, and security. Innovations result from open exchange with fresh perspectives and the best experts from across organizational boundaries. In Innovation Management, TSY picks up on and develop impulses within various global communities that are actively involved with the latest technological developments. This includes Research & Development, venture capital investments and Partnerships and cooperation with start-ups.
TSY operates data networks and processes data on behalf of its customers worldwide in its own data centres, giving absolute top priority to data protection and data security. The ICT provider therefore has its services audited regularly by independent institutes.
TSY has been working for globally leading companies for more than 25 years. TSY provide their customers with all the necessary building blocks for innovative information technology and digitalization, giving them holistic advice and support while doing so: through development, implementation, integration, and the operation of private and public IT infrastructures and applications – including strategic digitalization and the transformation solutions that accompany this. TSY puts its considerable resources and potential to work here: extensive IT and telecommunications competencies and sound industry know-how combined with many years of experience, strength of innovation, and a global network of experts.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

3.1.3 Business Model Canvas

At the beginning of the development of new business models, basic research and analysis of existing alternatives are required. This involves both a detailed assessment of the identified business models and an exchange with experts who have already successfully established platform solutions on the market. On this basis the most valuable business model for the SUP were identified. As one central method to describe and develop the business model the Business Modell Canvas from Osterwalder was used. The following passages show one possible business model.

3.1.3.1 Key offering

The key offering of the SUP is customizable and easy to implement. It comprises only a small solution that focuses on one particular core function within the IoT stack: mediation. That leads to a comparable low amount of required initial investment because the user is not forced to buy a whole set of functionalities at once, which are not needed. The core function includes an IoT harmonization layer that enables the system to control actuators and read sensor data without the knowledge of the different backend technologies. A basic graphical user interface (GUI) visualizes the devices in connection with their real-time data and complements the core element of the solution to facilitate a direct start of operation.
The connector between the OGC and the oneM2M standard gives potential customers with OGC standard- based solutions the chance to easily integrate the SUP in their existing system.

To sum it up, the SUP offers:

- A harmonization layer within a city's IoT stack, which facilitates the combination of data independently of the involved data providers' backends and therefore enables create data driven offerings
- A slim solution with comparable low initial investment costs (upfront costs)
- A non-proprietary system, based on the open standard oneM2M that avoids the disadvantages of a vendor lock-in

Figure 9: T-Labs Solution has strong competitive advantage compared to other market players

3.1.3.2 Customer Segments

The main customer segments are data provider, data enhancer and data consumer. The first segment comprises cities and public entities, service providers (for, e.g., street lighting and waste management), and photovoltaics owner, who can be private owners and businesses.
All the mentioned produce data that can add value to the city and citizens when they are combined and enhanced. The waste management for example could benefit from data concerning the filling level of the city's waste bins to optimize their pick-up routes of their fleet.
Data providers can also be in the position of data consumers as well as third parties that use the data to create new applications. The data enhancer segment comprises in general service providers, that modify data including but not

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

limited to cleaning it up, removing anomalies, combine it with other data or apply analytics. Those services add value to the data and make it more valuable for data consumers like cities and citizens.

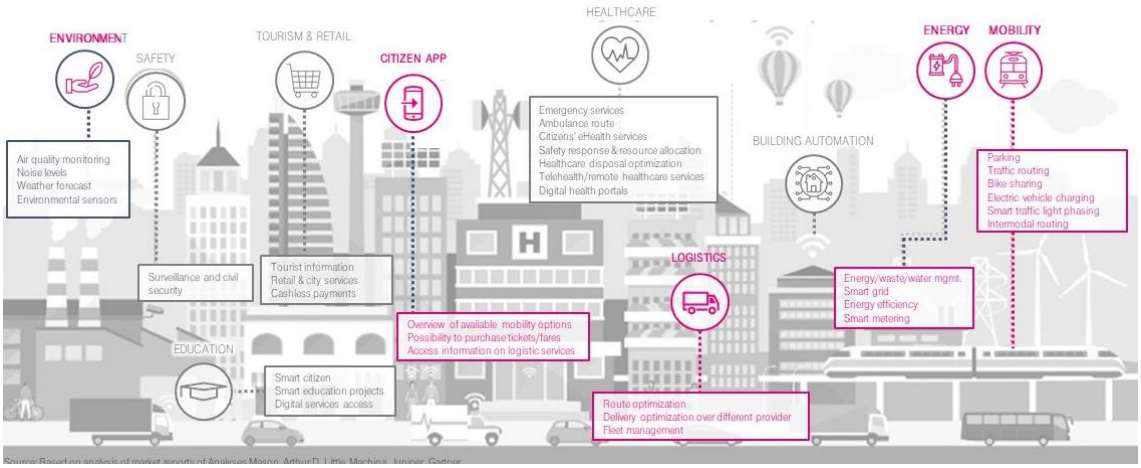

Figure 10: potential services & opportunity

3.1.3.3 Value Proposition

Customers are looking for an easy to integrate system that offers fast and easy data access. The SUP offering bases on that assumption.
The value proposition for the Smart Urban Platform comprises the following characteristics:
1) higher levels of efficiency,
2) future proof and
3) image improvement.
Higher levels of efficiency are achieved through the enablement of easy data exchange between actuators, such as sensors and streetlights, and therefore an automated interaction between IoT devices. The SUP is a system of systems that paves the way for an infinite amount of use cases built to e.g., save energy, save water, and optimize routes for waste collection to reduce time and money expenses. Besides that, it also creates the basis for making city data more transparent and more broadly available.
Due to the use of the open standard oneM2M, users do not have to deal with the disadvantages of a vendor lock-in. That means that any provider who is familiar with oneM2M can carry out additions to the original system when a city's needs change or require a higher variety of applications in the future. Therefore, the system provides enough flexibility to support a city's obligation of selecting suppliers by tendering and to choose the most cost-efficient option available.
In addition, the system gives cities the chance to improve their image by enabling third parties to develop new applications and services. That fosters an environment for innovations that help to improve a city's level of sustainability, quality of life and thus make it overall more attractive.

3.1.3.4 Key Resources

The key resources split up into the IT components and human resources. The IT components contain the system itself, the IT Infrastructure e.g., the cloud infrastructure, and (data) security components. The human resources include on the one-side personnel for business related tasks like administration, support and service and sales. On the other side there is the IT personnel, which are the DevOps and developer for the further development of the SUP. They need knowledge about one M2M, OGC, microservices and agile development.
Since the SUP is based on Microsoft Azure in the current status, this is one resource needed for the cloud infrastructure. However, the provider for the cloud infrastructure is replaceable according to the customers' needs.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

3.1.3.5 Key Partners

Key partners with respect to promoting the SUP in the market are the members of the mySMARTLife consortia including the city of Hamburg. Especially the city of Hamburg serves as a reference for the feasibility of the SUP. Further key partners are associations of municipalities and cities and original equipment manufacturers (OEMs) for e.g., streetlights to push for the installation of the SUP within the cities. Furthermore, Deutsche Telekom partners from the IoT and Smart City field can be used as sales partners to contact customers and promote the SUP.

3.1.3.6 Customer Relationships

The customer relationships expand over various channels. The approach must take the size of a city, municipality, or company into account to choose the right mix of touchpoints. Since the public sector in Germany is very special, personal contacts and tender processes are the major touchpoints to acquire new customers. Hereby city units and bodies like IT departments, city marketing, the mayor and citizens' dialogues are of special interest. Additional information can be provided via websites to provide potential customers with general information, as well as they can be used as a contact, and trigger for further interest. Further channels are exhibitions in and partners from the IoT and Smart City field. Nevertheless, personal contact and support is needed most, especially since smaller cities do not have a separate IT department. That means consulting and support is needed in advance and during the running project. Thus, personal contacts are most important.

3.1.3.7 Distribution Channels

The distribution channels for the SUP are various channels of Deutsche Telekom, partners of Deutsche Telekom as well as the city of Hamburg by serving as a role model for other cities and a customer testimonial.

3.1.3.8 Cost Structure

The cost structure is partly in line with the key resources of the SUP. On the one side there are the cost of personnel for administration, marketing & sales, support & service, developer, and DevOps. On the other side there are the costs that include anything else but the personnel. Those are costs for the maintenance components, marketing and sales material, travel cost and further administrative overhead. In addition to that, the cost for the IT infrastructure, especially the cloud infrastructure, accounts for a critical share of the cost for the SUP.

3.1.3.9 Revenue Streams

There are three main streams of revenue.
1) The revenue from providing the product,
2) the revenue from customized additions to the product and
3) the revenue for consulting, e.g., for special use cases.

The first stream includes one-time installation payments for setting up the system and payments from licenses and subscriptions. Providing both mentioned payment options provides the opportunity to offer customers a model that is better aligned with their budget plan. The price is staggered according to the size of the city or organization and to choose extent of usage referring to the number of functionalities, storage, and data usage. In addition to this, there is an optional payment for a higher degree of customization on a pay per use basis for additions to the system that are developed individually.
The second revenue stream includes payments for service & support that are freely selectable and staggered according to performance level. A basic service is included in the purchase price of the product. The service hours can be extended to a 24/7 availability for an additional fee.
The third revenue stream includes consulting offers for support cities and organizations with obtaining public funding for installing the SUP as part of a smart city project.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Key Partners
- Consortia of mySMARTLife
- One reference city (Hamburg)
- Associations of municipalities & cities
- Telekom partners from the IoT & smart city field
- OEMs (e.g., street lighting)

Key offering
- Small and easy to implement (No data analysis)
- Control of actuators & reading of sensors by UDC solution without knowledge of various backend technologies
- Visualization for PoCs, Demo UI
- Extendable by additional features

Key resources
- System
- IT infrastructure
- (Data) security
- Personnel
  - Administration
  - DevOps
  - Developer
  - Support & Service
  - Sales

Value Proposition
- Efficiency:
  - Cost savings
  - Time savings
  - Transparency
- Future proof:
  - Avoidance of vendor lock-in by using open standards
  - Transparency
- Better image:
  - Possibility of developing new services by connecting different IoT devices & sensors (e.g., for street lighting, air sensors, waste monitoring, photovoltaic monitoring)
  - Supporting the development of a sustainable city via e.g., enablement of energy savings

Increasing the attractiveness of the city

Customer Relationships

Approach tailored to the size of the cities, municipalities & companies
- Addressing existing customers via personal conversation
- Tender processes
- Partners
- Exhibitions (Smart City, IoT)
- Website

City departments
- IT
- City marketing
- Mayor
- Citizens' dialogue

Distribution Channels
- Distribution Channels Telekom
- Distribution Channels of partners
- Hamburg

Customer Segments
- Data provider
  - Cities and Public entities
  - Service Providers, e.g., street lighting
  - Owners of PV (private owners & organisations)
- Data enhancer
- Data consumer
  - Cities and public
  - Service providers

Costs Structure
- Maintenance costs, incl. infrastructure (MS Azure)
- Further development
- Marketing & sales
- Support & service

Revenue Streams
- One-time installation payment
- Payments for a license or subscription depending on e.g., type of organization (consider customer preference) → e.g., license e.g., two years; subscription billed monthly
- Prices staggered according to e.g., size of the city, extent of use (e.g., number of microservices, connectors, storage, data usage)
- Pay per use: optional -> integration of new APIs (effort driven), degree of customization
- Service and support staggered according to performance level (24/7, weekdays only etc.),
- Offer consulting for funding

Figure 11: TSY Platform Business Model Canvas

3.2 Part 2: Pilot analysis (BM validation)

As wrote in part 1, the Smart Urban Platform contains two parts, the oneM2M based data platform and Hamburg's OGC based Urban Data Platform. Here only the deliberations to the data platform were described because the Hamburg Urban Data Platform is not planned to commercialize. Like the usage in this project the oneM2M based data platform is planned to be used as a piece in a bigger platform and will not be a single product.

What indicators did you define to assess the performance of your services/product? What kind of data did you take from them? What did you learn from these data? Are your forecasts met?

The data platform can connect sensors and sensor backends and delivers sensor data to other services. One-M2M provides a protocol and format that is also sufficient for more complex data exchange. Due to the fact, that the SUP is based on a state-of-the-art microservice architecture, it is scalable in terms of load and traffic. Typical data to assess the status of the platform is used CPU load and memory usage. Currently no bottlenecks in our architecture within the given project setup were found.

What improvements did you introduce in your product/service during its development/ construction?

OGC enabled a second standard besides, oneM2M. Urban data and the insights derived from it can be visualized for the customer in a dashboard. There will be no such guidelines like "the standard" for Smart City. Rather more there will be different standards and technologies. A connector between OGC/STA and oneM2M were developed to give Cities more flexibility in their technology choice. By enabling an interworking between these standards, the risk of choosing the "wrong" technology decreased.

What are the major technical, design, adoption or manufacturing hurdles to be solved?

The main hurdle is the variety of different sensor data and their protocols. The purpose of the SUP is to acquire, store & process data from diverse sources and make it selectively available for utilization.

The solution is well-defined and easily understood by the target customer?

The oneM2M data platform is based on a microservice structure and can be combined with other IoT or data aggregation platforms. Some marketing effort is necessary to explain the structure and possibilities of the SUP towards target customers in an easy way. The flexibility and future-proof by integrating the standard-based SUP is the key to explain to customers and cities.

What are the most complex barriers/difficulties/challenges that customers are facing when using your product or service?

The SUP is a pre-product. There is no direct interaction between the customer and the SUP. As a part of a whole technology stack the integrator needs a very deep insights into technology to understand the benefits of the SUP.

Is your solution within the budget of the target market?

During the project phase the first indicators for a given budget and the willingness to pay for a SUP as pre-product was given. This first rough analysis showed the market related budget for the SUP, which is possible to target. Nevertheless, since the SUP is just a pre-product and the budget will be approached for the whole solution, an additional market survey has to consider the whole solution when applicable

What are the most complex barriers/difficulties/challenges that the market presents to you?

There is still no common standard for smart cities. The amount of different standardized or proprietary platform solutions for cities is very high. Customers/ cities as well as vendors have to decide on which standards and protocols

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

they bet. For this development oneM2M in connection with OGC was chosen, but at this moment, it is still unclear if oneM2M will be the most used standard for city platforms. So, the biggest hurdle would be another main standard or even proprietary solution.

Do you have clear ways to reach your target market? Did you have any problem with the channel through with you deliver your value proposition?

It is planned a common offering with our T-Systems Smart City business unit. This is a well-established and common way to offer such a service, which should not cause any additional problems.

What are the main takeaways you get from pilot intervention?

The pilot operation was a very good way to proof our assumption from the beginning of the project. A first insights and feedback about the system was collected, which helped us to developed it further, e.g., robustness within the system itself.

3.3 Part 3: Financial Viability

The separate market launch of the SUP is not planned yet. Therefore, a focus on qualitative rather than quantitative assumptions was set.

3.3.1 Potential benefits

During the development of the connection of Hamburg's Urban Data Platform and the oneM2M based data platform a lot about existing technical infrastructure in cities and requirements related to special use cases was learnt. This leads to further development of the microservice based platform for collecting sensor data and gain knowledge about requirements on such a platform, e.g., performance and resilience. Apart from the technical view, also the needs and plans of cities depending on their size were understood. This is important for further development of T-Systems Smart City roadmap.

Another point is the benefit for the cities. They become a more attractive location for businesses seeking a digitally developed environment. Also, the active involvement of citizens in the development of their city is important for the acceptance of digitization and new services. This leads to an increase of the quality of life and the satisfaction of residents.

A third point is the benefits for service providers. They can explore innovative ways to offer services based on the newly provided technologies to an open-minded community of citizen. The implementation of innovative offerings in a fast and easy way and leads to portfolio extension of service offerings. This is also a benefit for Deutsche Telekom. The new business opportunity to establish a running system in the cities' Iot Stack will be possible. As a result, also an increase of business opportunities, e.g., scale solutions to other comparable cities and transfer it to other application fields by offering different use cases. Thanks to this project a future additional revenue streams for Deutsche Telekom has been identified.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

4. Smart lighting - Engie [4]

Engie's smart lighting solutions have already been tested and introduced into the market. Their know-how and expertise led them to continuously improve solutions according to the market demand. These smart lighting solutions create substantial impact in reducing energy consumption and emission of greenhouse gases (GHG). In fact, the required reduction of greenhouse gas (GHG) emissions made the energy consumption efficiency one of the top priorities for most of the countries and their cities. To this end, the very flexible and adaptable smart lighting solutions of Flashnet (which have been successfully developed, tested and commercialised) allied to the size and well-established market of Engie and offers promising perspectives of market expansion at European and Worldwide scale.

4.1 Part 1: Business model description[5]

4.1.1 Value Creation Ecosystem

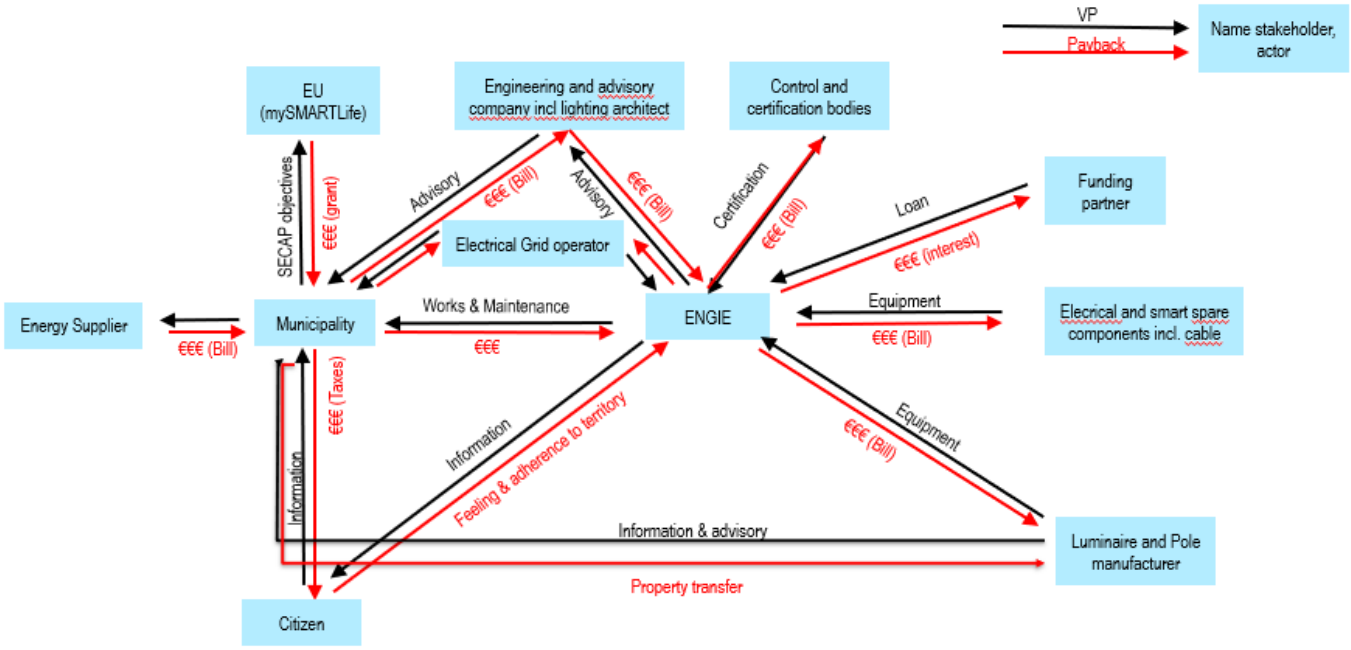

Figure 12: Value Creation Ecosystem of the Smart Lighting from ENG

The value creation ecosystem of the smart lighting is composed by several types of actors.

