D5.16: +Trondheim sustainable investment and business concepts and models

+CityxChange | Work Package 5, Task 5.11
Final delivery date: 08-03-2023

Deliverable version	v.0.6
Dissemination level	Public
Authors	Bjørn Ove Berthelsen, Klaus Livik, Tom Jensen, Kelly Riedesel (TK); Roberta Casapietra, Filippo Giglio, Vincenzo Cimini, Giuseppe Martino, Valentina Scavelli (OV)
Contributors	Silja Rønningsen (TK); Bernhard Kvaal (TE); Øystein Bogfjellmo (Relog/NHP); Dirk Ahlers (NTNU)

Article 29.5 Disclaimer
This deliverable contains information that reflects only the authors' views and the European Commission/INEA is not responsible for any use that may be made of the information it contains.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 824260.

Document Information

Project Acronym	+CityxChange
Project Title	Positive City ExChange
Project Coordinator	Annemie Wyckmans, Norwegian University of Science and Technology
Project Duration	1 November 2018 - 31 October 2023
Deliverable Number	D5.16: +Trondheim sustainable investments and business concepts and models
Dissemination Level	PU-Public
License	CC-BY4.0 Creative Commons Attribution, except where otherwise noted. https://creativecommons.org/licenses/by/4.0/
Status	Completed
Due Date	31-07-2022
Work Package	WP5 – +Trondheim
Lead Beneficiary	OV
Contributing Beneficiaries	TK, NTNU, NHP, TE, RK, POW, 4C, ABG, SV

Revision History

Date	Version	Author	Substantive changes made
23-09-2020	v.01	OV/TK	Shared Understanding of the Task/report; basic structure
29-10-2021	v.02	OV/TK	First completed report draft
29-04 2022	v.03	OV/TK	Full ToC incl second draft and new analyses
19-09-2022	v.04	OV/TK	Revised version & inclusion of updated analyses based on completed PEB solutions
08-02-2023	v.05	OV/TK	Report version for internal QA
08-03-2023	v.06	OV/TK	Submitted version

Table of Contents

List of Acronyms

BESS	Battery Energy Storage System
BMS	Building Management System
BRP	Balance Responsible Party
CAPEX	Capital expenditure
CSR	Corporate Social Responsibility
DSCR	Debt Service Cover Ratio
DSO	Distribution System Operator
EIAH	European Investment Advisory Hub
EIB	European Investment Bank
eMaaS	Electric Mobility as a service
EMS	Energy Management System
EPCs	Energy Performance Contracts
ESCO	Energy Service Company
ESG	Environmental Social Governance
EV	Electric Vehicle
FC	Follower City
FRSM	Financing Risk Sharing Model
GA	Grant Agreement
GIEM	Green Investment Evaluation Model
ICT	Information and Communications Technology
KD	Cost of Debt
KPI	Key Performance Indicator
LEM	Local Energy Market
LHC	Lighthouse City
LLCR	Loan Life Cover Ratio
LMO	Local Market Operator
NPV	Net Present Value

O&M	Operation and Maintenance
OI	Operational Income
OPEX	Operational Expenditure
PBP	Payback Period
PEB	Positive Energy Block
PED	Positive Energy District
PPP	Public Private Partnerships
PV	Photovoltaics
RES	Renewable Energy Source
RME	The Norwegian Energy Regulatory Authority (Reguleringsmyndigheten for energi)
ROI	Return On Investment
SDG	Sustainable Development Goal
SPP	Simple Payback Time
SPV	Special Purpose Vehicles
SROI	Social Return On Investment
TIF	Tax-increment Financing
TSO	Transmission System Operator
V2G	Vehicle-to-Grid (2-way EV charger)
WP	Work Package

Executive Summary

This report presents the outcomes and results from the work on sustainable investments performed within the +CityxChange project in Trondheim. The project has focused on developing and fostering the implementation of novel business and investment models for the establishment of Positive Energy Blocks/Positive Energy Districts (PEBs/PEDs). The work comprises financial and economic analyses, and the development and implementation of new, innovative business, investment, and risk sharing models with the objective to show how involved stakeholders can plan for and perform business in PEBs and local energy markets. The models have been improved and adapted to local conditions in cooperation with main actors operating in the PEB. This includes cost and revenue structures for required infrastructure/hardware/software and related financial investments.

The assessment of the sustainability of each investment is described and discussed by applying a defined methodology with a set of belonging indicators. The investment and business models developed, demonstrated, and verified, are targeting real estate companies, the DSO, the local energy market operator (LMO), and solution/technology providers necessary in order to enable the Trondheim PEBs.