- **Municipalities** owns the public lighting infrastructure.
- **ENGIE** builds, operates, maintains the equipment.
- For new project, or renovation, cities can be advised by lighting architect or give the design phase to ENGIE (using internal expertise or the support of a **lighting architect) to** propose the most accurate lighting, adapted to each type of street and seeking to limit light pollution.
- ENGIE relies on **suppliers of lighting products** such as pole, luminaires, electrical equipment, remote control equipment, etc. ENGIE also supplies electrical equipment as cable.

[4] ESADE wanted to include a risk analysis and implementation plan in part 4, as it was presented in the action plan send last December, however, these two analyses were finally included in D8.6, so it does not make sense to repeat it in this deliverable.

[5] The tools to be used in part 1 (value creation ecosystem, internal value chain and business model canvas) were presented las December.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

- Lighting service runs with electricity. It is usually connected to the electricity grid dedicated to public lighting or using the common electric grid. Municipalities buy electricity for lighting services from **energy supplier**. On the other hand, grid extension, as Municipalities generally own the grid, is performed under the supervision of an **electrical grid operator** for new electrical installation (as electric cabinet) or renovation.

This service is targeting **citizens** and users of public space. The citizens participate in this service via taxes.

Public authorities as the European Commission (with mySMARTLife project for example) helps municipalities and its partner ENGIE to propose new solutions for public lighting. The European Commission participates in funding to accelerate and show the technical, financial, and environmental interests of renovation of public lighting infrastructure, and the interests of the development of remote system for new services.

4.1.2 Internal Value Chain

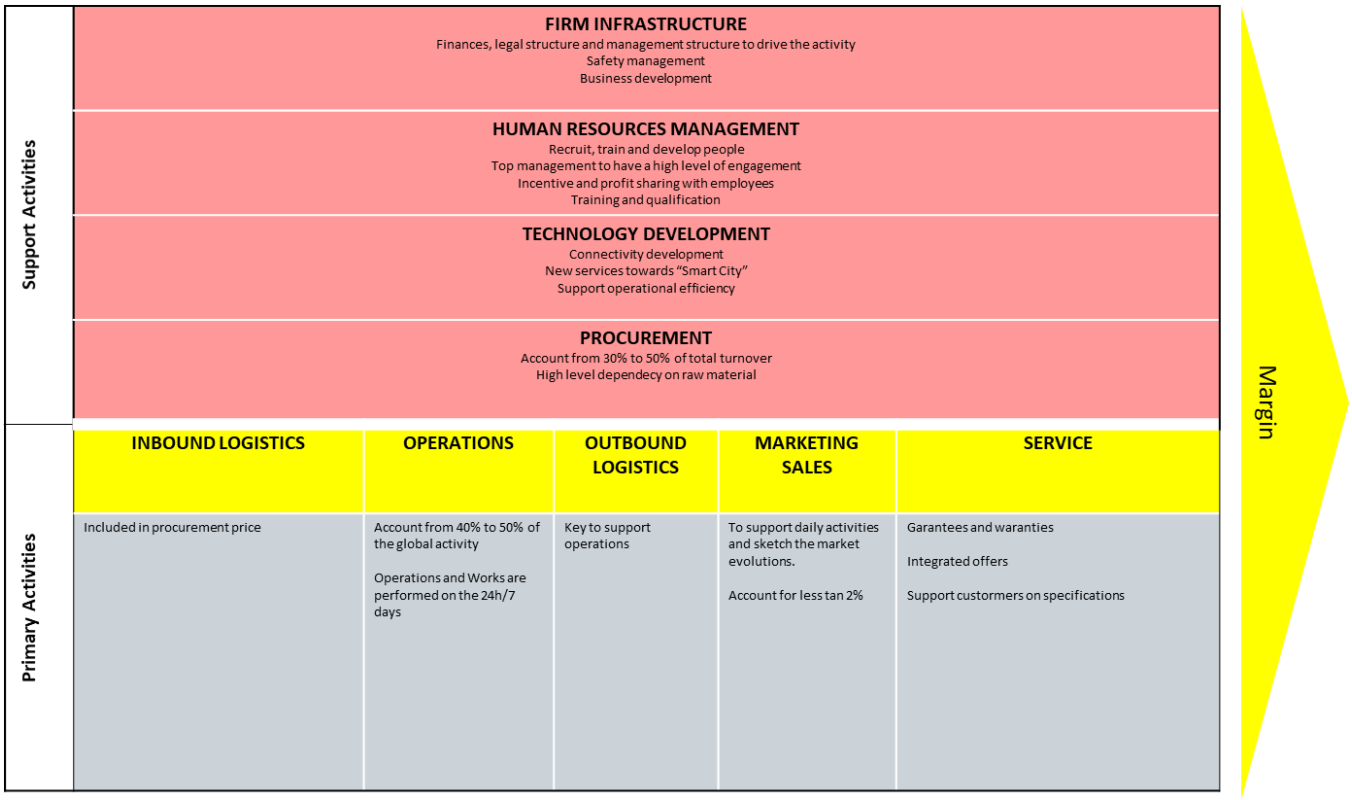

Figure 13: Internal Value Chain of the Smart Lighting from ENG

The role of key internal players is explained below:

SUPPORT ACTIVITIES:

The support activities work with 4 mains departments.

- The **Firm Infrastructure**. The general management oversees financial and legal aspects of business, they manage the corporate. Besides, the team develops the business, find new clients, and proposes new solutions. The firm is accountable for safety management: to limit the work accident, and allow all employees, subcontractors, partners… to work in a safe environment, and propose solutions to improve working conditions.
- The **human resources department** is concerned with recruitment and the training of people to acquire human resources of high quality. Indeed, working on lighting grid requires certification and qualification. Besides, with development of new services, new products and new solutions, the team of the human resources proposes training course to keep employees up to date with new technologies.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

- The **technology department**: smart lighting is a new market based on new LED technologies, connectivity for drivers, with new smart city features. This department owns expertise on technical solutions and supports local teams to propose and develop smart lighting solutions adapted to their client's need.
- The **procurement department**: the purchase of materials plays an important financial part in smart lighting activities: it accounts from 40 to 60% of the turnover. It is important to provide a balance between a good price level and robustness where the suppliers could become partners to develops the activity.

PRIMARY ACTIVITIES:

The primary activities are based on 5 principals:

- **Inbound logistic**: before installation or maintenance, the lighting concept is designed, products are selected, and bought properly. Equipment must be delivered to the right place at the right time.
- **Operating**: The main activity of smart lighting market is made by operators. It accounts from 40% to 50% of the global activity. They install, maintain, and operate smart lighting infrastructure.
- **Outbound logistics**: Operators are backed by support services to help them to provide an efficient service.
- **Marketing sales**: they develop activity daily and respond to customer needs including RFPs. They follow market trends.
- **Services:** they oversee warranties and guarantees, support customers on specifications.

4.1.3 Business Model Canvas

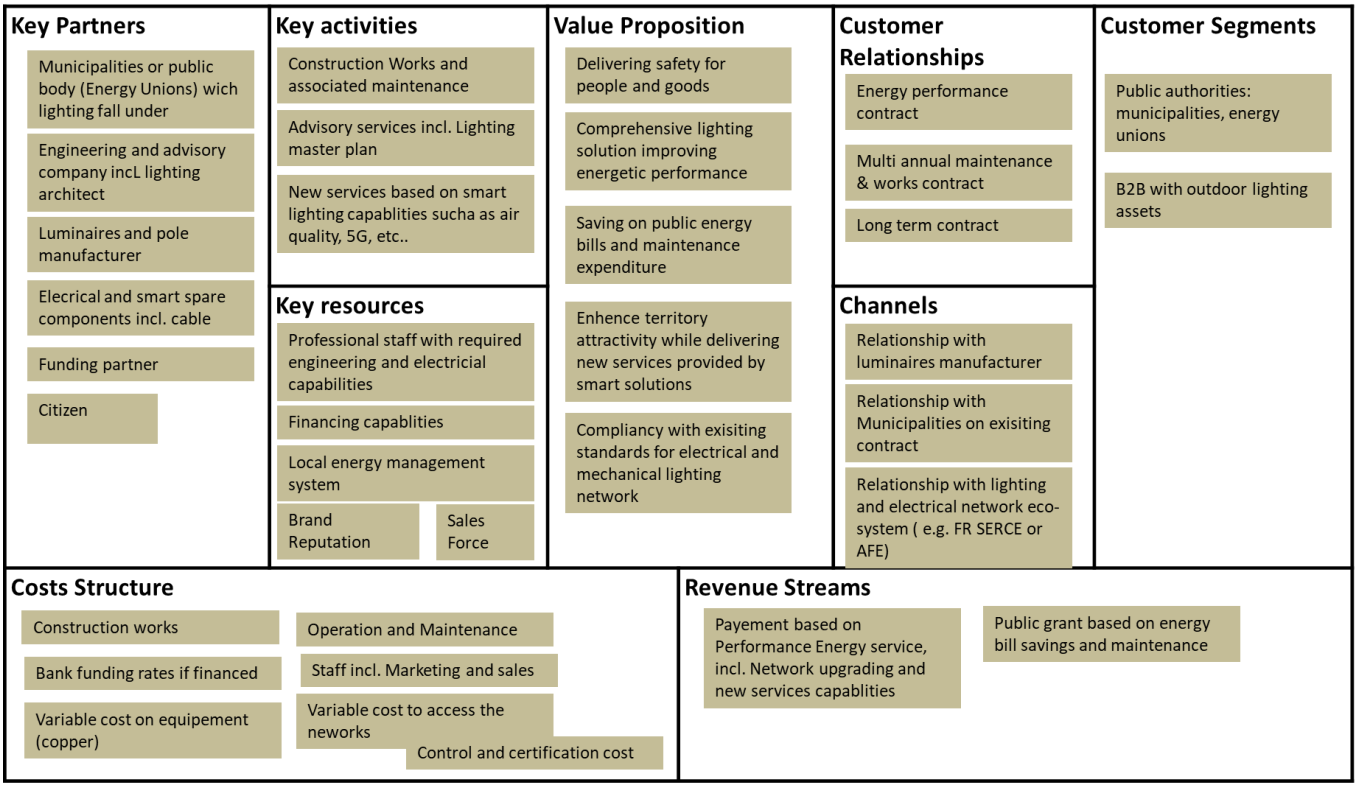

Figure 14: ENG Smart Lighting Business Model Canvas

- **Key partners:** this section highlights who are the various stakeholders of a lighting project, from the owner to the beneficiaries
- **Key activities:** this section presents the simplified value chain for smart lighting.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

- **Key resources:** all the duty resources to perform such kind of project which is incorporated under clear policies and regulations to make those project occur.
- **Value proposition:** this section intent to capture the key benefits of smart lighting from the basics, safety of people and good in the public space to the most advanced one where the lighting network will act as the nervous system of the smart city with new features to make our cities more liveable.
- **Customer relationship:** encompasses the various contractual mode of relationship with the client.
- **Channel:** this section summarizes the key channel that will support the relation with the parties around such project.
- **Customer segment:** presents the two (2) main kind of customer whom smart lighting is source of interest.
- **Cost structure:** presents the cost structure of the project with the key expense component.
- **Revenue streams:** this section highlight that the smart lighting will generate two (2) streams of revenues; the principal from the basics of public lighting and the secondary from all the new ancillary services.

4.2 Part 2: Pilot analysis (BM validation)

Business models developed with the BMC, or with other methodologies, usually answer questions such as "What", "Who", "When", "How" or "How Much" (Mitchell *et al.*, 2004), but they always do it based on a series of hypotheses, so an important part of the study should consist in experimenting to validate if the hypotheses are correct.
Lean start-up (figure 1), which is based on three different works: Blank (2005), Rise (2011) and Blank and Dorf (2012), is a methodology that was developed precisely to help organizations to perform this task. Its objective is to develop a product or services through an iterative process and continuous learning based on empirical data obtained from pilot interventions.

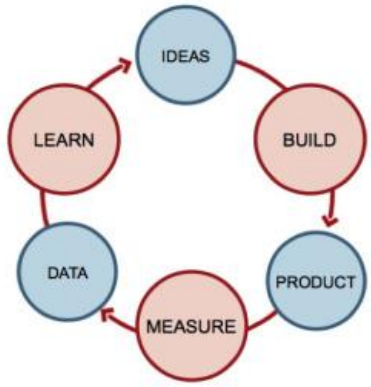

Figure 15: Build-Measure-Learn feedback loop (Rise, 2011)

The business model validation process starts with developing (build) the pilot intervention. The second activity to be carried out is to develop a set of indicators to assess the reliability of the hypotheses. Once the indicators are stablished the next stage is for the organization to analyse the data and extract conclusions that allow it to increase the knowledge of the product or services that they offer (learn). Based on what they learn through to the Build-Measure-Learn loop, companies can introduce changes into their business model and, as a direct consequence, the result, the new business model is improved. Companies usually must go through this validation process several times until they reach an appropriate business model.

What indicators did you define to assess the performance of your services/product? What kind of data did you take from them? What did you learn from these data? Are your forecasts met?

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

LED technology has been implemented to replace the traditional bulbs aiming to reduce energy consumption up to 60%. Together with this transformation, the Smart lighting solutions thanks to the manageable electronic drivers included in the LED upgrade will contribute to an even bigger energy saving. Indeed, the current driven out of the driver to the LED will be remotely managed to fit the exact needs of the city timeframe (during the night and according to the moment of the year).

Principal indicators:

- Energy consumption (kWh per Lighting Point)
- Maintenance savings level (% or EUR Saved)
- Availability of the system (% Equipment Up and Running)

Secondary indicator:

- Dimming level (%)
- Ancillary services connected (#, revenue EUR)
- Failure impact over operation of the parc (Fail safe capability)
- Saving on construction cost for dedicated energy network by using smart lighting to measure and bill energy consumption (EUR Saved)

What improvements did you introduce in your product/service during its development/ construction?

Dynamic lighting system that enables a real ON/OFF capability through:

- Photocell
- Astronomical Clock
- Connected relays (Often through CPL)
- Connected relays (Radio Proprietary protocol unlicensed frequency)
- Connected controller controlling LED drivers through DALI or 1-10 protocol (Radio unlicensed frequency)
- Connected controller IoT technology on Operated radio network (LTE or NBIoT)
- Open standardized protocols (TALQ, Ucify, etc…) for transparent integration within an IoT-platform

Remote management

Ancillary services capabilities

What are the major technical, design, adoption or manufacturing hurdles to be solved?

- Technical standardization of the different hard and soft layers (connectivity protocol & supervision soft) of the architecture to allow interoperability in between the vendors.
- Design impact with NEMA or ZHAGA module integration or post luminaire installation, especially on old luminaires not remote management readymade.
- Price adoption level.
- Getting the equipment approved for energy metering and billing purposes.
- Manufacturing of an outdoor equipment robust enough to stand rough exterior conditions including electricity grid bad quality (surge of tension)

The solution is well-defined and easily understood by the target customer?

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

- A large part of the customers has understood the advantages of the solution.
- They are not so much confident on the equipment reliability at a large scale.
- They also do not understand what the real advantages and disadvantages are in choosing one technology more than another (licensed frequency vs unlicensed / Open protocol vs proprietary / Mesh vs Local area coverage)

What are the most complex barriers/difficulties/challenges that customers are facing when using your product or service?

- Scale up pilot project
- Technical background of the maintenance and construction team not IT oriented
- Contract management lies to manufacturer accountability

Is your solution within the budget of the target market?

In terms of budget, the adaption of the solution to the local requirement is necessary. Smart Lighting suppliers are divided in two main groups:

- the local start-up that will sell a cheaper solution and benefit from their proximity to maintain the system up and running through a lot of interventions.
- International suppliers that have installed their system in larger and more numerous sites. Those ones have developed more robust solutions using better components. This will result in a higher price at first but less maintenance work after.

The chosen solution needs to balance the two options as supporting local industry is important within public market.

What are the most complex barriers/difficulties/challenges that the market presents to you?

- low price of energy
- low price of manpower to manually detect defects through patrols
- Qualification of bankable business models for ancillary revenues

Do you have clear ways to reach your target market? Did you have any problem with the channel through with you deliver your value proposition?

- Marketing: Doing better with less resources is one of the main pillars of the Smart City. If the Smart City does benefit today from a good exposure due to the largely spread good political reputation of it, the budget to finance it are difficult to gather within bankable models. As Public Lighting is a mature market with organized financial structures, Smart Lighting is one of the most relevant way to enter smart city. Thus, it is largely presented during all Smart City presentations and events.
- Offers: Public Tenders are very transparent for common construction and maintenance project or Bankable PPP organized around Public Lighting transformation from classical discharge bulb technology to intelligent LED luminaire.

Did you have any problem with your key partners? How did you deal with it?

Suppliers usually discuss directly with the final customer in order to promote their product. This limits the flexibility for the integrator in choosing the solution that fits better the context. Such flexibility may be useful as many projects require a certain level of heterogeneous architecture.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

How to deal with it:

- Upstream by promoting open architecture within our suppliers
- Downstream by positioning us as an agnostic integrator and identifying very early what is the preferred vendor and positioning its product at the best suitable location within the proposed solution
- Promoting also contract oriented to acquire quality lighting as a service more than products and installation services

What are the main takeaways you get from pilot intervention?

How the solution suits the specificities of the city context meaning the:

- Environment specificities: radio coverage, quality of the electricity, temperature, architectural requirements, dimming capabilities to meet cities' usage and habits, etc …
- Operational specificities: each city has its own way to deal with public lighting and this is very much related to the team that maintain and operate it. The solution needs to be a tool to enhance these particular practices.
- Business specificities: ancillary revenues either direct through service selling or indirect through saving are to be explored in the field

4.3 Part 3: Financial Viability

In this stage of the project, managers need an objective financial assessment, identifying what resources (costs) and benefits are required for implementations. This is a highly technical exercise, and according to Mersey Care (2011), it should ensure that all financial consequences of a proposal have been identified and accurately reflected, allowing the comparison between various options and various scenarios. It is not only a question of predicting the volume of sales, or the price of the products, but it is also a question of trying to predict workers' wages or the price of raw materials... However, the most important thing is to explain what assumptions have been made and why.

4.3.1 Scenarios for business evolution

A business scenario is a view of a possible future external environment based on a set of assumptions about important uncertainties which face the business, and which may affect organizational performance. When a company is planning for various financial scenarios, it will generate several probable future contexts for its business. In financial validation, this process is typically used to estimate changes in the value of a business through the re-evaluation of the most relevant concepts such as operating costs, product pricing, inflation, customer metrics or interest rates.

4.3.1.1 Business as usual

This is a scenario for future patterns of activity which assumes that there will be no significant change in people's attitudes and priorities, or no major changes in technology, economics, or policies, so that normal circumstances can be expected to continue unchanged.
Each scenario is encompassed under three (3) dimensions: technology (T), economy (E) and policies (P)
(E) Low energy price; China manufacturing system is dominant; no lack of raw resource dedicated to electronics.

(P) Low to mid-level Carbon tax.

(T) savings range up to 60% for efficiency and 30% for maintenance.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

4.3.1.2 Best case scenario

This is the ideal projected scenario and is almost always put into action by management to achieve their objectives. It will provide the best possible outcome. Although you are creating a best-case scenario, the data you use should still be realistic.