Prevailing energy legislation in Norway and energy regulatory issues hamper the establishment of functional and profitable PEBs/PEDs. The +CityxChange project in Trondheim has received a special acceptance from the national regulatory body to trade energy and capacity between actors/assets locally. The Trondheim PEB set-up involving a Local Energy Market (LEM) could not be possible without this acceptance (or a possible dispensation in other cases). The investment and business models and costs/revenues shown in this report are thus only valid for the Trondheim cases, involving energy/capacity trade.

The following models have been developed and applied: Rooftop PV, battery storage, vehicle-to-grid charging (V2G), sector coupling electric - thermal sector, local energy markets (LEM), and a Financing Risk Sharing Model (FRSM) supporting procurement of equipment necessary to establish and operate a PEB. The FRSM provides concrete outputs and results for the calculation of reduced Simple Payback Periods (SPP) and increased return on investment (ROI) for a variety of green and renewable energy measures. The FRSM also supports community development providing the picture of players, investments, revenues, risks, and how they can be shared to optimise business scenarios. All the models represent interventions that, together with energy efficiency measures, make up the constituents of the Trondheim PEBs. In the Trondheim LEMs, energy and capacity are traded between a series of buildings and producers/providers and customers of energy where investment/business models are developed for, and where all assets (PV, battery storage, etc.) work together and are fully interconnected and integrated in order to have fully functional and efficient PEBs. The FRSM is thus a key and a main means to fully analyse the profitability of the Trondheim PEBs.

A relevant and innovative part of the work has been to *move from a cost to a value creation focus*. In order to succeed with a green energy transition we need to shift focus from "total reduced costs" to "total added value", understood as the sum of increased revenues including decreased SPP/increased ROI, increased values of assets/equity, value creation through ESG factors for the private stakeholders, societal outcomes and improvements for the city, and reduced investment needs for critical and important infrastructure.

This deliverable includes investment models for the deployment of the Sluppen and Brattøra PEBs in Trondheim, which are prototype PEBs. The PEBs have a total cost of around 4,1 and 3,7 M€ each. 33 % (Sluppen) and 13 % (Brattøra) respectively of those costs are covered through EU funding; Sluppen higher since more companies there have received EU funding. Despite the extensive EU funding, in-kind contributions make up 62 % of the total PEB Sluppen prototype total cost. Investment costs make up appproximately 70% of the total PEB cost. These calculations are based on investment costs and estimated operational costs. The PEB costs are 105 €/m² building floor area for both PEBs in Trondheim. Calculations indicate that commercial level cases have an initial unit cost of 77-80 €/m² (costs prior to applying the project developed investment and finance models).

With an initial global investment for the Sluppen PEB of € 2.791.103 and considering an average cost price of energy of 0,26 €/kWh, the resulting total revenues amount to € 455.438 with a Payback period of 6 years. The model analysis through using the FRSM gives the opportunity to simulate various scenarios and revenues with different energy prices (as duly described in section 5).

According to indirect impacts analysis, the initial Sluppen PEB investments generated a further € 28 million cascade investments with linked indirect 181 jobs with an estimated leverage factor equal to 1:10 (€ 28 million/€2,7 million). This can be defined as "seed money", i.e. with a potential to generate further investments and impacts.

The main conclusion from the Trondheim PEBs is that they have positive payback periods (SPP) and return on investment (ROI), coherent with stakeholders' expectations, and where each investor/stakeholder shares a different financial risk related to the pro-quota invested and related revenues.

Single intervention investment models are important for benchmarking costs and revenues in PEBs/green energy neighbourhoods. However, an FRSM is a crucial model and tool for concluding whether an area based approach to energy interventions (i.e. PEBs) is profitable or not.
Detailed FRSM analyses further show that

- The total revenue is positive for all actors of the Trondheim PEBs; the highest for the building owner (R Kjeldsberg in this case)
- The cash flow is also positive for all actors
- Simple payback times vary from 2 - 17 years, with an average SPP of 6 years
- ROI varies from 1 - 17 %, with an average of 7,8 %; for building owner RK it is 10,3 %
- For the LEM which is novel and important for the whole PEB solution in Trondheim: Investments take 11 years to be recovered (SPP), and the ROI for the LEM (Aneo - Trønderenergi) is 1,9 %
- An ESG oriented company/business has more easy access to the financial capital market. Lower debt cost (KD) of capital means lower cost debt and lower financial risk
- If a company increases its ESG CSR score by 1 point (i.e they add an additional strength in one of the areas of ESG - CSR or are no longer engaging in an activity deemed as a ESG_CSR concern), there should be a cost debt reduction of around 0,5 points

Other important outcomes and results from the Trondheim cases/PEBs:

- Rooftop PV systems may exhibit net positive revenues from year 8 on when financed through an annuity loan at 5 % interest rate. This requires sales of surplus production in the LEM during 4 Summer months, and a depreciation scheme with a variable monthly (albeit fixed annual) depreciation dependent on the monthly PV production
- The PV case may be profitable from year 1 if, in addition to the factors above, the PV investment receives interest rate support of 3 %. Interest rate support for such a case could for instance be through a national/international funding instrument, or through a mix of public and private incentives (private for instance through a green loan)
- Interest rate support is a far more efficient use of money than one-off funding schemes, in the way that 5 times more PV systems can be funded from year one for the same cost
- The battery storage case is not itself economically profitable due to high investment costs. A battery storage is, however, crucial in PEBs/LEMs involving PV, and a local battery storage being part of a LEM will significantly improve the cost situation. The value of battery storage of 200 kWh can be 13.560 €/year which is close to 70 €/kWh of battery storage capacity
- V2G chargers may have net positive revenue from year 1 if charge/discharge is optimised, and energy/capacity from the EV batteries are sold in a LEM. ROI may be close to 11 % already from year 1, and 27 % from year 8. Total revenues over the assumed technical lifetime of the V2G charger of 10 years are close to € 70.000 for 10 EV chargers at one location, e.g. connected to a commercial EV sharing scheme

PEBs/PEDs/smart energy neighbourhoods are complex systems claiming a larger and precisely defined set of stakeholders. Having such ecosystems becoming economically profitable is even more complex to ensure. A series of lessons are already learnt during the process of setting up and implementing the PEBs, and implementing viable business and investment models for the PEBs:

- Joint cooperation among private and public actors-local authorities is a fundamental success factor
- Building Owner/Real Estate developer and in the Trondheim cases the Local Market Operator (LMO) are core players in the PEB implementation success
- PEB implementation needs public funding at an early stage in order to design and test tailored business models in the pilot phase
- A public body/local authority is needed as driver and facilitator for escalation to PED, replication and for overall profitability
- Moving to a total value concept is a long and complex process that requires a long planning phase, strong dialogue among local stakeholders, system thinking and a collaborative mindset. This process has to be governed, preferably by a player that can be a recognised public authoritative stakeholder or a cooperative team

The work on sustainable investments has brought about innovative investment and business models including solutions on how to analyse and calculate the cost structure and profitability of Positive Energy Blocks. Experiences have been gained and processed from the PEBs, local energy markets and use cases. The report also addresses how the financial models and analyses fit in and can be applied for the operation of smart, green energy neighbourhoods.

1 Introduction

This report describes the necessary actors and their roles and responsibilities, preconditions, and ingredients in order to develop, establish, and verify new investment and business concepts and models for Positive Energy Blocks (PEBs) in the European Lighthouse City (LHC) of Trondheim, with local energy resources and local energy markets as key content and options. A PEB is in the LHC Trondheim demonstrations understood as a minimum of three buildings including energy interventions, local renewable production, energy storage, and local energy distribution and redistribution. A defined goal is that the PEB consumes less energy than what is generated locally over a year. This means that the developed investment and business models are focusing on local energy resource optimisation.

Establishing a PEB, or a smart energy neighbourhood, means moving from single buildings and single interventions to combinations of integrated interventions on an area level. A requirement and precondition for the prevailing project is that the demonstrated PEBs are scalable to district level as Positive Energy Districts (PED) and preferably beyond as described in figure 1.1.

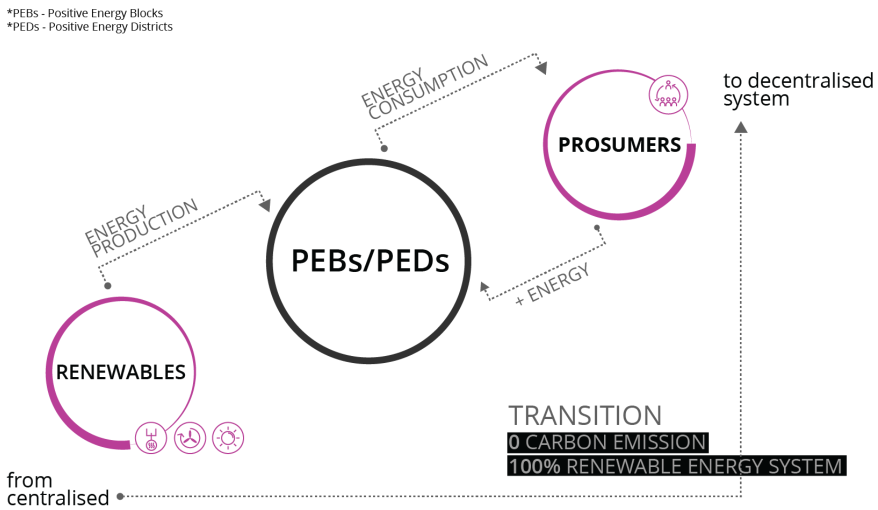


Figure 1.1 The PEB/PED approach - moving from single buildings consumption towards local energy systems. (Important definitions and terms are described and explained elsewhere [1 2 3]. Source: +CityxChange.)