(E) high energy price +20% to 30 %; China manufacturing system is missing growth making raw material price down; scale effect from massive implementation from 5 to 10 % on node price

(P) high-level of Carbon tax (EU scenario's reaching 200 EUR / t_{CO2})

(T) electronic driver is mandatory and connectivity later; obsolescence of traditional bulbs and ferromagnetic ballast (e.g., Fluorescent Balloon lamp)

4.3.1.3 Worst case scenario

This scenario considers the most serious or severe outcomes and prepares the company for potential problems. It can help you avoid issues or at least prepare for them by creating an action plan.

(E) high energy price drop -> ROI 2 or 3 times later than material age average; lack of availability of raw resource dedicated to electronics -> high level of pressure on China -> raw price is rising by 20 to 30% (e.g., COVID impact)

(P) LED before smart node (higher ROI than with smart node)

(T) Lack of uniformization of connectivity protocol and lack of standards.

4.3.2 Financial indicators

Considering the three scenarios describe above and in order to do develop an objective financial assessment, *industrial partners should calculate the following indicator: Net present value (NPV), Internal rate of return (IRR), Payback period, Return on Investment (ROI) and Return on Assets (ROA); describing what they are considering in each scenario.* The interpretation of the results of these indicators will depend on the interests of each organization.

4.3.2.1 Net present value (NPV)

Net present value (NPV) is the difference between the present value of cash inflows and the present value of cash outflows over a period. NPV is used in capital budgeting and investment planning to analyse the profitability of a projected investment or project. The project is accepted if the NPV>0 at time n.

$$NPV = \sum_{t=1}^{n} \frac{V_t}{(1+k)^t} - I_0$$

Where

t= is the time of the cash flow

n= end of the exploitation period.

k= is the discount rate

V_t=is the net cash flow (cash inflow – cash outflow) at time t.

I_0=is the initial investment

4.3.2.1.1 Business-as-usual

n= 15 years, usual tender duration for such public smart lighting market

k= WACC @ 6%

I_0=is the initial investment in this case a new LED luminaire incl. a smart node with dimming capabilities. The range of price luminaire varies depending if a road luminaire or a town centre stylish luminaire is used. The average price

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

@ **650 € HT**. Another investment **200 € HT** is set @12 years to deal with driver failure based on the laboratory benchmark holds by ENGIE.

Other hypothesis

	Market standard
Installed Power by luminaire - kW [Based on France 1300 MW for 9 million LP)	150
Running hours [3200]	3200
Targeted Power [-60%]	60
Energy price [Eur/KWh ; EU Commission price analysis]	0,21
Inflation scenario [%/y]	2%
Average maintenance price per luminaire [Eur/y]	30,00 €
Min Led running hours	50 000
Max Led running hours	100 000
Average lifespan	25

The following table shows a positive NPV making the project acceptable

year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
initial investment	**- 650,00 €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- 200,00 €**	**- €**	**- €**	**- €**
Energy savings revenue	30,24 €	61,69 €	62,92 €	64,18 €	65,47 €	66,77 €	68,11 €	69,47 €	70,86 €	72,28 €	73,72 €	75,20 €	76,70 €	78,24 €	79,80 €
Maintenance savings revenue	9,00 €	9,18 €	9,36 €	9,55 €	9,74 €	9,94 €	10,14 €	10,34 €	10,54 €	10,76 €	10,97 €	11,19 €	11,41 €	11,64 €	11,88 €
	39,24 €	**70,87 €**	**72,29 €**	**73,73 €**	**75,21 €**	**76,71 €**	**78,25 €**	**79,81 €**	**81,41 €**	**83,04 €**	**84,70 €**	**86,39 €**	**88,12 €**	**89,88 €**	**91,68 €**
Cashflow	**- 610,76 €**	**70,87 €**	**72,29 €**	**73,73 €**	**75,21 €**	**76,71 €**	**78,25 €**	**79,81 €**	**81,41 €**	**83,04 €**	**84,70 €**	**- 113,61 €**	**88,12 €**	**89,88 €**	**91,68 €**
WACC [@6 %]	6%														
Actualisation factor	0,94	0,89	0,84	0,79	0,75	0,70	0,67	0,63	0,59	0,56	0,53	0,50	0,47	0,44	0,42
Cashflow updated @ WACC	- 576,19 €	63,07 €	60,69 €	58,40 €	56,20 €	54,08 €	52,04 €	50,07 €	48,18 €	46,37 €	44,62 €	- 56,46 €	41,31 €	39,75 €	38,25 €
NPV @WACC for 15 years	**20,40 €**														

Table 3: Cashflow and NPV of Smart Lighting in the scenario where the business is as usual

4.3.2.1.2 Best-case scenario

n= 15 years, usual tender duration for such public smart lighting market

k= WACC @ 6%

I_0=is the initial investment in this case a new LED luminaire incl. a smart node with dimming capabilities. The range of price luminaire varies depending if a road luminaire or a town centre stylish luminaire is used. The average price @ **600 € HT** benefiting the price scale effect.

The energy price is 20% higher than in the usual scenario.

Other hypothesis

	Market standard
Installed Power by luminaire - kW [Based on France 1300 MW for 9 million LP)	150
Running hours [3200]	3200
Targeted Power [-60%]	60
Energy price [Eur/KWh ; EU Commission price analysis]	0,25
Inflation scenario [%/y]	2%

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Average maintenance price per luminaire [Eur/y]	30,00 €
Min Led running hours	50 000
Max Led running hours	100 000
Average lifespan	25

The following table shows a positive NPV making the project acceptable in 10 years

year	1	2	3	4	5	6	7	8	9	10
initial investment	**- 600,00 €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**
Energy savings revenue	36,29 €	74,03 €	75,51 €	77,02 €	78,56 €	80,13 €	81,73 €	83,37 €	85,03 €	86,74 €
Maintenance savings revenue	9,00 €	9,18 €	9,36 €	9,55 €	9,74 €	9,94 €	10,14 €	10,34 €	10,54 €	10,76 €
	45,29 €	**83,21 €**	**84,87 €**	**86,57 €**	**88,30 €**	**90,07 €**	**91,87 €**	**93,71 €**	**95,58 €**	**97,49 €**
Cashflow	**- 554,71 €**	**83,21 €**	**84,87 €**	**86,57 €**	**88,30 €**	**90,07 €**	**91,87 €**	**93,71 €**	**95,58 €**	**97,49 €**
WACC [@6 %]	6%									
Actualisation factor	0,94	0,89	0,84	0,79	0,75	0,70	0,67	0,63	0,59	0,56
Cashflow updated @ WACC	- 523,31 €	74,05 €	71,26 €	68,57 €	65,98 €	63,49 €	61,10 €	58,79 €	56,57 €	54,44 €
NPV @WACC for 10 years	**50,95 €**									

Table 4: Cashflow and NPV of Smart Lighting in the best-case scenario

4.3.2.1.3 Worst-case scenario

n= 10 years, usual tender duration for such public smart lighting market

k= WACC @ 6%

I_0=is the initial investment in this case a new LED luminaire incl. a smart node with dimming capabilities. The range of price luminaire varies depending if a road luminaire or a town centre stylish luminaire is used. The average price @ **650 € HT** suffering the rise of raw material from China (+30%). Another investment **200 € HT** is set @12 years to deal with driver failure based on the laboratory benchmark holds by ENGIE.

The energy price drop by 30%

Other hypothesis

	Market standard
Installed Power by luminaire - kW [Based on France 1300 MW for 9 million LP)	150
Running hours [3200]	3200
Targeted Power [-60%]	60
Energy price [Eur/KWh ; EU Commission price analysis]	0,15
Inflation scenario [%/y]	2%
Average maintenance price per luminaire [Eur/y]	30,00 €
Min Led running hours	50 000
Max Led running hours	100 000
Average lifespan	25

The following table shows a <u>negative</u> NPV making the project <u>not</u> acceptable.

year	1	2	3	4	5	6	7	8	9	10
initial investment	**- 800,00 €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**
Energy savings revenue	21,17 €	43,18 €	44,05 €	44,93 €	45,83 €	46,74 €	47,68 €	48,63 €	49,60 €	50,60 €

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Maintenance savings revenue	9,00 €	9,18 €	9,36 €	9,55 €	9,74 €	9,94 €	10,14 €	10,34 €	10,54 €	10,76 €
	30,17 €	**52,36 €**	**53,41 €**	**54,48 €**	**55,57 €**	**56,68 €**	**57,81 €**	**58,97 €**	**60,15 €**	**61,35 €**
Cashflow	**- 769,83 €**	**52,36 €**	**53,41 €**	**54,48 €**	**55,57 €**	**56,68 €**	**57,81 €**	**58,97 €**	**60,15 €**	**61,35 €**
WACC [@6 %]	6%									
Actualisation factor	0,94	0,89	0,84	0,79	0,75	0,70	0,67	0,63	0,59	0,56
Cashflow updated @ WACC	- 726,26 €	46,60 €	44,84 €	43,15 €	41,52 €	39,96 €	38,45 €	37,00 €	35,60 €	34,26 €
NPV @WACC for 10 years	**- 364,87 €**									

Table 5: Cashflow and NPV of Smart Lighting in the worst-case scenario

4.3.2.2 Internal rate of return (IRR)

Internal rate of return (IRR) is the interest rate at which the net present value of all the cash flows from a project equal zero. IRR is used to evaluate the attractiveness of a project. The project is accepted if the IRR>MARR (minimum acceptable rate of return).

$$\sum_{t=1}^{n} \frac{V_t}{(1+IRR)^t} - I_0 = 0$$

where

t= is the time of the cash flow

n= end of the exploitation period.

V_t=is the net cash flow (cash inflow – cash outflow) at time t.

I_0=is the initial investment

4.3.2.2.1 Business-as-usual

IRR = 6,6% for NPV =0 for a duration of 15 years

4.3.2.2.2 Best-case scenario

IRR = 8,1% for NPV =0 for a duration of 10 years

4.3.2.2.3 Worst-case scenario

The project is not rentable and acceptable with a negative NPV

4.3.2.3 Payback period (PbP)

Payback period (PbP) is the amount of time it takes to recover the cost of an investment, or in another words is the length of time an investment reaches a break-even point.

$$PbP = \frac{I_0}{V}$$

where

I_0=is the initial investment

V=is the net cash flow (cash inflow – cash outflow) per year, being this value a constant.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

4.3.2.3.1 Business-as-usual

The MARR is the actual WACC @6% **PbP** = 15 years

4.3.2.3.2 Best-case scenario

The MARR is the actual WACC @6% **PbP** = 10 years

4.3.2.3.3 Worst-case scenario

The MARR is the actual WACC @6% **PbP** = 30 years

4.3.2.4 Return on Investment (ROI)

Return on Investment (ROI) is a performance measure used to evaluate the efficiency of an investment. ROI is calculated dividing the benefit (or return) of an investment by the cost of the investment. The result is expressed as a percentage.

$$ROI = \frac{NPV}{I_0}$$

where

NPV= is the net present value

I_0=is the initial investment

4.3.2.4.1 Business-as-usual

ROI = **3,1%** for an NPV=20,4 € et I_0=650 € and a payback period of 15 years.

4.3.2.4.2 Best-case scenario

ROI = **8,5%** for an NPV=50,9 € et I_0=600 € and a payback period of 10 years.

4.3.2.4.3 Worst-case scenario

ROI = **0,6%** for an NPV=4,57 € et I_0=800 € and a payback period of 30 years.

4.3.3 Other potential benefits

Cities are at the heart of the global energy transition, with **half of the world's population**, **75% of its energy consumption** and **80% of CO_2 emissions**.
Public lighting represents from **20% to 40% of cities' energy bill**. One third of existing light bulbs use technologies from the 60's with a very low energy efficiency, with **huge perspectives of energy savings** (up to 60%), with new LED and smart technologies whit a better overall availability.
Renovating **public lighting** thus **improves** both the **quality of life** and **urban comfort**, and **reduces energy consumption** in a city, leading to significant **operational savings** setting the **lighting infrastructure as the nervous system of cities**.
The **lighting infrastructure** can provide the basics capabilities to enhance features for such as **security**, **traffic analysis**, **parking management**, **air quality**, etc. This **convergence will extend to connectivity**, since 50% of 5G antennas will be installed on luminary and security poles. It may extend to other services requiring light infrastructure disposed in a regular network on the public space such as air quality sensors, charging stations for vehicles, advertising and all the other connectivity services that are booming

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

5. Electric Power Tenant Supply - ENH[6]

ENH solution of direct power delivery is the core for the cooperative, which stands for citizen participation and citizen responsibility in the Hamburg energy transition. The photovoltaic (or other source) local facilities directly connected to customers is a very effective way of using and generating electricity, reducing transfer loss and further use of free landscape. Electric Power Tenant Supply could contribute significantly to climate protection and CO_2 emission reductions. These ERs are fundamental for the commercial strategy of the solution in ENH. On the other hand, should be mentioned that the solution faces several hurdles mainly bureaucratic to be easily and broadly rolled out. This is a key aspect (legal rules and frames) that ENH must deal with in order to exploit the main ER from its solution.

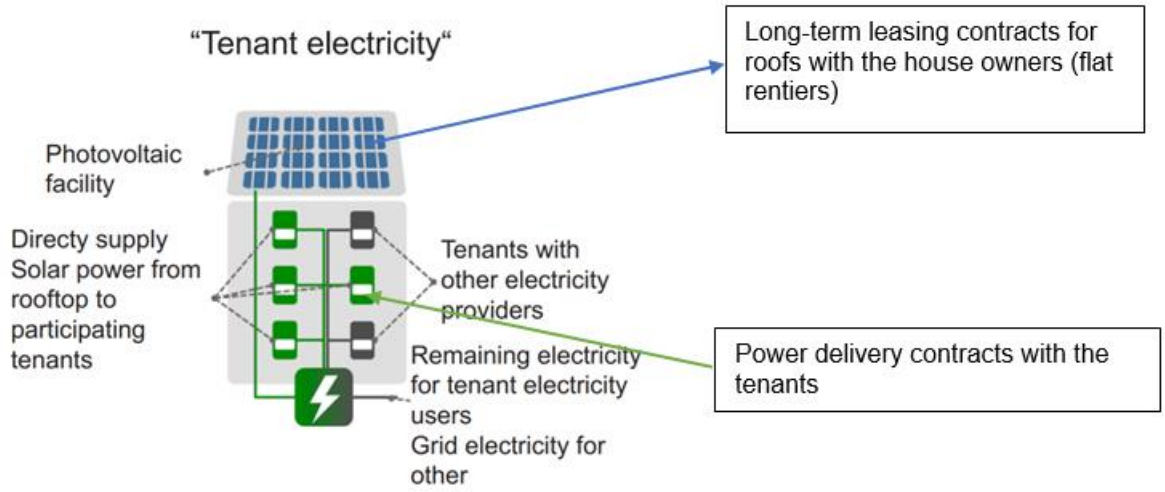

Figure 16: Concept of EPTS, source: ENH

5.1 Part 1: Business model description[7]

5.1.1 Value Creation Ecosystem

The value creation ecosystem (VCE) of the Electric Power Tenant Supply is very complex. It is formed by several parallel loops without direct contact points (see Figure 17)

ENH is co-founder of the **Solar offensive**, whose platform is mostly used by citizens who are interested in obtaining electricity from the "own" roof or by houseowners and SMEs who offer their roof for a PV system with direct power supply.

The bottleneck of the business lies in the acquisition of suitable roofs. Negotiations with **houseowners** with suitable roofs are usually long and difficult. The aim is to achieve long-term contracts, (over 20 years). In order to operate the systems economically, only a very small roof lease is possible. Owners who do not use the building themselves do not benefit from the favourable price for real green electricity. Environmental awareness and the will to contribute to climate protection is helpful as well as the commitment to climate protection measures by means of legal requirements.

The same applies to **municipalities** and district administrations, which must also take European public procurement law into account when concluding contracts for roof use and electricity supply.

[6] ESADE wanted to include a risk analysis and implementation plan in part 4, as it was presented in the action plan send last December, however, these two analyses were finally included in D8.6, so it does not make sense to repeat it in this deliverable.

[7] The tools to be used in part 1 (value creation ecosystem, internal value chain and business model canvas) were presented las December.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

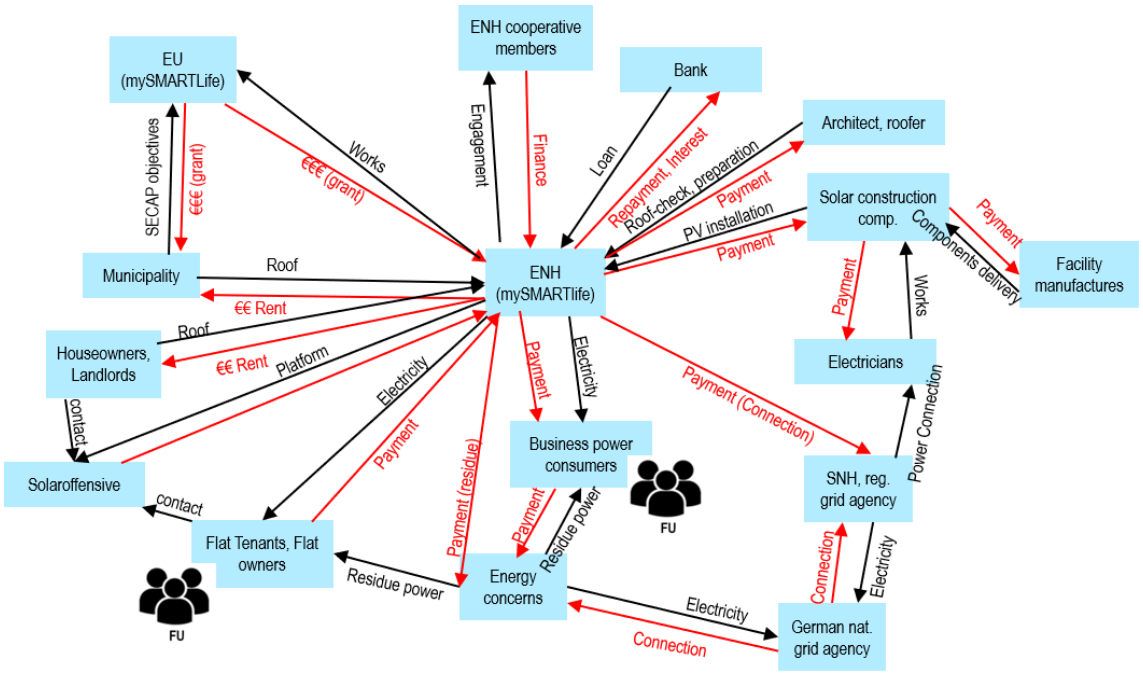

Figure 17: Illustration of the VCE of Electric Tenant Power Supply (FU = Final User = Power Consuming), source: ENH

Support by projects such as **mySMARTLife** is particularly helpful. The financial support gives the freedom for time-consuming research and preparatory work. It enables the economic viability of expensive innovative technology. The interaction of the consortium promotes the dissemination of the project goals and, consequently, the awareness of the participating companies. This creates new contacts and, at best, a beneficial network.

The **members of the cooperative** form the basis for the company. They subscribe for shares in the cooperative and provide it with additional financial resources for the implementation of projects in the form of loans. The ENH supports its members in their commitment to renewable energies, advises and implements the projects.