Investment and business concepts should be developed in a way that enables upscaling and replication. The new models need to make sense and become important to create businesses, products and services.

The main goal is to develop new business concepts and models for a green energy transition. This involves the design, development, and verification of novel investment and business

[1] https://cityxchange.eu/knowledge-base/positive-energy-block-peb/

[2] https://smart-cities-marketplace.ec.europa.eu/action-clusters-and-initiatives/action-clusters/sustainable-built-environment/positive-energy

[3] https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/lc-sc3-scc-1-2018-2019-2020

models for increasing revenue streams, decreased payback times (SPP), and increased return on investment (ROI) for innovative energy solutions.

The report addresses and describes measures and actions that enable and boost innovative, sustainable investments for building owners, real estate developers, local energy market operators, and DSOs (Distribution System Operators), and important service, solution, and technology providers.

Additional objectives and goals are:

- Map and monitor stakeholders' prevailing business models using a project developed interview guide
- Business model improvements which take into account impacts of the frame condition changes including regulatory mechanisms, and scenarios on how and to what extent legislative changes may improve business models on a longer time scale
- Detailed economic analyses and forecasting tools especially designed for sustainable commercial interests businesses and DSO/LMO investments; for maximising impacts including environment/energy, cost/benefit, and return on investment for scaling up and replication throughout the city
- Feed the improved and disruptive business and investment models into the +CityxChange work on upscaling, replication, and commercialisation (WP8)

All across Europe renewable investments and measures are increasing in numbers and volume. However, in the public descriptions and discussions of these projects, it is still a strong focus on cost rather than value creation. An important goal for the +CityxChange project is to innovate and demonstrate how sustainable investments and business models enable a shift from a cost to a value creation focus. "Total added value" and "total value creation" including societal, job creation, and additional investment outcomes are essential for the city/local communities and are highly important in this context.

This report has the following structure:

- Section 2: Methods, models, tools for economic analyses and forecasting, and basics on value creation
- Section 3: Trondheim demonstrations projects and the PEB approach
- Section 4: Innovative funding solutions
- Section 5: About the Financing Risk Sharing Model (FRSM) and financial and profitability analyses for the PEB as a whole
- Section 6: Investment models for single interventions (PV, battery storage, etc.) and value creation of single solutions
- Section 7: Investments and replication monitoring
- Section 8: Conclusions, lessons learnt, and recommendations.

Project structure and task dependencies, project KPIs, and detailed project data, calculations, and analyses are provided in the Annex. New models enabling upscaling and replication are important for the city in order to enable a green energy transition. This means that the city authorities need to be active in the development phase. In Trondheim, this is closely linked to main goals in the societal master plan for Trondheim, *Trondheimsløftet*[4].

[4] https://sites.google.com/trondheim.kommune.no/kommuneplanen/samfunnsdelen

2 Methodology and models

2.1 Development approach for business methods and models

The approach, methodology and work in +CityxChange on Sustainable Investments[5], are presented in the report D2.4 - *Report on the bankability of the demonstrated innovations* (Cimini, Giglio, Carbonari, 2019)[6]. Basic bankability concepts are characterised by being acceptable to/at a bank, having a high profit potential/guarantee, bringing acceptable cash flows and having a high probability of being viable and successful over time. This is implemented in the PEB and local energy markets frameworks and solutions. From that, the new value chains are derived leading to the development of the integrated investment model as described in figure 2.1.

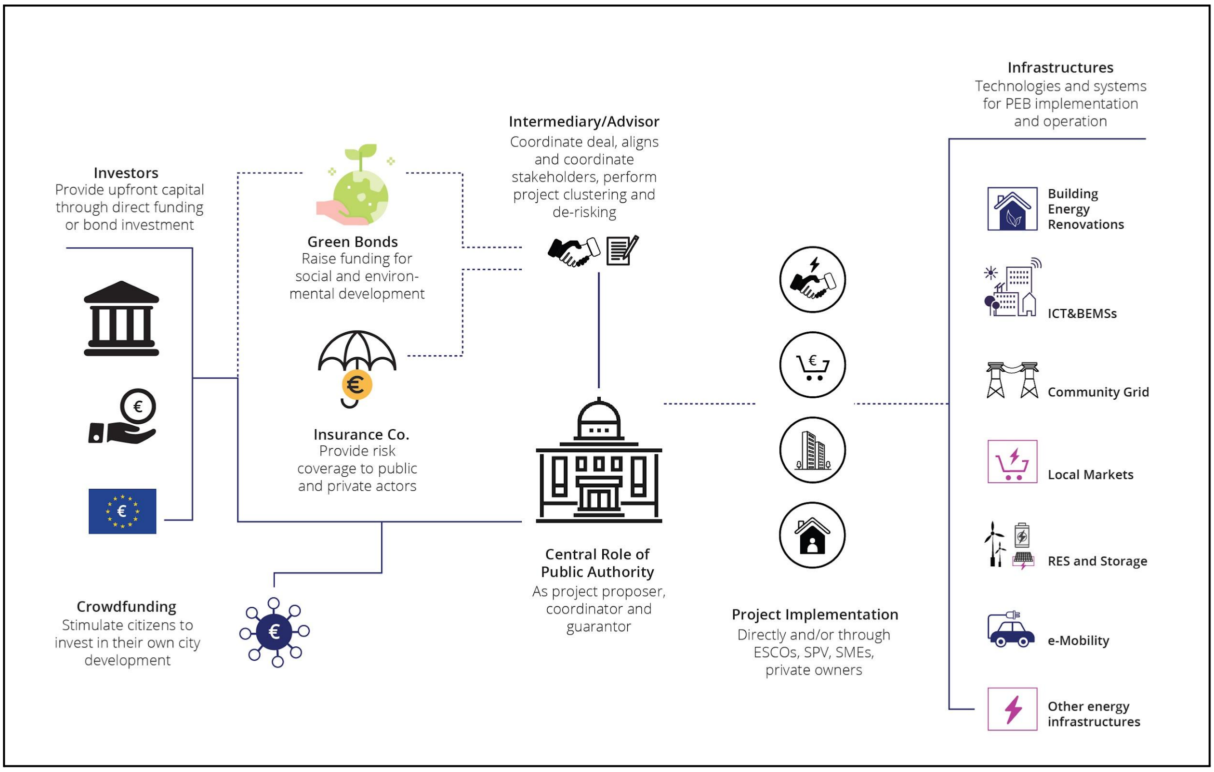


Figure 2.1 Generic Integrated Investment model for implementation and operation of PEBs and Local Energy Markets. Source: +CityxChange report D2.4 - Report on the bankability of the demonstrated innovations (Cimini, Giglio, Carbonari, 2019)

The business concepts, models and investment performed in the present work are especially designed for Positive Energy Blocks (PEB), scalable to district level (PED).

2.2 Investment and business models in a value creation context

The project focuses on individual and concrete investment and business models on the asset level in addition to a financial sharing risk model (FRSM) on the building/company and area level. It combines those in order to maximise revenue, reduce payback times and

[5] +CityxChange Tasks 5.11 and 2.7
[6] https://cityxchange.eu/knowledge-base/report-on-bankability-of-the-demonstrated-innovations/

increase return on investment[7]. The applied models and underlying calculations integrate impacts of external frame conditions, funding opportunities, etc. It includes taking into consideration the positive impacts of ESG factors on the final business models. This is executed on a qualitative level since these are difficult to quantify at present. As presented in figure 2.2. frame conditions, developed FRSM, funding schemes, and ESG factors contribute to several parts of the total value creation process.

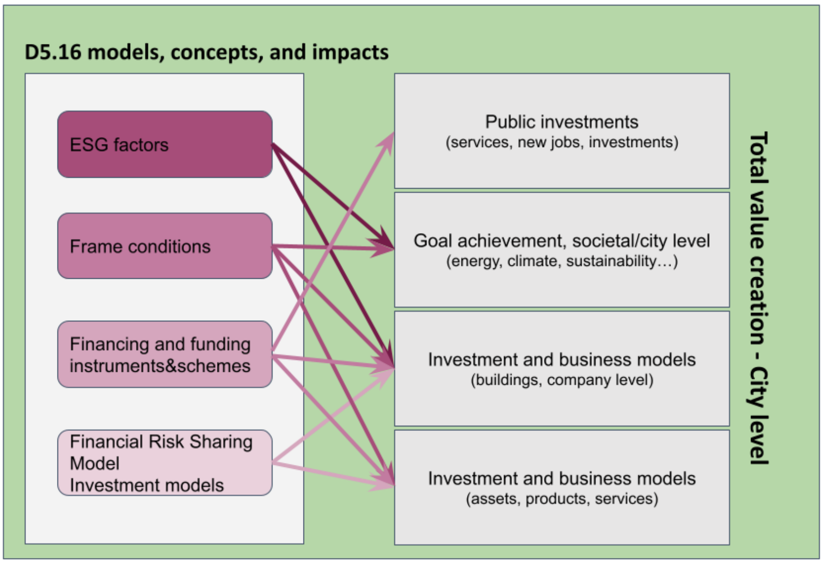


Figure 2.2 Accumulated value creation for green/renewable energy measures in the city.