Payment transactions are handled via the **Bank**. In addition, the Bank grants project-related loans for PV-plants, battery storage and other RES facility.

In the illustration above the **Architect** and the **Roofer** are only linked to ENH to check and prepare the roof for the PV-plant. That is only one way. For most PV projects on new buildings, the owner already requests the architect to plan the roof requirements for a PV-facility. Finally, in the case of particularly complicated roofs, the solar construction company consults with the architect to design the optimum layout for the roof.

The tasks of the **solar construction company** are the technical planning of the system, the purchase of the coordinated components at the **facility manufactory** and the installation of the system. If necessary, it coordinates the scaffolding erectors and, if earthworks are required to lay a cable, the work of the civil engineer. The solar builders are also the contact persons and clients for the **electricians** who carry out the grid connection.

The regional network operators are indispensable in the implementation. In the Hamburg metropolitan region, Stromnetz Hamburg **(SNH)** and Schleswig-Holstein Netz **(SH-Netz)** are the contacts from which the respective grid connection is applied for and approved. They provide the connection to the supra-regional electricity market via the German Network Agency (Bundes-Netzagentur).

Energy concerns or municipal power producer are another element of the VCR. They supply the additional required power that is not produced by the PV-systems. **Business customers** have a parallel supply contract with their chosen electricity producer. Residential **tenants**, i.e., private users, obtain their residual electricity from ENH. For this purpose, ENH has concluded a collection contract with a provider of ecological electricity. Both – the flat tenants (flat owners) and the Business power consumers are **the finale users** of the Value Creation Ecosystem of the business of electricity tenant power supply.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

5.1.2 Internal Value Chain

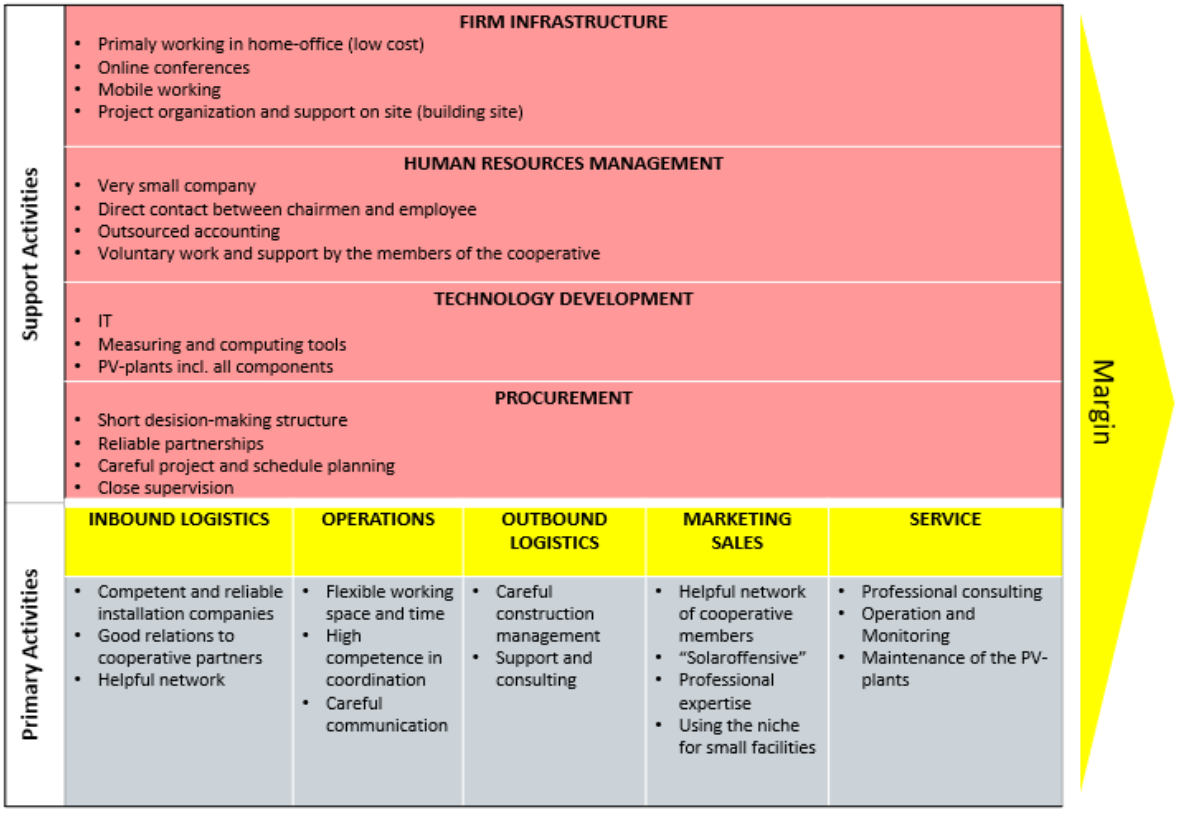

Figure 18: Internal Value Chain of ENH business

In this chapter, we´ll have a look at the internal structure of ENH, that makes the company strong and flexible likewise.

5.1.2.1 Support Activities

The support activities are particularly characterised by the fact that ENH is a very small company built on the shoulders of its nearly 300 members.

FIRM INFRASTRUCTURE

The cooperative has a flat hierarchy that suits the company. ENH is managed by two legally required board members, one of whom is also an employee. ENH also employs an industrial engineer who is responsible for the technical planning and construction management of the PV projects. Business development and key decisions are monitored by the Supervisory Board. The cooperative is supported by the Management Board, the Supervisory Board and some members in the form of voluntary work.

ENH has a small budget and keeps a close eye on costs. For this reason, ENH does not operate expensive office space. The employees work in their home office. This also includes the efficient use of working time. Conferences take place mainly online. This eliminates travel time and travel costs.

There are also times of mobile working and support on site (building site) for the building inspection while a PV system is being installed and connected. Just like roof checks and discussions with house owners and tenants, the Project organization requires local flexibility.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

HUMAN RESOURCES MANAGEMENT

ENH is a very small company with two part time HR-employees. This results in the following a direct contact between chairmen and employee. The accounting and other administrative functions are outsourced. Another part of the organisational tasks as well as the management functions are performed on an honorary basis. In addition, support is provided by members and partners (see figure below).

This allows employees to concentrate on their tasks in project management and research. Overall, the lean structure leads to great flexibility and high quality.

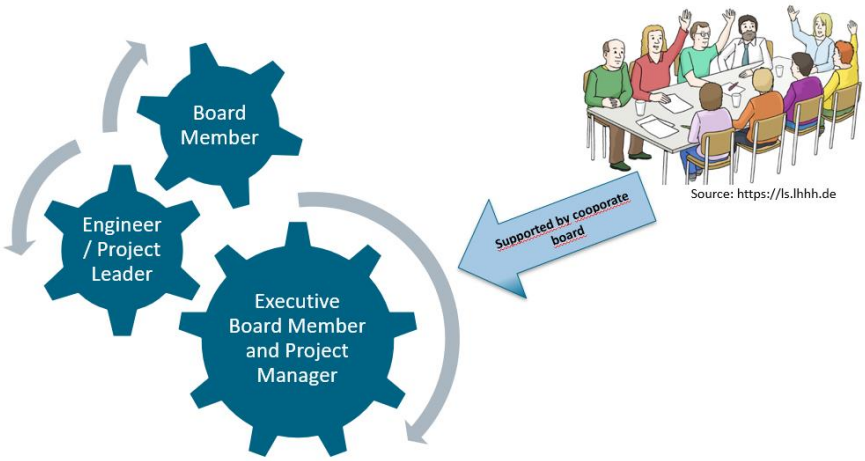

Figure 19: Company Structure of ENH

TECHNOLOGY DEVELOPMENT

IT: The employees work with laptops. For data exchange and storage, rented space in a cloud is used. The electricity bills and invoicing are carried out on the servers of an IT company.

Measuring and computing tools: During the roof check exact measurements are taken and the buildings, technical rooms and roofs are documented with photos. Measuring tapes, an inclinometer and a camera are the technical tools needed for this. All further planning work, e.g., the module allocation plan, is carried out on the computer with appropriate programs or on the platforms of the solar companies.

PV-plants incl. all components: The most important technical facilities of ENH are the photovoltaic systems with all components. They are the investment objects in which most of the cooperative's capital is tied up. Each plant is developed to the latest technical standards. The electricity produced is sold to tenants and commercial direct consumers in the building on which the plant is installed. Alternatively, the power is fed into the grid. The ENH covers its costs with the electricity sales, feed-in tariff and income from consulting services.

PROCUREMENT

Thanks to the extremely short decision-making channels, ENH can react very flexibly and quickly in procurement. But for the installation of PV systems, counts on long-term and reliable partnerships. This enables to guarantee high quality. In addition, close cooperation facilitates coordination with other crafts, especially in the case of PV-plants on new buildings, where schedules are repeatedly postponed.

In ENH's business, careful project and schedule planning is a prerequisite for the successful implementation of tenant and direct power concepts. As also shown in the VCE, numerous stakeholders, from the property developers to the construction companies and the contracting with the electricity customers, must be coordinated during the installation of the plants. Close supervision guarantees smooth processes from start to finish.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

5.1.2.2 Primary Activities

INBOUND LOGISTICS

The simple company structure makes internal logistics simple and fast. Processing is carried out via direct communication in team meetings, by telephone or computer (mail, Skype). The inbound logistic is the main task of the board members.

For planned plants, an offer is requested from ENH's competent and reliable installation partners. The offers received are compared carefully and, if necessary, renegotiated. After decision a company is commissioned with the installation of the plant and carries it out in close coordination with ENH and the house owner or developer. The good relations to the cooperative partners help to ensure the trustful implementation and completion of the projects.

When acquiring new roofs, ENH is supported by a helpful network of cooperative members and other partners. These partners establish contact with interested persons. These people will be informed by ENH on the possibilities of using solar energy. At best, they decide on a long-term contract for roof use with a solar power concept.

OPERATIONS

While the project manager has an overview of the coordination between the different projects and other tasks, e.g. participation in research projects, the project leader is responsible for the proper execution of the specific projects.

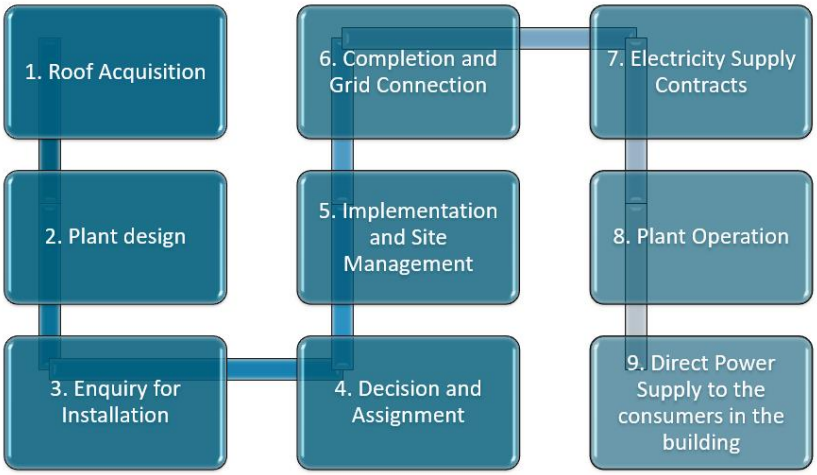

Figure 20: Operations Process

In the phase of implementation of PV projects, the employees of ENH are flexible in working space and time. Due to the specialisation and meanwhile many years of experience of the project manager, the organisation has developed high competence in coordination and construction management. Careful communication contributes to the success of the projects. Figure 20 shows the process of a PV-project.

OUTBOUND LOGISTICS

The outbound logistic is characterised by a careful construction management. This guarantees an uninterrupted power supply of electricity and thus calculable income.

At first sight the outbound logistic seems quite simple: ENH supplies the electricity from the PV systems to the direct consumers and the grid. For this it receives payment. There are far more complex processes behind this:

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

- There are very strict legal requirements for electricity contracts in Germany, which must be considered when concluding contracts.
- Customer service is particularly extensive in the tenant electricity sector. Tenants move in and out, change bank accounts, etc. All these processes must be carefully followed.
- Advances are paid monthly. The various statutory and tax surcharges must then be taken into account in the annual settlement. In 2020 this will be even more complicated due to the Corona special regulation with a VAT rate that changes in the middle of the year.

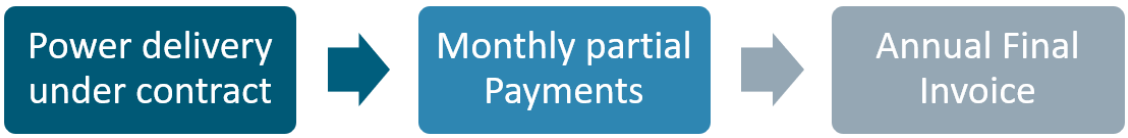

Figure 21: Outbound logistic of electricity power supply

Further pillars of ENH are consulting services in the field of photovoltaics with direct power consumption concepts and participation in research projects in the field of renewable energies.

MARKETING SALES

ENH can use the helpful network of cooperative members for marketing. The members and friends of the cooperative make recommendations and establish contacts with potential stakeholders. They also provide valuable information on new construction projects.

Another external channel is the "Solar offensive" platform. ENH has set up this site together with other players of the regional electricity market and the consumer advice centre to promote the dissemination of PV systems on the roofs of the metropole region of Hamburg.

Thanks to the experience and the realised PV systems, ENH has been able to build up professional expertise and now has a good reputation for the implementation of small roof-mounted PV systems. Due to the high costs and relatively low contribution margins, there are only a few competitors in this niche.

SERVICE

ENH's offers professional consulting as a valuable service for house owners, companies and property developers who want to generate solar power on the roof.

Further services are the operation and the monitoring of the PV-plants. ENH takes care of the maintenance and, if necessary, orders solar companies with necessary work and repairs. This also includes checking the roofs and surroundings for vegetation that causes shading on the system.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

5.1.3 Business Model Canvas

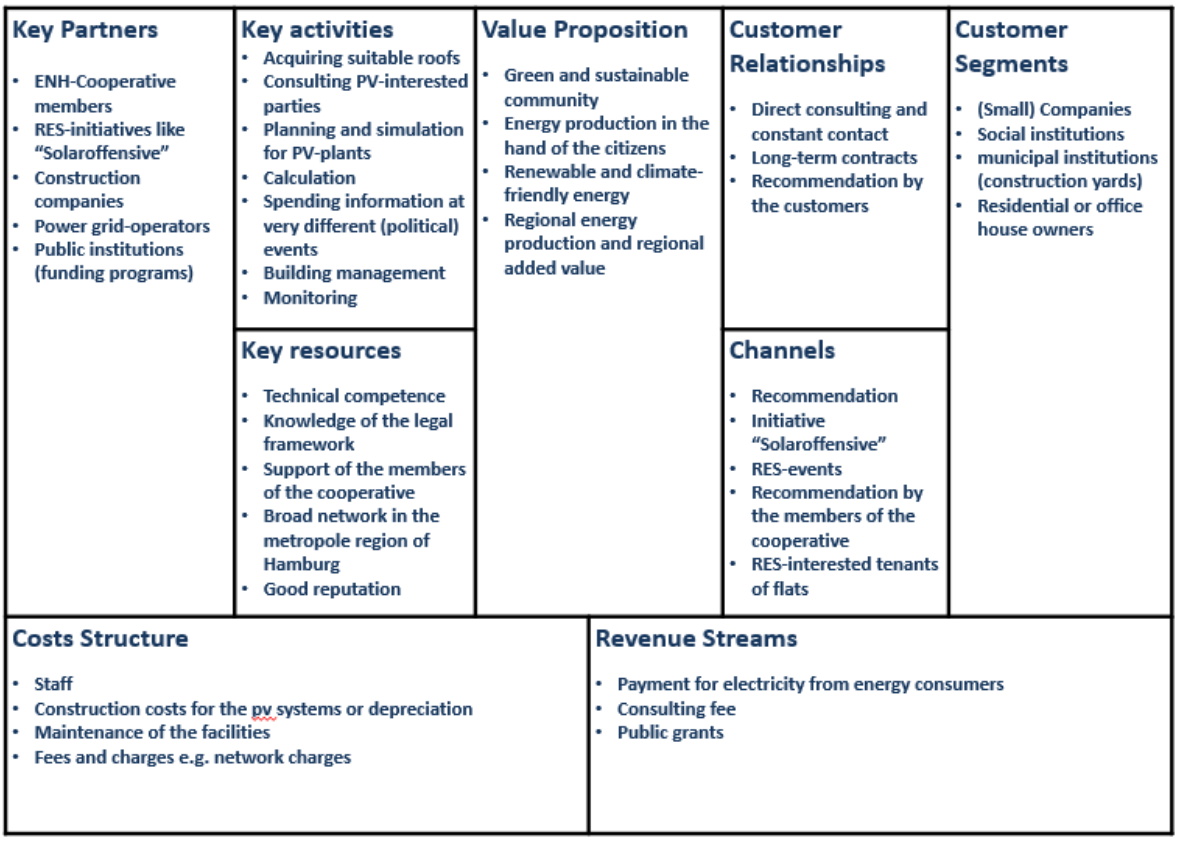

Figure 22: Business Model Canvas of ENH

Key Partners

The rules of the ENH-Cooperative members and the RES-initiatives like "Solar offensive" are described under 1.2.2 in the marketing chapter. The members are also financiers of the cooperative. the majority of the investment in facilities is financed, with the shares and the loans provided by some members,

The rules of the other key partners named in the model (construction companies, power grid-operators and public institutions with funding programs as mySMARTLife) are explained in chapter 1.1. Value Creation Ecosystem.

Key activities

The first step of each project is consulting PV-interested parties. Most of the time the staff spends is related to acquiring suitable roofs. This is very elaborate. The roofs are first checked online e.g., with google maps for their position, inclination to the sun and possible shading. Then roof plans (construction drawings) are viewed, and the state of the roof surface will be evaluated during a personal inspection. The power cables in the house and the metering room will also be inspected. The results are supplemented with photos and documented.

If the roof is proper, planning and simulation for PV-plant starts. One important point is an accurate calculation. If the result is positive, ENH will start negotiations with the house owner. Due to the general conditions (long-term contract, legal basis, low margin), these are often lengthy and tough, and only a small proportion conclude contracts.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

During the implementation of the projects, ENH is responsible for the building management and then coordinates the grid connection and commissioning. Installed electricity producing PV-plants are operated and monitored. Electricity supply contracts are concluded, the electricity is delivered and invoiced.

ENH is also politically active and performs at very different (political) events with information about RES.

Key resources

Most of the resources of ENH comes from the people involved:

- The technical competence of the employed engineer and the solar partners
- Knowledge of the legal framework and political encouragement
- Good reputation through successful projects
- Support of the members of the cooperative (financial and by recommendations)
- Broad network in the metropole region of Hamburg

Value Proposition

ENH stands for a green and sustainable community.

It is interesting to bring the energy production in the hands of the citizens. On the website8 the positions of the cooperative are presented as follows:

- We want the Hamburg energy revolution to be placed in the hands of the citizens and the City of Hamburg. We want the added value it creates to remain in the city, in the region and in the hands of the citizens.
- We want Hamburg's energy supply to be renewable and climate friendly. We want the generation of electricity and district heating to be converted in such a way that renewable energies also have priority in Hamburg.
- To this end we want to promote energy system transformation projects in the metropolitan region.