Constituents included in the analyses, calculations, and developed models grouped in financial and technical segments are:

- Investment models for PV, battery energy storage system (BESS), V2G/eMaaS, and local market actors and assets
- Technical solutions involving value propositions which involve the businesses building owners, local market players, and tech solution providers. The asset focus is on BMs for V2G, BESS, sector coupling, and PV

Single intervention investment and business models are important in the prevailing project, due to extensive such measures being performed. However, taking the PEB perspective and deploying a Local Energy Market (LEM) claims the joint efforts and investments by a series of actors. This implies that investment and business models will be extensively intertwined and dependent on each other; i.e. there are more actors to share the risk, but also several actors to share the revenues. For a PEB approach, including a LEM in the LHC Trondheim case, a specific type of model is important: A Financing Risk Sharing Model (FRSM). The FRSM is capable of handling a series of interconnected interventions and provides outputs and results on a series of financial KPIs, not the least the profitability for the individual actors involved, and the profitability for the PEB. Investment Models (IM) in combination with an FRSM especially developed and tailored for PEBs is a powerful tool for the +CityxChange itself, but also for the city moving towards scaling and replication.

[7] CityxChange KPIs 24 and 25

It is important to keep in mind that the *total* value creation for sustainable, green energy measures on the city level also comprises societal values (figure 2.2). The +CityxChange models include concrete investments, business, and FRSM. They are developed taking relevant international, national, and local frame conditions and financing/funding schemes and ESG into consideration. The D5.16 outcomes are important and valuable on a city level, they provide value creation beyond the commercial side, and can be used as input for LHC Trondheim Bold City Vision (*Positive Energy City 2050*) including a green energy transition in the city.

2.3 Tools for economic analysis and forecasting

2.3.1 Introduction to models used in a value creation approach

A variety of financial models and tools are developed through the +CityxChange project. This section describes the different models, how they are interconnected, which models are being implemented in Trondheim, and which models are developed but not implemented.

The models comprise single intervention level models (PV, battery storage, etc.), a novel Financing Risk Sharing Model (FRSM), and a Green Investment Evaluation Model (GIEM). Most models are primarily focusing on investment analyses, while the GIEM represents a flow sheet displaying pathways from a now-situation up to interventions on a local energy system level. The demonstrations at Sluppen and Brattøra are a combination of renewables, energy storage (stationary and batteries through V2G chargers), other innovative interventions like sector coupling, and a developed and implemented Local Energy Market.

The integrated interventions imply several actors, where risks and revenues will be shared. For this reason, an innovative novel +CityxChange developed FRSM is implemented to demonstrate total revenues on a system (PEB) level, as well as revenue/value shares between the different actors involved.

To boost and optimise revenue on the PEB level, investment and business models and value propositions have been developed for single interventions. They are implemented as models to showcase and display innovative opportunities. The models are only partly demonstrated.

The models developed, implemented and/or demonstrated - and the relation between them - are shown in figure 2.3. Details including who has developed the different models and where in the report they are described are summarised in table 2.1.

In addition to the models displayed in figure 2.3 a number of systems, analyses, and methodologies have been included, as they are crucial in order to build and obtain data and results for the total value capture in PEBs. Examples are:

- Financial analyses of PEBs
- Innovative risk analysis based on ESG and Corporate Social Responsibility (CSR)
- Basic value capture approach and methodology
- Investments and replication monitoring methodology

These are all developed and deployed by OV, also performing the necessary analyses, work, and calculations.

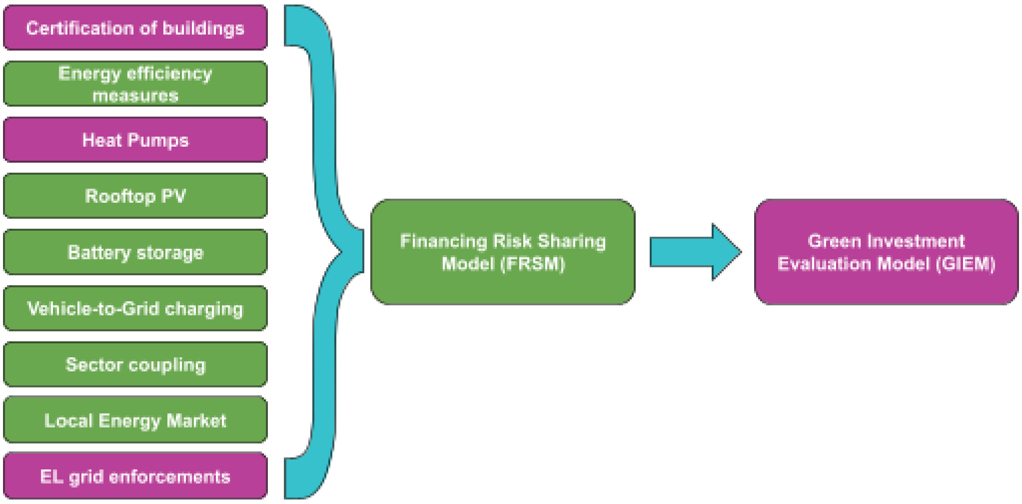


Figure 2.3 The interrelationships between the developed models and tools. Green models: Developed and implemented. Purple models: Developed but not implemented.

Table 2.1 List of developed individual models, who is the owner(s), whether implemented or not, and where to find details/descriptions in the D5.16 delivery report.

Model	Developed by	Report reference	Comment
Certification of buildings	NHP (Relog Property)	6.2 Annex 6	Not implemented.
Energy efficiency measures	RK	6.8	Implemented at Sluppen.
Heat pumps	NTNU / TK	6.6	Not implemented. All HPs (8) however integrated with the PEBs and local energy market. HPs integrated with sector coupling (7.8). Specific model developed for projecting/engineering of new HPs (Annex 8).
Rooftop PV	TK	6.3 Annex 8	Implemented. Sales of production (kWh) and capacity incl. peak shaving (kW).
Battery storage	TK	6.4	Implemented. All 4 use-cases will be implemented.
V2G	TK	6.5 Annex 10	Implemented. EV sharing company centric model implemented.
Sector coupling	TE (Aneo)	6.6	Implemented at Sluppen. Shift between HP and district heating.
Local Energy Market	TE (Aneo)	6.7	Implemented. Sales of local production, user flexibility, incl capacity + system services.
Financing Risk Sharing Model	OV	5 Annex 9	Implemented. Overarching model for PEB and LEM value creation.

2.3.2 Demonstration of a green investment evaluation model

The Green Investment Evaluation Model (GIEM) is developed by Trondheim Municipality (TK). Figure 2.4 visualises and describes the pathways of alternatives (A1- A5) from the now-situation (pre-intervention stage) to the highest level within the Trondheim PEB project - an operational Local Energy Market including a variety of services and products traded (energy, capacity, system services). It comprises the most important interventions and ingredients within the Trondheim PEBs (local, energy smart neighbourhoods) ecosystem. Both the single intervention models and the FRSM in figure 2.3 will provide crucial inputs to the GIEM. This GIEM is the basis for the single models that provide inputs and data (costs, revenues) to the possible alternative outcomes presented in figure 2.4.

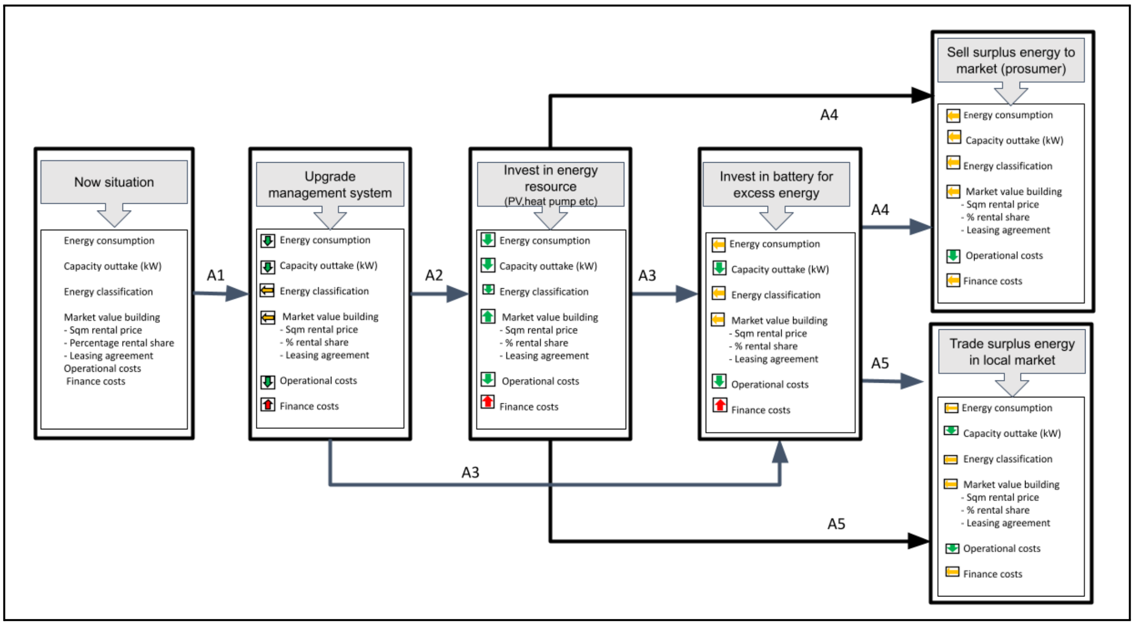


Figure 2.4 +CityxChange Green Investment Evaluation Model(GIEM) for the demonstrated PEBs in Trondheim describing alternative pathways (A1-A5) towards a functioning Local Energy Market or a seller of surplus. Green arrows: Factors that can increase revenue. Orange arrows: Factors that neither increase or decrease revenue. Red arrows: Factors that decrease revenue.