Customer Relationships

The business model of ENH leads to direct consulting and constant contact with the customers. The nature of the business requires a limited number of customers. Long-term contracts require recurring contacts and a reliable customer relationship.

Recommendation by the customers is very valuable for the business.

Channels

The channel ENH mostly uses is directly from person to person, only few results from Internet-Platforms or the website. They are all described in the figure below.

[8] https://www.energienetz-hamburg.de/wer-wir-sind/ access 23/07/2020

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

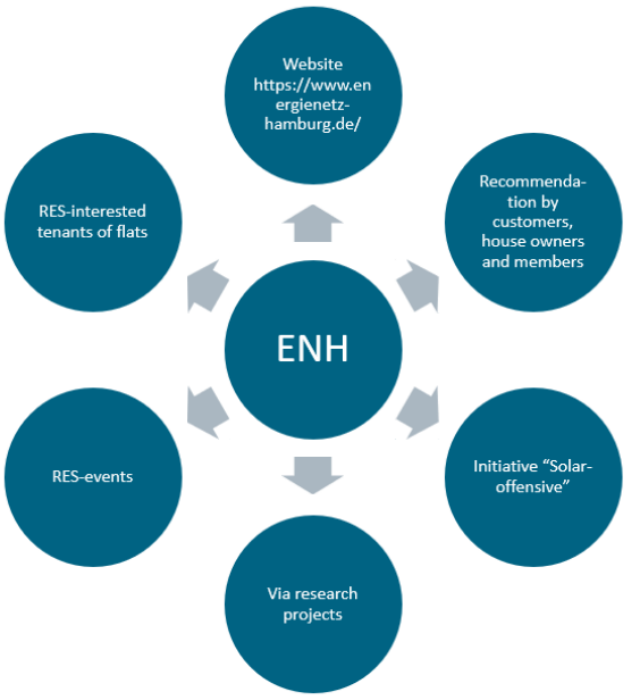

Figure 23: Channels to get in contact

Customer Segments

Because ENH itself is a small company with a limited scope, customers are also found in this segment. The tenant electricity consumers are private individuals. Direct electricity supplies also apply to small and medium-sized enterprises and social institutions. Residential or office house owners are roofers and partly electricity consumers. To the extent that this is compatible with European public procurement law, municipal institutions (construction yards) are customers of ENH.

Costs Structure

ENH has a very lean cost structure and is very economical. The employees are working in home office, which means that ENH does not have to finance office space. The cost structure is dominated by three main items:

- Salaries for employees
- Construction costs for the PV systems in form of depreciation
- Maintenance of the facilities

Other cost items are Internet costs, external accounting costs, fees and charges e.g., network charges and travel costs. The time-related spreading of costs is smooth and thus costs and expenses can be planned well.

Revenue Streams

The income of ENH stands on three legs:

- Payment for electricity from energy consumers and feed-in tariffs
- Consulting fee
- Public grants from research projects and Subsidy for components.

The payment for the electricity represents a fixed basic income with monthly payments and a final annual accounting. ENH can calculate long-term with these revenues. Consulting fees are very volatile and have declined

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

due to Corona. Grants for participation in research projects are well predictable for the research period but limited to the project duration.

5.2 Part 2: Pilot analysis (BM validation)

Business models developed with the BMC, or with other methodologies, usually answer questions such as "What", "Who", "When", "How" or "How Much" (Mitchell *et al.*, 2004), but they always do it based on a series of hypotheses, so an important part of the study should consist in experimenting to validate if the hypotheses are correct.

Lean start-up (figure 1), which is based on three different works: Blank (2005), Rise (2011) and Blank and Dorf (2012), is a methodology that was developed precisely to help organizations to perform this task. Its objective is to develop a product or services through an iterative process and continuous learning based on empirical data obtained from pilot interventions.

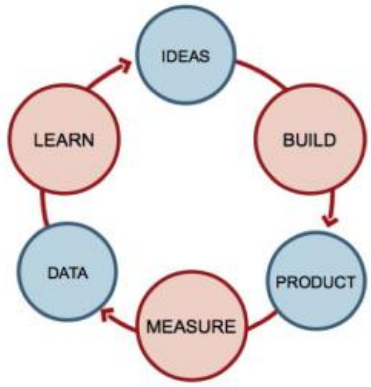

Figure 24: Build-Measure-Learn feedback loop (Rise, 2011)

The business model validation process starts with developing (build) the pilot intervention. The second activity to be carried out is to develop a set of indicators to assess the reliability of the hypotheses. Once the indicators are stablished the next stage is for the organization to analyse the data and extract conclusions that allow it to increase the knowledge of the product or services that they offer (learn). Based on what they learn through the Build-Measure-Learn loop, companies can introduce changes into their business model and, as a direct consequence, the new business model is improved. Companies usually must go through this validation process several times until they reach an appropriate business model.

What indicators did you define to assess the performance of your services/product? What kind of data did you take from them? What did you learn from these data? Are your forecasts met?

The answers should consider that direct electricity concepts with photovoltaics are a special and a very long-term business with contract periods of 20 to 25 years. Accordingly, a short-term assessment is difficult.

ENH uses the contribution margin (per plant) as the most important indicator. Only PV projects that promise more than three-and-a-half percent and a contribution margin of 1000 Euros a year, if carefully calculated, will be implemented. The calculation is based on the ROI, the expected electricity production and the estimated electricity prices or feed-in tariffs.

Experience shows that it is a very narrow degree on which the business model is based. Even small additional costs can make a system uneconomical. A further uncertainty results from the changes in the framework conditions caused by politics in recent years. Feed-in tariffs, for example, have fallen drastically. this makes medium-term economic planning considerably more difficult.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

The results show that the forecasts for the PV-plants implemented were correct and that ENH is achieving the expected turnover. Due to the above-mentioned aspects, a forecast for future projects is only possible in the short term and tailored to the plant. General economic planning beyond next year is difficult to predict.

What improvements did you introduce in your product/service during its development/ construction?

Each PV system is built according to the latest technical standards with modern components. For new projects, whether the addition of a power storage unit is useful and practicable is always checked.

What are the major technical, design, adoption or manufacturing hurdles to be solved?

The biggest technical hurdle is an unsuitable roof surface or a roof surface that is in poor condition and needs to be restored first. Poor building statics can also prevent a PV system. Further technical problems arise from the cabling, the space for the measuring equipment and the building's house connection.

There is no design problem in this sense with the plants. However, the optimal layout of the roof with the solar modules is often a challenge. Roof superstructures, chimneys and masts must be considered, as well as safety regulations that specify the distance from the edge of the roof. Sometimes the PV-plant that could be installed under these conditions is too small for economical operation.

Since almost all components for PV systems are produced in China or Korea, the supply chain is very long. This can lead to difficulties, especially for new buildings, as the deadlines are very tight. Under the influence of Corona, this resulted in supply bottlenecks, with the consequence that ENH had to install lower quality modules and the plant is not as efficient as expected.

The solution is well-defined and easily understood by the target customer?

Since climate protection through renewable energies is a widespread topic, the concept of direct power supply with PV systems is easy to communicate and meets with open ears.

What are the most complex barriers/difficulties/challenges that costumers are facing when using your product or service?

The biggest difficulty is to find suitable roofs and homeowners who will provide their roof with a long-term contract. And the installation on your "own" roof is the prerequisite for supplying solar power to the house inhabitants.

Is your solution within the budget of the target market?

The electricity price for tenant electricity concepts is limited by law to 90 % of the basic supply tariff. This means that the price is even below the usual market price.

What are the most complex barriers/difficulties/challenges that the market presents to you?

- The general lack of suitable roof surfaces in good condition with proper statics.
- Many house owners are not willing to provide their roofs in a long-term contract without a profitable financial return.
- legal reforms at short intervals create (economic) uncertainty.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

In January 2020, „Hochschule für Technik und Wirtschaft Berlin“ (htw) published a study with the biggest obstacles for urban PV expansion9. On the site you´ll find a link to a PDF-File with a list of 56 hurdles and a diagram of the classification of obstacles for PV expansion according to the quantitative impact and height of the respective obstacle as well as a prioritization for remedial action.

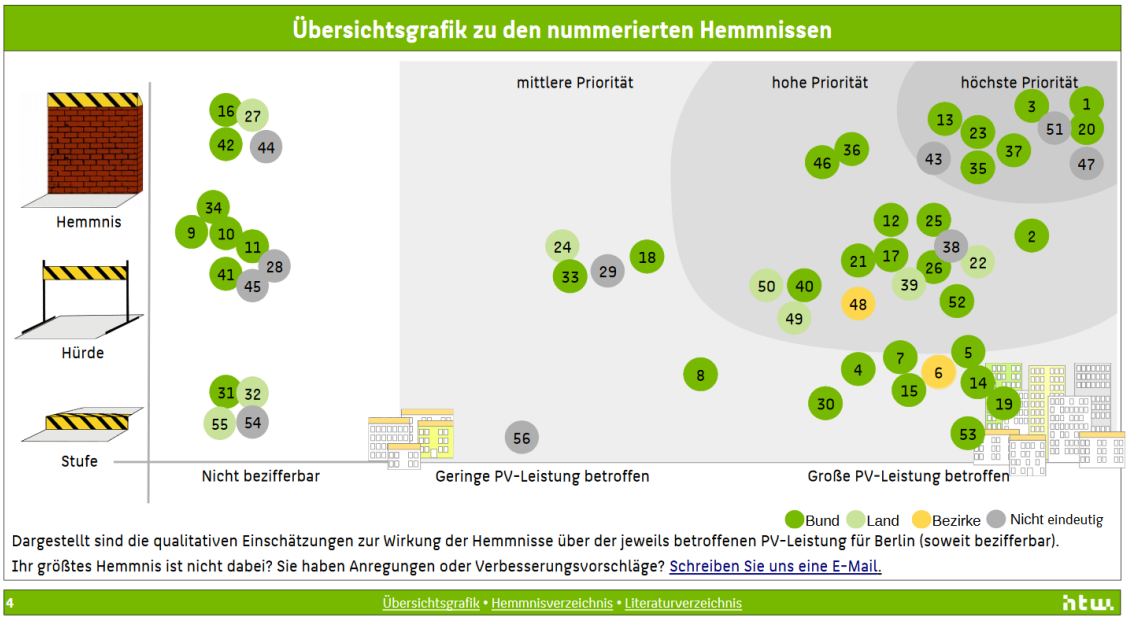

Figure 25: Obstacles to urban PV expansion, source: htw, 2020 Hemmnisse für den städtischen PV-Ausbau

The hurdle with the highest amendment priority (#1, Legal framework - no feed-in tariffs for PV output above 52 GW) was indeed finally removed in July 2020 with the "Kohleausstiegsgesetz" (Coal Exit Act).

Barrier #3 (complexity of the electricity market), also a legal point, is currently even intensified by the entry into new electricity tariffs with time-of-use dependent electricity prices.

Also # 20 (annual expansion target of 2.5 GW) is part of the legal framework conditions and provides for a monthly reduction of the feed-in tariff for feeding the remaining electricity volume into the grid. This means that only plants with an increasing direct electricity consumption are economically profitable.

51 (skills shortages) and # 47 (information deficits) fall into the category of socio-economic conditions. The other obstacles are not listed individually here but can be taken directly from the study.

Do you have clear ways to reach your target market? Did you have any problem with the channel through with you deliver your value proposition?

Our way are direct contacts and intensive discussions. Because of ENH's reputation, it is easy to communicate its value propositions.

Did you have any problem with your key partners? How did you deal with it?

ENH had a problem with the reliability of a solar installation company and consequently increasingly commissions. The contracts went to another solar installer based in Hamburg.

What are the main takeaways you get from pilot intervention?

[9] https://pvspeicher.htw-berlin.de/veroeffentlichungen/studien/hemmnisse-fuer-den-ausbau-der-solarenergie/ access 25/07/2020

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Not applicable.

5.3 Part 3: Financial Viability

The financial viability of small-scale projects is low. Therefore, competition in this business sector is also low and the profit-oriented energy concerns stay away. Most of the plants in this category are realised by citizens' energy cooperatives or other initiatives that focus on climate protection rather than profit. For these actors, it is enough if the plants yield a margin that is sufficient to cover the company's costs, including salaries.

5.3.1 Scenarios for business evolution

In the following, the business as usual, the best case and the worst case for the business model of PV-plants with direct electricity consumption are presented. All financial calculations are based on estimates and assumptions and are specific to the projects. The calculations may not consider all costs or risks associated with the concept, but only allow an indication of the financial viability of the business.

5.3.1.1 Business as usual

Through various channels (information events, platform "Solar offensive10", recommendations), ENH encounters people who want to contribute to energy system transformation and promote RES by means of a PV system and direct current concepts. Tenants who contact ENH are asked to make contact with the house owner. Because only with him can a roof utilisation contract be concluded.

If the result is positive, ENH will start negotiations with the house owners. If an agreement is reached, the roof will be examined in detail, the PV plant will be planned, and electricity supply contracts will be offered to the users/tenants of the building. If these steps come to a positive conclusion, ENH will implement the plant. This happens in about 10 percent of the contacts.

One reason for this low success rate are the long-term (min. 20 years) roof occupancy contracts, which, due to the ROI, inevitably limit the house owners regarding reconstruction and own roof use. Moreover, many roofs in the existing building stock are not suitable for the plants (to old, statically weak, adverse form or direction).

ENH finances the PV-plants with its own capital or loans, which are mainly provided by the members of the cooperative. The construction of the plant is carried out by a reliable business partner of ENH. ENH handles all legal and bureaucratic tasks itself. After initial starting, ENH also operates the plant and delivers the electricity to the direct consumers or feeds it into the grid in return for a feed-in tariff.

Currently ENH is implementing 5 to 6 PV projects per year.

5.3.1.2 Best case scenario

In the best-case scenario, the planned "solar examination obligation" will become legally valid in Hamburg and the possibility of exemption from this obligation will be severely limited. Then all suitable new buildings in Hamburg would have to be outfitted with a PV system. The majority of owners of residential and office buildings will not want to deal with the complex issue of installing and operating a PV system and will then look for competent partners. In this case, ENH, as a regionally rooted contact partner with a good reputation, has the chance to find numerous new cooperation partners on whose account they will realise and operate the systems.

In this case, acquisition would be significantly simplified, and the success rate would increase. ENH could thus implement more projects with the same personnel resources.

[10] https://solaroffensive-hamburg.de/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

In addition, there could be positive changes in the PV and the electricity markets. Furthermore, a possible reduction in investment costs through building cost subsidies is conceivable:

- The prices for modules and other components of PV systems are falling due to more efficient production processes.
- Consumer electricity prices are rising due to higher grid fees resulting from necessary infrastructure measures on the electricity grid. As the latter do not apply to direct electricity, ENH can use the difference to implement higher producer electricity prices.
- If they are obliged to install PV systems, house owners are more willing to contribute to the investment costs of PV systems by means of a construction cost subsidy in the form of advance payments.

5.3.1.3 Worst case scenario

Even the worst case would be caused by a change in the legal framework. Two aspects are possible here:

If the "solar examination obligation" in Hamburg is only weak (many exceptions possible), it will not lead to any noticeable improvement.

Much more serious is the possible impact of the currently discussed reform of the "Erneuerbare Energien Gesetz" (EEG = renewable energy act). The draft contains new and more comprehensive hurdles for the implementation of PV systems from a size of 30 kWp upwards. In addition, the already overflowing bureaucracy surrounding the construction and operation of PV systems will be expanded. The EEG once was an excellent instrument of promoting renewable energies. In recent years, reforms - especially under the current German government - have made the framework conditions for RES increasingly unfavourable.

The implementation and operation of the plants would at least become more difficult and require more personnel resources.

Market situation: Most components of PV systems are currently produced in the Far East, mostly in China. So, another unfavourable factor would be a price increase for the modules and other components of PV systems. This would be conceivable if:

- transport costs increase significantly due to the emissions permit tax,
- When supply chains break down due to the corona problem
- If import duties are imposed because of the prices that can only be obtained through high subsidies
- or China assembles the components itself instead of exporting them and the market becomes empty.

5.3.2 Financial indicators

The following sub-chapters present estimates of the financial calculations and the financial indicators of the business-as-usual scenario. As the markets in the photovoltaic sector and the electricity markets are very volatile, only a momentary view of the current situation can be assumed as a basis. ENH takes the PV-projects realized in the context of mySMARTLife for the financial outcome. The best-case scenario and the worst-case scenario are then qualitatively derived from the business-as-usual scenario.

In order to develop an objective financial assessment, ENH will calculate and interpret the following indicators: Net present value (NPV), Internal rate of return (IRR), Payback period, Return on Investment (ROI) and Return on Assets (ROA); describing what they are considering in each scenario.

All calculations are based on the following assumptions:

- Investment EUR 262,200
- Interest rate 3 percent
- Duration 20 years (minimum for PV projects)
- Annual power loss of the modules 1 percent

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

- Constant feed-in tariff/producer electricity price over the term

5.3.2.1 Net present value (NPV)

Net present value (NPV) is the difference between the present value of cash inflows and the present value of cash outflows over a period of time. NPV is used in capital budgeting and investment planning to analyse the profitability of a projected investment or project. The project is accepted if the NPV>0 at time n.

$$NPV = \sum_{t=1}^{n} \frac{V_t}{(1+k)^t} - I_0$$

Where

t= is the time of the cash flow

n= end of the exploitation period.

k= is the discount rate

V_t=is the net cash flow (cash inflow – cash outflow) at time t.

I_0=is the initial investment

5.3.2.1.1 Business as usual

In this case an Excel-Sheet, that shows the capital development of the projects over the whole lifetime reports a positive result of 45,600 Euro over 20 years.

Investment (€):	262.200,00				
Interest rate (%):	3,0%				
Year (n) 1 = half year of charge in	Income (€) *	process costs (€) 1 incl. start-up costs	Surplus (€)	Discount rate (%)	Cash value (€)
1	12.950,00	2.500,00	10.450,00	0,97	10.145,63
2	25.900,00	2.500,00	23.400,00	0,94	22.056,74
3	25.641,00	2.500,00	23.141,00	0,92	21.177,29
4	25.384,59	2.500,00	22.884,59	0,89	20.332,66
5	25.130,74	2.500,00	22.630,74	0,86	19.521,48
6	24.879,44	2.500,00	22.379,44	0,84	18.742,43
7	24.630,64	2.500,00	22.130,64	0,81	17.994,24
8	24.384,34	2.500,00	21.884,34	0,79	17.275,70
9	24.140,49	2.500,00	21.640,49	0,77	16.585,64
10	23.899,09	2.500,00	21.399,09	0,74	15.922,93
11	23.660,10	2.500,00	21.160,10	0,72	15.286,50
12	23.423,50	2.500,00	20.923,50	0,70	14.675,32
13	23.189,26	2.500,00	20.689,26	0,68	14.088,38
14	22.957,37	2.500,00	20.457,37	0,66	13.524,73
15	22.727,79	2.500,00	20.227,79	0,64	12.983,45
16	22.500,52	2.500,00	20.000,52	0,62	12.463,66
17	22.275,51	2.500,00	19.775,51	0,61	11.964,51
18	22.052,76	2.500,00	19.552,76	0,59	11.485,18
19	21.832,23	2.500,00	19.332,23	0,57	11.024,90
20	21.613,91	2.500,00	19.113,91	0,55	10.582,91
Summe	463.173,26 €	50.000,00 €	413.173,26 €		307.834,28 €
	* degression of 1 % for moduls				
				NPV table:	45.634,28 €

Figure 26: Financial development of the projects, source: ENH

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

5.3.2.1.2 Best case scenario

In the best case, a reduction in investment costs of almost 10 percent was assumed. This assumption is based above all on the expected willingness of the building owners to support the cooperation partners (in this case the ENH) in realising the solar obligation by assuming preliminary construction work (instrument transformers, provision of scaffolding, upgrading the electrical connection), in return for which they do not have to deal with the extremely complex framework conditions for the construction and operation of a solar energy system themselves. These grants represent the greater part of the investment cost savings. A smaller part is caused by falling material prices.

Furthermore, feasible price increases of 3 percent for producer electricity were assumed every five years. This scenario seems possible, as certain electricity price components which do not arise in the case of direct electricity supplies will increase according to available forecasts. In the case of electricity supply contracts that are not long-term price-fixed (tenant electricity), this offers scope for the company to raise its own prices. Contracts with commercial electricity customers are usually concluded for a longer period of up to 20 years at a fixed price.

The assumptions made allow an NPV of EUR 83,000.

Net Present Value (NPV)

Investment (€):	240.000,00
Interest rate (%):	3,0%

Increased Price 3%

Year (n) 1 = half year of charge in	Income (€) *	process costs (€) 1 incl. start-up costs	Surplus (€)	Discount rate (%)	Cash value (€)
1	12.950,00	2.500,00	10.450,00	0,97	10.145,63
2	25.900,00	2.500,00	23.400,00	0,94	22.056,74
3	25.641,00	2.500,00	23.141,00	0,92	21.177,29
4	25.384,59	2.500,00	22.884,59	0,89	20.332,66
5	25.884,67	2.500,00	23.384,67	0,86	20.171,82
6	25.625,82	2.500,00	23.125,82	0,84	19.367,51
7	25.369,56	2.500,00	22.869,56	0,81	18.595,05
8	25.115,87	2.500,00	22.615,87	0,79	17.853,17
9	24.864,71	2.500,00	22.364,71	0,77	17.140,69
10	25.354,54	2.500,00	22.854,54	0,74	17.005,93
11	25.101,00	2.500,00	22.601,00	0,72	16.327,44
12	24.849,99	2.500,00	22.349,99	0,70	15.675,83
13	24.601,49	2.500,00	22.101,49	0,68	15.050,04
14	24.355,47	2.500,00	21.855,47	0,66	14.449,04
15	24.835,27	2.500,00	22.335,27	0,64	14.336,16
16	24.586,92	2.500,00	22.086,92	0,62	13.763,84
17	24.341,05	2.500,00	21.841,05	0,61	13.214,20
18	24.097,64	2.500,00	21.597,64	0,59	12.686,34
19	23.856,67	2.500,00	21.356,67	0,57	12.179,41
20	23.618,10	2.500,00	21.118,10	0,55	11.692,58
Summe	486.334,35 €	50.000,00 €	436.334,35 €		323.221,37 €
	* degression of 1 % for moduls				
				NPV table:	83.221,37 €

Figure 27: Development of the NPV at the best, source: ENH

These calculations neglected the fact that roof acquisition will certainly be easier if solar energy is mandatory and so ENH could implement approx. 20 percent more PV-systems by saving on personnel resources.

5.3.2.1.3 Worst case scenario

A precise calculation of the worst-case scenario is currently not possible, due to the unforeseeable effects of (currently upcoming) legislative changes. However, one thing is clear: if the general conditions become even more difficult without an increase in realisable electricity prices and thus an increase in sales, the economic realisation of such small-scale PV projects will no longer be possible.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Already now, projects that do not generate at least a 50 percent share of direct electricity consumption are no more profitable due to the sharp drop in feed-in tariffs over the last three years. And the feed-in tariff will continue to fall rapidly to 0. As a result, the investments will have to finance themselves and the operating costs through direct electricity marketing on their own. For this, hardly any structures are yet available for systems below 100 kWp.

Consequently, ENH would have to entirely rethink its business model.

5.3.2.2 Internal rate of return (IRR)

Internal rate of return (IRR) is the interest rate at which the net present value of all the cash flows from a project equal zero. IRR is used to evaluate the attractiveness of a project. The project is accepted if the IRR>MARR (minimum acceptable rate of return).

$$\sum_{t=1}^{n} \frac{V_t}{(1+IRR)^t} - I_0 = 0$$

where

t= is the time of the cash flow

n= end of the exploitation period.

Vt=is the net cash flow (cash inflow – cash outflow) at time t.

I0=is the initial investment

The result of the IRR for business as usual is a value of 2.36 percent. This is just about acceptable for a company like ENH, whose focus is on implementing the energy turnaround and not on profit, in low-interest phases such as the current one. However, the results do not give ENH much room for change.

5.3.2.3 Payback period (PbP)

Payback period (PbP) is the amount of time it takes to recover the cost of an investment, or in another words is the length of time an investment reaches a break-even point.

$$PbP = \frac{I_0}{V}$$

where

I0=is the initial investment

V=is the net cash flow (cash inflow – cash outflow) per year, being this value a constant.

Payback period (PbP) is the amount of time it takes to recover the cost of an investment, or in another words is the length of time an investment reaches a break-even point. For the PV projects of ENH realised in the context of mySMARTLife, the date of the repayment of the investment capital used is in the 16th project year.

This long payback period poses a particular challenge for ENH. The roofs on which the PV-plants are built must be in a sufficiently good condition to survive this long period without the need for major repairs. Every repair and every conversion on the roof is associated with costly dismantling and rebuilding work on the modules. In addition, such a situation would lead to production losses, which would further prolong the refinancing and thus the payback period.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Year (n) 1 = half year of charge in	Cashback (€)
1	-252.054,37
2	-229.997,62
3	-208.820,33
4	-188.487,67
5	-168.966,19
6	-150.223,77
7	-132.229,53
8	-114.953,83
9	-98.368,20
10	-82.445,26
11	-67.158,76
12	-52.483,44
13	-38.395,06
14	-24.870,33
15	-11.886,88
16	576,78
17	12.541,29
18	24.026,47
19	35.051,37
20	45.634,28

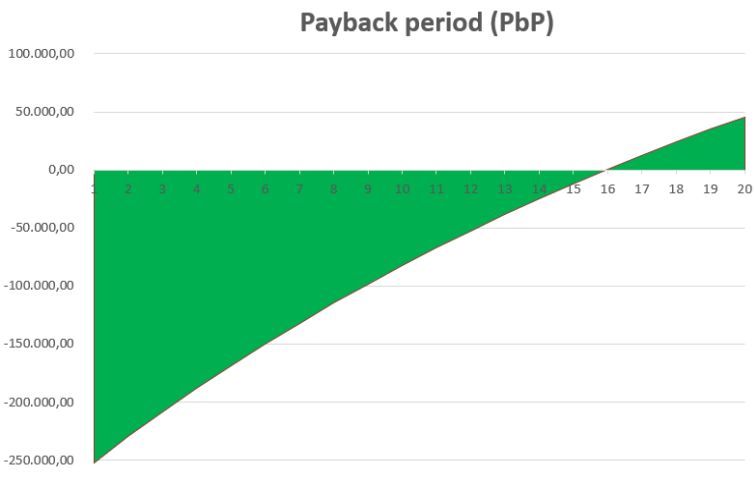

Figure 28: Payback charge, source: ENH

In the case of direct electricity supply to a company on whose roof the system is installed, the company must be examined carefully with regard to solvency and prognosis, since only the revenue from the direct electricity sales can be used to make a profit. The fallback option on the feed-in tariff with its crinkling rates covers hopefully the costs and the investment without a profit rate. So, a profit would no longer be achievable.

5.3.2.4 Return on Investment (ROI)

Return on Investment (ROI) is a performance measure used to evaluate the efficiency of an investment. ROI is calculated dividing the benefit (or return) of an investment by the cost of the investment. The result is expressed as a percentage.

$$ROI = \frac{NPV}{I_0}$$

where

NPV= is the net present value

I0=is the initial investment

Based on a normal situation, the ROI for a project bundle such as ENH has implemented with mySMARTLife is 17.40 percent calculated over the entire term for undisturbed operation and electricity supply. In the ideal case, these success rates would double slightly to 34.68 percent overall, 1.73 percent per year. The occurrence of the worst-case scenario, however, would require completely new strategic considerations.

5.3.3 Other potential benefits

Due to the low profitability of small PV systems, the ENH is currently still dependent on additional income from participation in research projects, conducting training and information events and other services.

The disadvantage of the long terms of the contracts relating to electricity generation with photovoltaics is also an advantage. A plant, once installed and running properly, produces electricity reliably over a long period of time and thus generates revenues.

The Fridays for Future-Activities in 2019 brought a lot of awareness for climate protection. Hoping also, that this will go on to a faster pace, when the corona issues are solved.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

6. Heat Demand Response Service - Helsinki [11]

The Heat Demand Response Service is considered as the next generation of Heat Demand Response Solution which improves considerably the energy efficiency of heating systems by reducing the use of energy and the emission of GHG. This solution is adequate to the demand concerning new models of energy management. To this end, the solution, providing head demand response (Helen), smart energy controls (Salusfin) and smart energy services (Fourdeg) present interesting ERs that are clearly aligned with companies' commercial strategies.

6.1 Part 1: Business model description[12]

Introduction of the solution

The purpose of heat demand response solution is to reduce the need for heat during peak consumption hours and enable greater system level flexibility. Generally, the peak production, that follows peak consumption, is more expensive than the basic production, due to more expensive energy sources, fuels and energy procurement. Therefore, peak consumption times increase the costs as well as emissions of energy production. With consumption being shifted to a different time of the day, the demand response solution aims to flatten out consumption peaks that would otherwise occur.

Helen has evaluated the potential of heat demand response in Helsinki, the benefits in system level and the possibilities to implement heat demand response in a preliminary project Evaluation of heat optimization and the potential of demand response of district heating in Helsinki. The preliminary project was done as a part of mySMARTLife (mainly as a part of actions 13 and 19) and it started in summer 2019 and ended in spring 2020 with definitions of next steps.

This deliverable describes the key findings of the preliminary evaluation project and considers the outcomes of the pilot projects on heat demand response done under mySMARTLife project as well as outside.

The main objective of the preliminary project of Helen was to determine the most realistic and profitable way of deployment of demand response of district heating in the energy system in Helsinki. The focus was on technical implementation possibilities as well as defining the need for heat demand response in the energy system of Helsinki. In addition, customer satisfaction and interests were considered in the project. The key research questions included:

- What is the impact of heat demand response on energy production?
- How heat demand response should be implemented from technical point of view?
- Is heat demand response considered as profitable from the perspectives of an energy company and customers, and what are the other benefits not related to economics (e.g., carbon neutrality targets, environmental responsibility)?

The preliminary project of Helen included few scenario analyses that are presented and discussed in this deliverable as a business-as-usual scenario, best scenario and worst scenario. More information about heat demand response as well as about the district heating system can be found in D4.5 Report on district heating and cooling improvements and new concepts. The results of the mySMARTLife heat demand response pilots in collaboration with smart thermostat solution providers are presented in D4.23 and D4.4.

The figure below presents an overview of the future city energy system of Helsinki. Heat demand response is done between heat production, consumption (i.e., customers) and heat storage systems and it brings additional flexibility to the energy system.

[11] ESADE wanted to include a risk analysis and implementation plan in part 4, as it was presented in the action plan send last December, however, these two analyses were finally included in D8.6, so it does not make sense to repeat it in this deliverable.

[12] The tools to be used in part 1 (value creation ecosystem, internal value chain and business model canvas) were presented last December.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

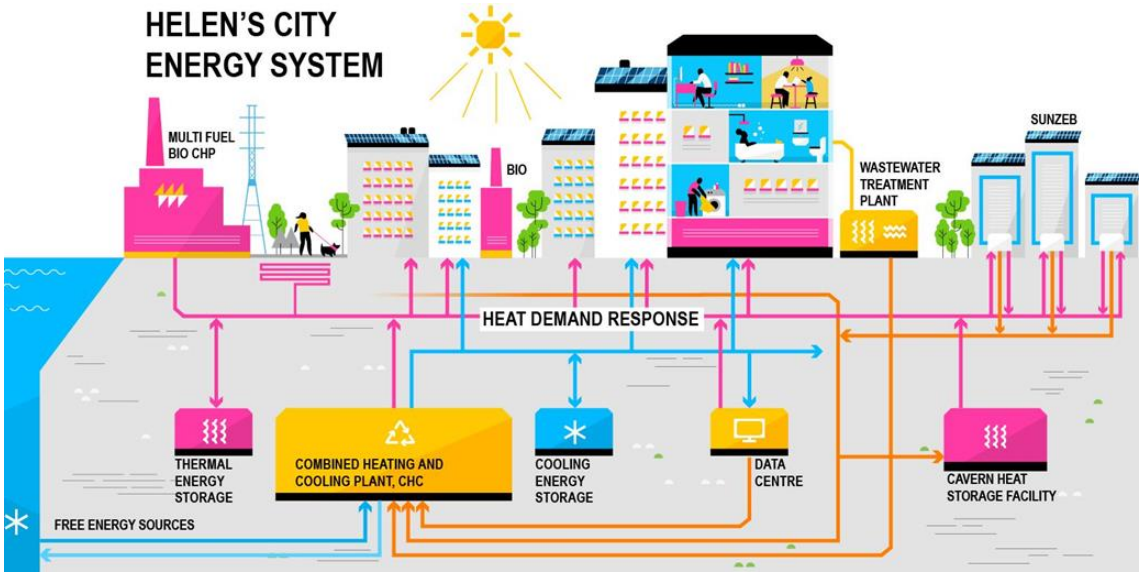

Figure 29: Future city energy system of Helen in Helsinki. Source: Helen Ltd.

Pilot projects

In mySMARTLife, Helen has tested heat demand response via room-level control, i.e., changing the set value of indoor temperature via smart thermostats in an office building and in an apartment building. However, smart thermostats are rather new technology and quite rare in the buildings in Helsinki. Therefore, other means to deploy heat demand response seem currently more viable.

Outside mySMARTLife, Helen has piloted demand response with Heka (Helsingin Kaupungin Asunnot Oy, apartments owned by the City of Helsinki) via building-level control, i.e., changing the temperature setting values of water coming to the radiator network of the building. In addition, Helen has participated in a heat demand response pilot with HUS Helsinki University Hospital. In the hospital pilot with HUS, both the radiator network and the ventilation network temperatures are controlled, and the water set values are changed in order to study the demand response capability of the building.

6.1.1 Value Creation Ecosystem

In the value creation ecosystem (VCE, see Figure 30), Helen is depicted in the middle as the energy company and operator and owner of the district heating network in Helsinki. Helen's main role in the VCE is to provide district heating to its customers and plan and forecast the production and consumption to operate the energy system efficiently. Helen uses production management systems provided by software companies to forecast the production demands and create production plans.

Heat demand response commands would reflect the status of heat production and consumption and the hourly commands would be calculated according to the need for heat demand response during the day. In the business operation, heat demand response commands would be sent to automation service providers via API interface. The automation service suppliers provide the technical capability for demand response control and transmit the heat demand command, i.e., demand response functionality, to the participating district heating customers of the energy company.

The customers in the VCE model include customers connected to the district heating network of Helen. The customers pay a fee for the energy company according to the consumption of district heating.

Currently in Helsinki, the price of district heating is the same during all hours of the day. With the current pricing system, energy company operating the DH network has the biggest interest of the stakeholders in the VCE to apply demand response. Heat demand response could bring system level benefits (economic savings and emissions reductions), if the use of more expensive and/or higher emission heat sources can be avoided during the peak consumption times.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Since the benefits of the solution are in the system level, the direct and immediate economic incentive for individual building owner to participate is small, although system level benefits could benefit the customer in the long run. For larger district heating customers, there could be also economic incentive to participate in a case that a remuneration for the participation is given. However, the drivers for customers to participate in heat demand response are not only related to economics, but to responsibility and contribution to emission reductions. To reach the system level benefits (emissions reductions, savings in the energy procurement), participation of a sufficient number of customers is crucial.

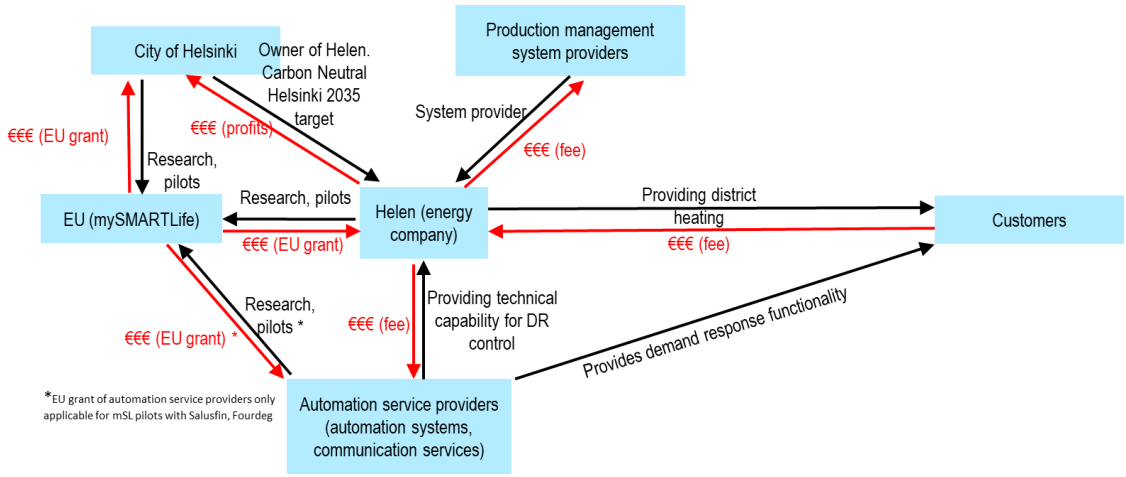

Figure 30: Value creation ecosystem of heat demand response solution

6.1.2 Internal Value Chain

The internal value chain (see Figure 31) depicts heat demand response from the viewpoint of Helen. Heat demand response is a digital service and therefore, some of the columns in the figure are not applicable.

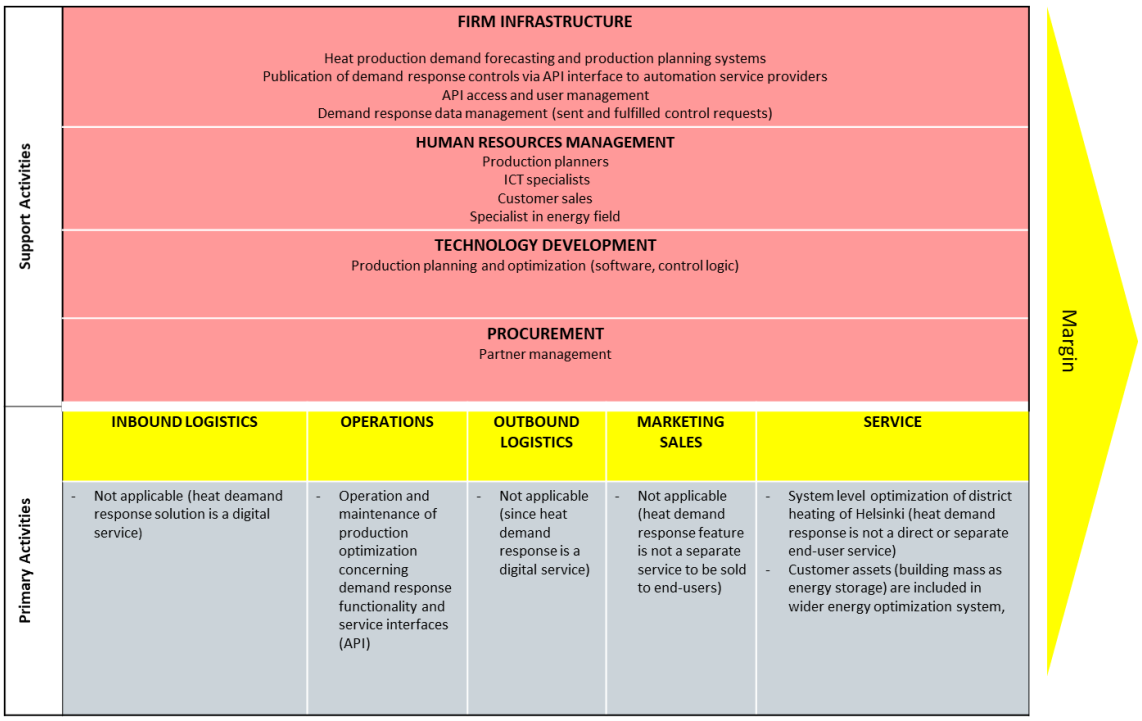

Figure 31: Internal value chain of heat demand response solution

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

The infrastructure and software needed to operate heat demand response include forecasting of heat production need, production planning systems, publication of demand response controls via API interface, API access and user management, demand response data management (sent and fulfilled control requests). In terms of human resources, production planners, ICT specialists, specialists in energy field and customer sales are needed. An important technology development for the energy company is the development of production planning and optimization system (software and control logic) that calculates the demand response commands and enables efficient use of the energy system.

Primary activities include operation and maintenance of production optimization concerning demand response functionality and service interfaces (API). The services created by heat demand response solutions are mostly related to the system level perspective, since heat demand response is not a direct end-user product. Heat demand response enables the integration of customer assets (building mass acting as “energy storage”) to a wider energy optimization system. Therefore, assets (buildings) owned by customers are able to participate in the energy system via demand response. Heat demand response could be offered to the customers together with other products, services and energy efficiency and optimization measures to offer a more comprehensive solution.

6.1.3 Business Model Canvas

The business model canvas (see Figure 32) represents the heat demand response solutions (digital service) from the viewpoint of Helen. For individual and small participants, the benefits of heat demand response are not necessarily reached in terms of economics. The benefits of the solution are in the system level and in the contribution to the emission reduction targets.

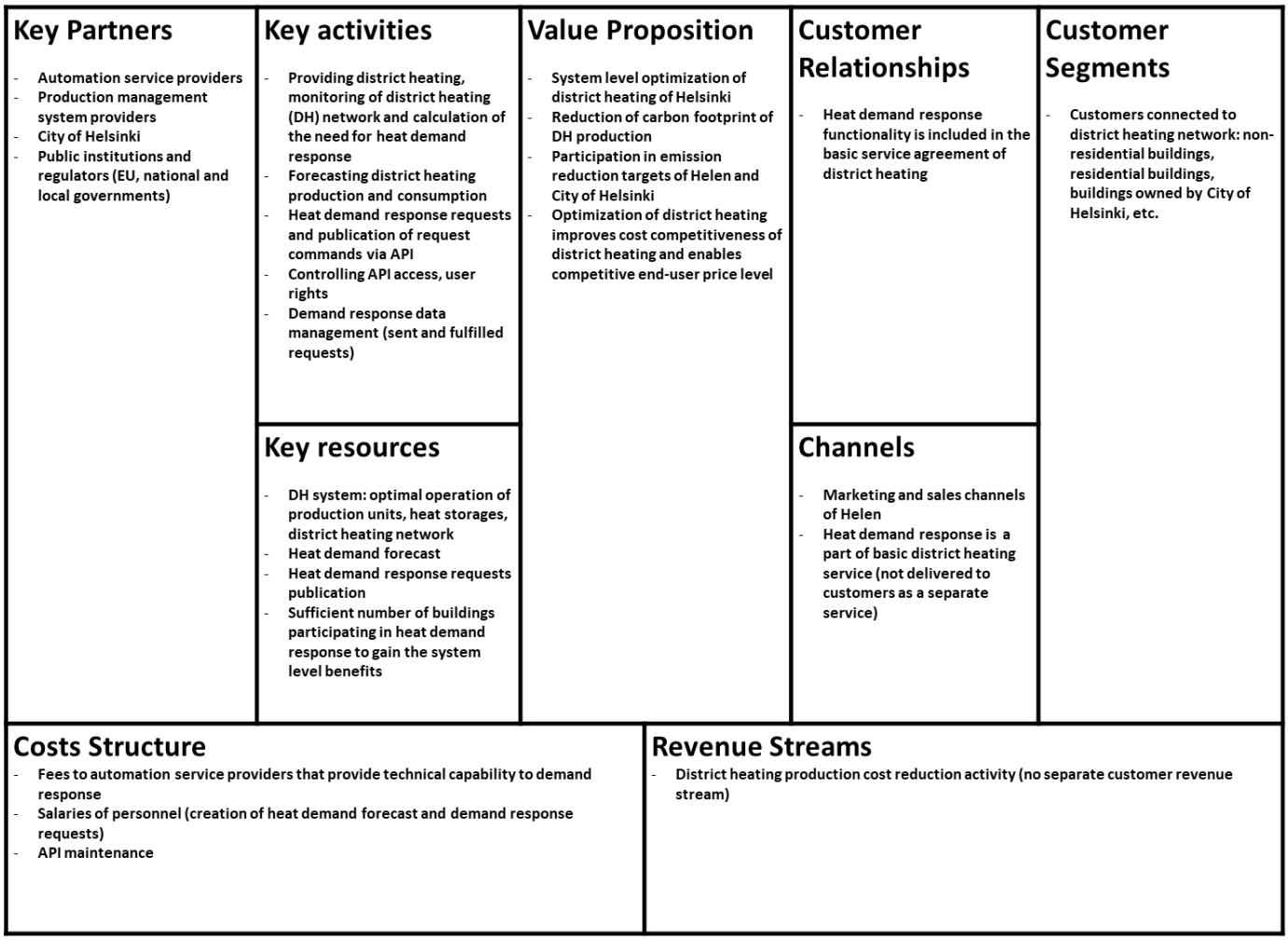

Figure 32: Business model canvas of heat demand response solution

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

If applied in the future system, heat demand response would be a digital service. The demand response of district heating is beneficial for the energy system as it brings additional control possibilities, flattens peak consumption times as well as potentially brings economic savings to the energy production as well as emission reductions.
In the preliminary project of Helen (Heat production optimization and potential of demand response of district heating), the effects of heat demand response to the district heating network were modelled. With small flexibility provision (roughly less than 100 MW), the effects to the pressure differences in the outer boundaries of the district heating network would remain rather small in the case of the district heating network of Helsinki. Therefore, in the power-scale of 100 MW, heat demand response would not have any significant impact on the pumping of district heating or network investments in the case of Helsinki.
If heat demand response is done in the heat distribution facility of the building (central heating system of the building), it is possible to lower the temperature of the return water of district heating and increase the cooling of the water, which helps to improve the energy efficiency of the system and decrease heat losses.
There are several options and technical solutions with different readiness levels to integrate buildings to the energy system and implement heat demand response. At the first stage, the solution could be a simplified, “first generation” version and then later further improved according to the identified needs. Especially for demand response functionality, there are several solutions available, however, the price level as well as the level of integration possibilities differ highly between solutions. For example, in some solutions, no information and measurement data is received (by the energy company) from the conditions of the building without a separate system for it. This would be a clear disadvantage.
On the other hand, there are more complete and diverse solutions available. If the integration is done to the building automation system, the integration enables control possibilities as well as data collection of the building and is therefore, a more comprehensive solution.
The scenarios presented in the section 7.3 are technically based on the solution where integration to the building automation system is done via automation service providers. Heat demand response commands of the energy company would be sent to the buildings by the automation system providers.

6.2 Part 2: Analysis of the preliminary project and pilots (BM validation)

What indicators did you define to assess the performance of your services/product? What kind of data did you take from them? What did you learn from these data? Are your forecasts met?

Preliminary evaluation project - heat production optimization and demand response of district heating

The objective of the project was to define the most realistic and profitable way of deployment of demand response of district heating in the energy system of Helsinki and suggest action points for the coming few years.
The project included several scenario analyses as well as comparisons of different technical solutions. The most relevant indicators in the project were 1) technical readiness and integration possibilities 2) economic feasibility 3) system level impacts and benefits (economical, energy procurement, emissions) 4) comprehensiveness and scalability of the solution.
The section 7.3 of this document describes three different scenarios that were chosen based on the scenario analyses of the preliminary project of Helen. The section 7.3 of this document (financial viability) will describe the key results in more detail.

Two pilot projects of mySMARTLife

Heat demand response was tested via smart thermostats in an apartment building (in Merihaka, Helsinki, smart heating solution of Salusfin) and in an office building (Viikki Environment House in Helsinki, smart heating solution of Fourdeg). The aim of the pilot projects of mySMARTLife was to technically test heat demand response via smart thermostats, but also receive information on how residents/employees experience the indoor conditions (temperature levels). The performance of heat demand response was followed from measurement data (technical analysis).
Feedback from residents/employees was collected to get information on their thermal sensations and whether heat demand response was noticed by the residents/employees. According to the results of these two pilots, heat demand response was not noticed by the residents/employees. However, since the study represents only two buildings and

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

a limited number of answers, no general conclusions can be made. The heat demand response commands were +1 and -1 Celsius degrees and those were transferred to the smart thermostat service providers via API.
According to the pilot experiences, implementation of smart thermostats and piloting the heat demand response functionality was easier in non-residential building. In residential buildings, an internet connection of the housing company (instead of personal internet connections of the residents) would be needed if the communication of the device is done via internet. This would make the installations easier and there would also be a more reliable communication channel to the smart thermostats, which is a perquisite for heat demand response functionality.
Smart thermostats could be suitable to be used for heat demand response in the case that the building already has smart thermostats installed. However, currently, smart thermostats are still rare in the buildings and therefore the solution is not currently well scalable and other technical solutions to implement heat demand response are more promising (i.e., integration to the building automation system and the automation system provider technically enables the functionality of heat demand response).
Results of the mySMARTLife pilot projects are described more in detail in WP4 deliverables D4.23 and D4.4.

Pilot project with Heka

(note: this pilot project was not done as a part of mySMARTLife, but it gives relevant information on the topic of the deliverable)

The aim of the pilot project with Heka (Helsingin Kaupungin Asunnot Oy, rental apartments of the City of Helsinki) was to 1) validate the technical capabilities of the solution 2) define how heat demand response commands can be sent and executed 3) compare different technical possibilities and readiness levels to perform demand response 4) get knowledge about the technical readiness level of the building automation systems to participate in demand response 5) define cost-benefit ratio of the solution (remains small for individual buildings since the benefits of the solution are in the system level).
The project included data analysis as well as collection and/or use of the following data: district heating consumption, heat demand response commands (how much decrease/increase and when), outdoor temperature values, weather forecasts, temperature and humidity of the apartments.
During the pilot, customer feedback survey (a paper survey) was done to receive information on how residents experience the indoor conditions in the apartments. The feedback survey was conducted in selected residential buildings in fall 2019. No link between heat demand response commands and responses of the residents (on their satisfaction level to the temperature conditions of the apartment) was identified during the customer survey period. However, before making any general conclusions, it needs to be considered that the survey was done during fall when the district heating need of the buildings is not as high as during winter.
Overall, the results of the survey and the pilot project were as expected. There are a lot of different factors that affect the temperature levels of the apartments. The influence of heat demand response to the indoor temperature and satisfaction remains very small or hard to identify. Furthermore, it is also personal how a certain temperature level is experienced (i.e., same temperature could be suitable for one and cold or warm for another).

What improvements did you introduce in your product/service during its development/ construction?

Preliminary evaluation project - heat production optimization and demand response of district heating

The scope of this project was to define the most realistic way to deploy demand response and therefore, improvements were not yet done during this project. However, the preliminary project has led to new internal projects at Helen e.g. related to the control and monitoring of a decentralized energy system including integration of customer-owned assets to the energy system (electricity and/or heating/cooling systems).

mySMARTLife pilots

The heat demand response commands of Helen were improved during the project. At the beginning of the pilots, the commands were decided based on predetermined calendars (i.e. fixed control times for each hour of the day). In the later stage of the project, the commands were based on a calculation logic in Helen's production management system. During the research phase, the commands were -1, 0 or +1 Celsius degrees, reflecting the estimated production status and need for demand response in Helsinki. Helen published the demand response commands in

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

a REST API interface and Salusfin and Fourdeg requested the commands via the interface. The smart heating management system (Salusfin's or Fourdeg's during the pilot) used these requests as inputs for heating management algorithms.
The calculation of the heat demand response commands was a pilot version at Helen and in a business operation, the heat demand response commands would be further improved and optimized according to more detailed forecasts.

Pilot project with Heka

The number of automation system providers was increased for the second year of the project. The customer feedback survey was also done during the second year of the project and overall, the number of buildings participating to the project was increased during the second year.

What are the major technical, design, adoption or manufacturing hurdles to be solved?

In general, the major hurdles to be solved are

- How the integration is done to the building automation systems to enable heat demand response functionality? How heat demand response commands are sent and fulfilled?
- The business case of heat demand response is challenging to define
    - Costs vs. benefits: The energy system has a need for demand response, but a single customer does not. There is a risk that the benefits to the energy system in comparison to the customers' expectations about the value of heat demand response do not meet (low economical value for a participating customer). However, for some customers, the solution may have other drivers than economics (contribution to emissions reductions, environmental responsibility for companies).
- There are several different types of building automation systems and several automation system providers with different readiness and cost levels to provide heat demand response functionality. Temperature measurements also need to be installed to the building if heat demand response is done. The different automation systems and several manufacturers create technical challenges.
- Automation service providers do not have ready solutions for heat demand response and/or in worst scenario, the costs of the development of the demand response functionality might result in unprofitable heat demand response operation
- Large buildings need to be analysed case-by-case to determine heat demand response potential of the specific building (heat demand response potential via radiation network and/or via ventilation).
- As the solution and concept are new, some resistance to change could be expected
- The solution may also be market/country and city specific. The benefits need to be defined for each energy system, since the structure of the energy system influences the need of demand response. Furthermore, heating solutions and technical capabilities are also diverse between countries, and therefore technical implementation of demand response may differ.

The solution is well-defined and easily understood by the target customer?

As a concept, demand response of district heating or electricity is difficult to understand for a general customer. Concrete examples would be needed to show the benefits of the solution for general customers. If the target customer group is larger customers (e.g., companies, buildings owned by the city) the concept is easier to understand since these types of customers usually have contact persons specializing in property management and/or energy field and responsibility.
Some larger customers (i.e., companies) have already shown interest for heat demand response. Currently, the motive for customer interest may arise from carbon neutrality targets, responsibility (especially for companies) and from energy efficiency measures in general. Some customers may also have interest in a potential remuneration (economic savings).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

From the point of view of the energy company, the larger customer segments (e.g., companies, buildings owned by the city) are an interesting target group due to the large connection sizes to the district heating network and due to the higher district heating consumption, i.e., more potential for demand response in one large building. Furthermore, in the segment of large customers, air ventilation could also provide potential for demand response.

What are the most complex barriers/difficulties/challenges that costumers are facing when using your product or service?

Heat demand response is a digital service, that is needed by the energy system but not necessarily by a single customer. The target of the solution is that the end users do not notice demand response in their thermal sensations nor in other indoor conditions of the building. Therefore, the solution does not require action from the end users' side, heat demand response is done in the background as is heating of the building.
The challenge with general customers could be the difficulty to understand demand response of district heating as a concept, "stick to old" attitude or fear that the new solution would affect the indoor conditions.
The technical integration of the building to heat demand response may require modernization of building automation systems which would cause costs and therefore, potential participation to heat demand response could be postponed by the customer to a later time when the building automation systems are in the end of the lifecycle and renovated in any case.
For the City of Helsinki, Carbon Neutral Helsinki 2035 action plan and targets are a key driver. However, demand response is only a portion of the solutions and there are other actions with higher and faster impacts on emission reduction targets.

Is your solution within the budget of the target market?

There is no specific existing market for heat demand response solution since it would be a completely new digital service potentially packed with other energy solutions and services to integrate the building to a part of the energy system. Therefore, currently, the demand response of district heating differs highly from the demand response of electricity since for electricity, there are already existing flexibility markets (reserve and balancing power markets) operated by transmission system operators (TSOs).
Currently in Helsinki, the price of district heating is the same during all hours of the day. There is only seasonal price variation. Therefore, currently, energy companies have the highest interest to deploy heat demand response, since customers do not have a price-based incentive to shift consumption hours during the day (there are no cheaper hours for the customer). For the energy company, the motivation is to improve system level efficiency and optimization, develop a two-way energy system, flatten consumption peaks and reach economic savings as well as emissions reductions in the heat production.
The profitability of deployment of heat demand response in a specific building is highly dependent on the technical readiness level of the building automation system provider as well as on how the automation system provider is setting a price for the provision of the demand response feature. Therefore, the economical profitability of heat demand response must be calculated case-by-case, especially in the case of large customers. Furthermore, some automation system providers have more advanced technical conditions to offer heat demand response feature. Generally, heat demand response becomes profitable for the system if enough buildings can be integrated to the solution so that the costs of integration and operation of the service do not make the solution unprofitable for the energy company or customer.

What are the most complex barriers/difficulties/challenges that the market presents to you?

The highest risk is that the buildings are integrated to smart heating systems without considering the needs of the whole energy system. This kind of situation would be harmful from the viewpoint of the energy system and, also from the viewpoint of the energy production, efficiency of the energy system, costs, and emissions.
The readiness level of automation system providers to provide the technical solution for heat demand response functionality varies highly in terms of technical readiness level but also in terms of price levels and needed development work. This creates a risk that the integration costs of the building to heat demand response would be

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

higher than the benefits. In addition, especially with larger buildings connected to the district heating network, the integration and demand response potential must be defined case by case, which reduces scalability and increases the costs of the integration.
Furthermore, as the devices and buildings are connected to remote control, cyber security plays a key role to operate systems securely.

Do you have clear ways to reach your target market? Did you have any problem with the channel through with you deliver your value proposition?

Future pilot projects are needed especially with larger customers and this will be a continuous process to define the digital service of heat demand response and to reach interested customers. The definition of heat demand response concept is a continuous process. Furthermore, cooperation with the City of Helsinki will continue in order to include some of the buildings owned by the city to heat demand response solution in the future. Moreover, piloting with the most promising building automation system providers is expected to continue. Finally, if heat demand response is linked to a more comprehensive solution to improve the energy efficiency of the building, it will make the solution more attractive and will provide more value for customers since demand response would be just one part of the whole service.

Did you have any problem with your key partners? How did you deal with it?

There is a diverse number of technical solutions, with different readiness and price levels, which is making the creation of the big picture of heat demand response more complicated. Some automation system providers already have more advanced systems making the connection of the building to heat demand response easier. The easiest way to proceed with the development of the solution is to continue piloting and discussions with those partners and automation system providers, that have technical readiness with suitable price levels as well as interest for further development and collaboration.

What are the main takeaways you get from pilot interventions and your preliminary project?

The preliminary project on heat optimization and potential of demand response of district heating defined the next steps as well as action suggestions and high-level plans for the coming few years. At Helen, internal new projects have already started as an outcome of the preliminary project, e.g., a development project focusing on control and monitoring of decentralized energy system. The preliminary project also contributed to the decision to acquire an extension to the current production optimization system. The new extension, digital optimization system for district heat production and network, will enable the management of production, consumption, and distribution in the entire district heating network through a single solution. The digital platform will also allow efficient building of demand response control in the future. In addition, the preliminary project defined few scenarios of heat demand response that would be profitable for the future energy system, where coal is being phased out.
The pilot projects within mySMARTLife and outside mySMARTLife gave concrete experiences and lessons on technical implementation of demand response as well as information on how residents/employees of a building experience indoor temperature and whether they notice heat demand response in the indoor conditions or not. The pilot projects also gave information on the future potential of heat demand response especially from the technical point of view.

6.3 Part 3: Financial Viability

6.3.1 Scenarios for business evolution

The following chapters introduce the chosen scenarios of heat demand response solution. All financial calculations are based on estimations and assumptions and are specific for the chosen scenario. The calculations may not consider all costs or risks related to the solution but give an estimate of the financial viability of the scenario.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

6.3.1.1 Business as usual

Currently in Helsinki, heat demand response solution is not implemented (excluding the pilot projects). However, since the aim is to constantly develop the system and improve optimization as well as efficiency, the aim of the future energy system is to include customer-owned assets (buildings in this case) to the energy system. It is therefore foreseen, that demand response of district heating is to be deployed in the future at least to some extent.
Therefore, the current state, without heat demand response, was not chosen as a business-as-usual scenario. Helen has discussed and piloted demand response with Heka (Helsingin kaupungin Asunnot Oy, rental apartments owned by the City of Helsinki) during heating seasons 2018-2019 and 2019-2020. Helen has also discussed potential of heat demand response with the City of Helsinki to include some buildings owned by the city to the solution in the future. Therefore, business as usual scenario assumes that heat demand response is done in the following buildings:

- 550 residential apartment buildings owned by Heka. Selection of buildings would be done based on technical readiness level of building automation systems
- Selected buildings (e.g., business properties, offices, schools) owned by the City of Helsinki. Assumption: 50 buildings connected to heat demand response at the first stage.
- In both cases, integration to the building is assumed to be done via building automation system providers. Costs of the integrations are roughly estimated for the scenario based on internal information at Helen and on discussions with several potential stakeholders.

6.3.1.2 Best case scenario

In the best scenario, in addition to the selected buildings of the business-as-usual case, also larger district heating customers of Helen will get interested and participate to the heat demand response. However, at this point of the research, it is difficult to define the financial viability for the participation of a large customer, since heat demand response potential of this customer segment needs to be defined case-by-case.
Heat demand response of large customers could also include control of air ventilation in addition to the control of radiator network. Furthermore, especially with larger customers, there is a possibility to include other energy solutions to the package with heat demand response solution. In this kind of solution package, the service is a wider solution and heat demand response would be only a one part of it. In the best scenario, the customers would invest in the wider service package.

6.3.1.3 Worst case scenario

The worst scenario would be that the buildings are not included in the heat demand response of an energy company at all. In this scenario, the situation would not continue as it is now either, but rather the buildings would start to use own smart optimization systems according to the specific needs of the building, but not considering the needs of the energy system. In the worst scenario, the system level need is not considered, and this would cause disadvantage to the energy system (district heating system) if the optimization of the energy use of the buildings is not in line with the needs of the system level. This would cause additional costs to the energy companies and peak consumption times would not be flattened. To prevent the worst-case scenario, buildings should be integrated to the energy system so that optimization and control can be done considered the needs of the whole energy system. Heat demand response is therefore highly linked to a wider aspect: how to integrate customer-owned assets and buildings to the energy system. Demand response is needed to support the transition towards decentralized, two-way energy system.

6.3.2 Financial indicators

The following subchapters present the assumptions and estimations behind the financial calculations in high-level as well as shows the financial indicators of the business-as-usual scenario. The best-case scenario and the worst-case scenario are then qualitatively compared to the business-as-usual scenario.

6.3.2.1 Business as usual scenario

Assumptions used in the model to calculate the financial indicators of the business-as-usual scenario include:

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

- Production topology of Helen
- Estimated consumption of district heating
- Estimated outdoor temperatures
- SPOT and fuel price forecasts, price forecasts of emission rights
- Discount rate: assumed to be 7 % (5 % interest rate, 2 % inflation)
- Investment costs and service fees are estimated by Helen based on internal information and assumptions as well as on the discussions with several potential stakeholders and technical solution providers
- Benefits for the energy procurement are calculated based on internal information of Helen as well as on the forecasts and estimations listed above

Key points of the model:

- The consumption forecast of district heating was cut in the model by flattening peak consumption times during the day
- The consumption forecast of the model was cut during times, when the use of non-CHP (combined heating and power) production plants was in the district heating production plan
- Note: The model used in the scenarios and financial calculations gives approximate results, which are dependent on the assumptions. In real environment use, an optimal model to run the energy system would be needed to operate the demand response of district heating.

Other key points of heat demand response solution:
Optimal way to perform heat demand response need to be found from the perspective of the energy system, since after a certain point (i.e. after sufficient maximum power for heat demand response is reached), the energy system does not benefit from any additional demand response power. For example, from the perspective of the energy system, it is not beneficial nor needed to include all buildings connected to district heating network to heat demand response - this kind of investment would be expensive and unprofitable.

Financial indicators of the business-as-usual scenario

The main target of the heat demand response solution is to reach savings in energy production costs and reduce emissions caused by the production by flattening out consumption peaks. The calculation of financial values of the solution is very case dependent, and the profitability of an investment in demand response of district heating should be calculated for each energy system and scenario. The estimations and values presented in the next subchapters are specific for the presented scenario and energy system of Helsinki. For another location, system or scenario, the financial values could differ highly.

Business as usual scenario: selected buildings of Heka and the City of Helsinki

- Assumption: 600 buildings in demand response of district heating
  - 550 residential apartment buildings of Heka, 50 other buildings (e.g., business premises, offices, schools) owned by City of Helsinki
  - Estimated maximum power for heat demand response: about 100 MW
- Investment costs (1.7 million euros) have been estimated based on internal information and discussions with several potential partners. Investment cost is much higher than yearly maintenance & service fees.
- Net cash flow has been estimated to be 0.24 million euros per year (i.e., cash inflow - cash outflow, roughly: estimated savings in energy procurement minus estimated service fees of heat demand response)
- Estimated payback time with optimal use of heat demand response: about 10 years
- Net present value (NPV): positive. According to the NPV, the solution would result in savings in energy procurement and district heat production.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

The following figure is presented to depict the calculation of the NPV and payback time of the chosen scenario. The initial investment is done at year 0 and the considered time in this scenario is 20 years with discount rate of 7 %. As presented in the figure, NPV is positive and therefore, the investment would be profitable for the energy system in the analysed scenario. In addition to the financial indicators, other drivers (i.e., development of carbon neutral, two-way energy system) than financial incentives need to be considered to implement the solution.

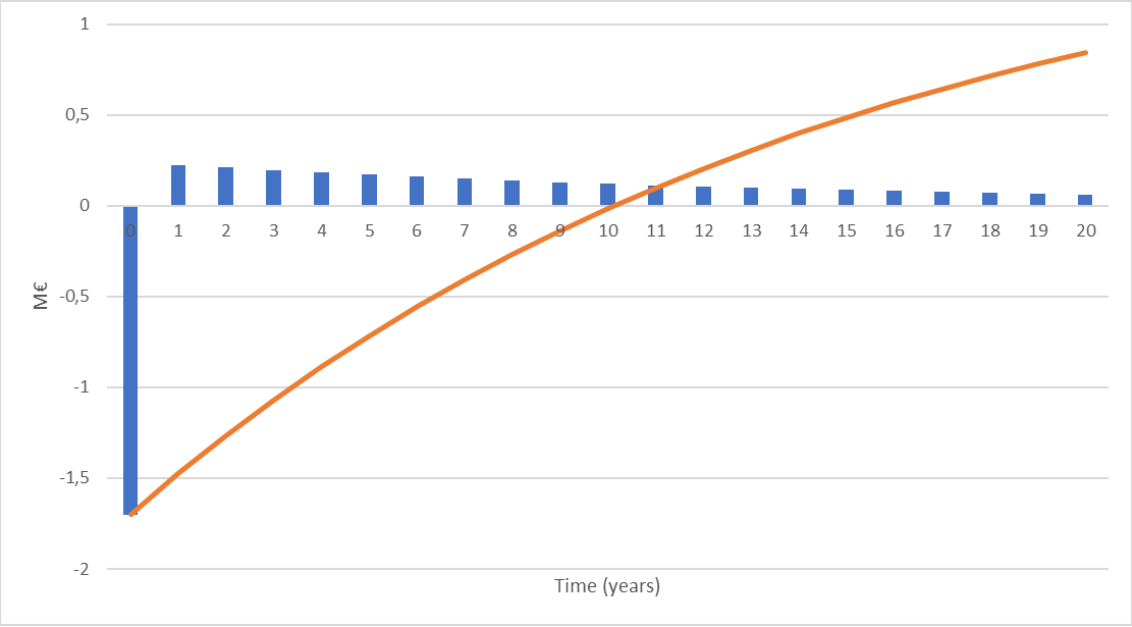

Figure 33: Overview of NPV and payback time for heat demand response solution in the business-as-usual scenario. The figure is based on estimations and assumptions.

6.3.2.2 Best case scenario

The key assumption in the best-case scenario is that it is possible to integrate large district heat customers to heat demand response in a profitable way (i.e., costs of the integration cannot be higher than the benefits). In the best scenario, the energy system is transforming from centralized, one-way system to a decentralized, two-way energy system with buildings and customer-owned assets integrated. The integration of the building to the energy system would also open other new possibilities, e.g., other energy solutions or general optimization of the energy consumption of the building could be offered to the customer at the same time with heat demand response service. Best case scenario includes the buildings of business-as-usual scenario plus few large district heating customers. The target of the best scenario would be to reach the optimal power capacity of heat demand response from the perspective of the energy system. In the best-case scenario, the profitability of the heat demand response in the system level is expected to increase from the business-as-usual scenario.
Since the best-case scenario considers individual, large district heating customers, heat demand response potential of these buildings should be defined and calculated case-by-case. To define the demand response potential of a specific building, a consulting company specializing in built environment might be needed, which increases the costs of the investment.
Due to the needed case-by-case studies, financial values cannot be calculated for the best-case scenario at this point of the research and piloting phase.

6.3.2.3 Worst case scenario

In the worst-case scenario, buildings are not connected to the demand response of district heating operated by an energy company. In this scenario, the situation would not continue as it is now either, instead, the buildings would be connected to optimization systems, but without the energy system level perspective.
In this scenario, the operation of the energy system would become more expensive for the energy company as well as for the customers when compared to the current situation. The worst case could result in higher production

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

costs and emissions, higher operation costs and higher consumption peaks, which would eventually result in higher price of district heating for the customers.

6.3.3 Other potential benefits

There are other benefits than economic savings in the heat demand response solution. In the big picture, the question is about how to integrate customer-owned assets to the energy system and how to operate a decentralized, two-way system efficiently. As an outcome of the preliminary evaluation project (Heat production optimization and demand response potential of district heating), Helen has started a project focusing on the control of the decentralized energy system, including the aspects of demand response of electricity as well as district heating. In a decentralized system, heat demand response could be packed with other energy solutions and services that are offered to the customers.
Furthermore, demand response is a part of the solutions towards a carbon neutral energy system. The carbon neutrality targets as well as responsibility play a key role for companies as well as cities, and therefore, environmental aspects act as drivers to participate in demand response of district heating in the future.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

7. Conclusions

The analysis carried out in this deliverable has served to reach the following general conclusions:

- The analysed companies offer products and services that help the transition to smart solutions in our cities and societies to promote a sustainable future.
- The methodology used for the study of each company, based on business models, is useful to categorize key aspects to take-up strategies for scaling up and replicate the proposed solutions.
- The exploitable results analysed are good examples of the market potentiality of the interventions addressed in SCC1 projects, in mySMARTLife project.
- In general terms, it should be highlighted the economic, environmental, and social benefits achieved if cities promote the four interventions analysed in this deliverable.
- From the organizations perspective, and according to the results presented in this deliverable, there is a business opportunity to replicate the ERs beyond mySMARTLife project, ensuring their long-term economic viability.

The main ideas for each type of intervention are the following:

7.1 Urban Data Platform

- The Smart Urban Data Platform (SUP) solution from TSY, provides a commercial platform for cities to develop their own system, that enables potential customers and bridges existing systems and sensors with others and new ones. The SUP is customizable and easy to implement and the user is not forced to buy a whole set of functionalities.
- The solution provides harmonization, request a low initial investment, and uses open standard features.
- Should be highlighted that there are no common standards or protocols among smart cities to develop and implement the solutions. Nonetheless, the pilot operation has been a very good way to proof TSY assumption from the beginning of the project.
- The pilot provided first insights and feedback about the solution, which helped the company to develop it further. The solution has also brought many insights about existing technical infrastructure in cities and requirements related to special use cases.

7.2 Smart Lighting

- The Smart Lighting solution from Engie has important impacts. The LED technology has been implemented to replace the traditional bulbs aiming to reduce energy consumption up to 60%. Furthermore, the smart lighting solutions thanks to the manageable electronic drivers included in the LED upgrade had contributed to an even bigger energy saving.
- The solution is economically viable, but it has to be adapted to local requirements depending on the type of suppliers and customers requirements in tenders.
- Also, there are concrete challenges related to low price of energy, low price of manpower and qualification of bankable business models for ancillary revenues. On the contrary, according to the financial indicators, the solution is acceptable in two scenarios.

7.3 Electric Power Tenant Supply

- The Electric Power Tenant Supply from ENH is of great value for a green and sustainable community. The solution is based on renewables, it is climate friendly and it provides an empowerment of citizens in the energy

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

sector. To this end, the solution provides an energy transformation in the metropolitan region of Hamburg using latest technical standards with modern components.

- On the contrary, it should be highlighted that the biggest difficulty is to find suitable roofs and homeowners who provide their roof with a long-term contract, as the installation on your "own" roof is the prerequisite for supplying solar power to the house inhabitants - not many house owners are willing to provide roof in a long-term contract without a profitable return -, also legal reforms at short intervals create economic uncertainty.
- Nonetheless, an important driver is that the electricity price for tenant electricity concepts is limited by law to 90 % of the basic supply tariff, which means that the price is even below the usual market price. Finally, it should be mentioned that the financial viability of small projects such as this one is low, but solutions' estimation for scenarios show positive results.

7.4 Heat Demand Response Service

- The Heat Demand Response Service objective from Helsinki (Helen, Salusfin and Fourdeg) was to reduce the need for heat during peak consumption hours and enable greater system level flexibility. The project wanted to define the most realistic and profitable way of deployment of demand response of district heating in the energy system of Helsinki.
- At this moment, there is no specific existing market for heat demand response solution since it would be a completely new digital service potentially packed with other energy solutions and services to integrate the building to a part of the energy system. Therefore, currently, the demand response of district heating differs highly from the demand response of electricity since for electricity there are already existing flexibility markets (reserve and balancing power markets) operated by transmission system operators (TSOs).
- The solution implies some risks, such as buildings which are integrated to smart heating systems without considering the needs of the whole energy system; readiness level of automation system providers to provide the technical solution for heat demand response functionality which varies highly in terms of technical readiness level and also in terms of price levels and needed development work; and as the devices and buildings are connected to remote control, cyber security plays a key role in order to operate systems securely.
- On the contrary, the solution states how to integrate customer-owned assets to the energy system and how to operate a decentralized, two-way system efficiently. As an outcome of the preliminary evaluation project (Heat production optimization and demand response potential of district heating), Helen has started a project focusing on the control of the decentralized energy system, including the aspects of electricity demand response as well as district heating.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

8. References

Argandoña, A. (2011). *Stakeholders Theory and Value Creation*. IESE Business School. 15p.

Blank, S. (2005). "The Four steps to the Epiphany: Successful Strategies for Products that Win". K&S. Ranch Press.

Blank and Dorf (2012). "The Startup Owner's Manual: The Step-By-Step Guide for Building a Great Company". K&S Ranch, Inc. Publishers, USA, 571 p. ISBN-10:0984999302

Casadesus-Masanell, R. & Ricart, J. (2010). From Strategy to Business Models and onto Tactics. Long Range Planning, 43, (1-2), 195-215.

Christopher, M., (2016), Logistics and Supply Chain Management. Fifth Edition, Pearson, UK, 328 p.

Demil, B; Lecocq, X; Ricart, J; and Zott, C. (2015). Introduction to SEJ special issue on business models: business models within the domain of strategyc entrepreneurship. Strategyc Entrepreneurship Journal, 9: 1-11 (2015). DOI: 10.1002/SEJ.1194

De Reuver, M., Bouwman, H. & Haaker, T. (2013). Business Model Roadmapping: a Practical Approach To Come From an Existing To a Desired Business Model. International Journal of Innovation Management, 17(1), 1340006. https://doi.org/10.1142/S1363919613400069

Johanson, J. & Mattson, L. (1992). Interorganizational relations in industrial systems: a network approach compared with the transaction-cost approach. In Markets, Hierarchies and Networks: The Coordination of Social Life, eds. G. Thompson, J. Frances, R. Levačić & J. Mitchell, SAGE, UK, pp. 256-264.

Lepak, D.P., Smith, K.E.N.G. & Taylor, M.S. (2007). Introduction to special topic forum value creation and value capture: a multilevel perspective, The Academy of Management Review, Vol. 32, No. 1, pp. 180– 194.

Mersey Care (2011). "Guidance on completing a Business Case". Service Dvpt & Delivery Department, UK, 15 p.

Mitchell, D.W. and Bruckner Coles, C. (2004), "Business model innovation breakthrough moves", Journal of Business Strategy, Vol. 25 No. 1, pp. 16-26. https://doi.org/10.1108/02756660410515976

Osterwalder, A. & Pigneur, Y., (2009). Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers. Modderman Drukwerk, Amsterdam.

Pfeffer, J. & Salancik, G. (1978). The External Control of Organizations. A Resources Dependence Perspective. Harpwe & Row, Publishers. 300p.

Planellas, M. & Muni, A. (2015). Las Decisiones Estratégicas. Conecta. Barcelona. 205p.

Porter, E. (1985). Competitive advantage. Creating & Sustaining Superior Performance. Free Press, Inc. New York.

Ries, Eric. The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses. Currency, 2011.

Shapiro, J. F. (2001). Modeling the Supply Chain. Pacific Grove, CA: Duxbury Press.

Urzmetzer, F., Martinez, V. & Neely, A (2016). The Ecosystem Value Framework: Supporting Managers to Understand Value Exchange between Core Businesses in Service Ecosystems. EurOMA, Norway, 10 p.

Wynn, M. T., Verbeek, H. M. W., Van der Aalst, W. M. P., Ter Hofstede, A. H. M. & Edmond, D. (2009) Business process verification: finally a reality! Business Process Management Journal,15(1), 74–92.

Zott, C. & Amit, R. (2010). Business model design: An activity system perspective. Long Range Planning, 43(2–3), 216–226. https://doi.org/10.1016/j.lrp.2009.07.004.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.