The GIEM model described in figure 2.4 defines several alternative energy related investments and decisions based on financial analyses. From the now-situation, the alternative steps from a cost benefit approach are addressed towards possible trade in a local energy market or sale of surplus to the power market. During the different steps, it requires several analyses and decisions. The GIEM can be used as a flow sheet that describes different priorities/pathways from now-situation and moving forward. All identified alternatives presented in the GIEM are listed and described in table 2.2.

Table 2.2 The alternatives (A1-A5) which describes potential actions outlined from actual energy performance and cost (now-situation).

Alternative (A)	Description
Now-situation	Building status regarding energy performance and cost.
A1	Prepare for further green investment evaluations and upgrade of energy management systems.
A2	Invest in energy resources to improve the building's green performance.
A3	If energy resources and/or flexible consumption are in operation - invest in a battery for excess/surplus electricity(energy, capacity).
A4	Sell excess/surplus electricity to the market as a prosumer/producer.
A5	Trade excess/surplus electricity in the local market.

Each alternative action (A1-A5) is a result of evaluation of financial analyses performed on alternative energy investments that will improve the buildings' green performance.

3 LHC Trondheim demonstration projects

3.1 LHC Trondheim Positive Energy Blocks

In LHC Trondheim the two demonstration areas Brattøra and Sluppen are set up using a specific methodology for operating a PEB. Within the demonstrations, there are costs covered by EU funding, in-kind financing, and 3. party financing. Another important factor in setting up a PEB is considering the local ecosystem and looking into factors such as the local energy market and which actors will be involved in implementing the project. When the demonstration projects in LHC Trondheim are completed, it is important to conclude results in order to improve and innovate for the future. This chapter represents an evolution of D2.4 (*Report on bankability of the demonstrated innovations*). The tables included there have been used as a basis for the updated representation of the PEB business models ecosystem in Trondheim and its improvements.

Brattøra is a dynamic PEB with a defined geographical boundary where all renewable power is generated from local resources within the geographic boundaries. Sluppen is a virtual PEB where parts of the renewable power are generated outside the geographic boundaries as described in figure 3.1.

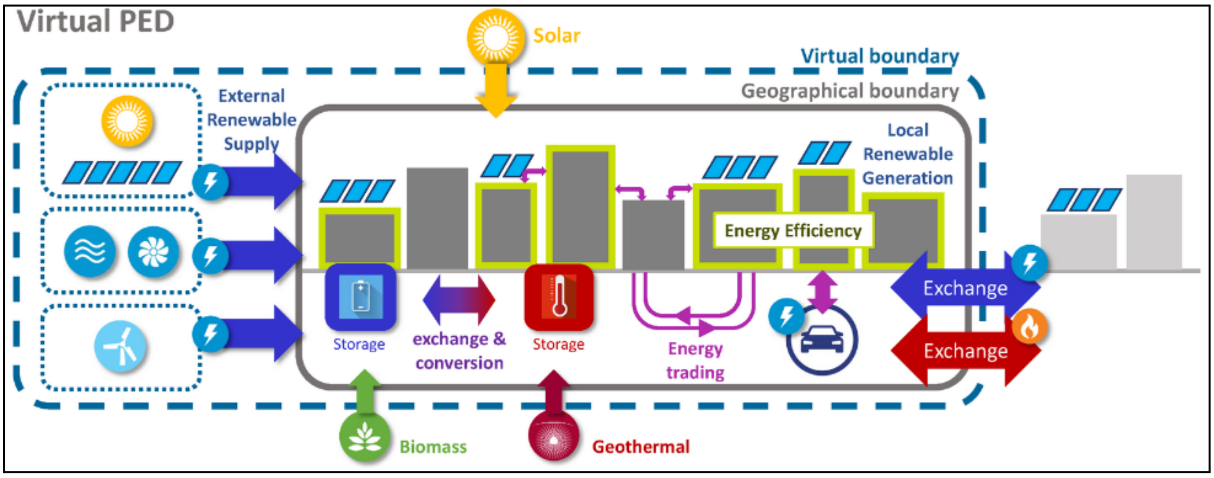


Figure 3.1 Description of virtual and dynamic PEBs/PEDs. (Source: Vandevyvere, Ahlers, Wyckmans, 2022)

There are no differences between dynamic and virtual PEBs concerning the development of investment and business models and the finalised models.

The demonstration areas and PEBs in LHC Trondheim are shown in figure 3.2, including the specific buildings making up the different PEBs. Detailed information about the Sluppen and Brattøra PEBs and PEB set-up is provided in table 3.1 below.

Figure 3.2 The LHC Trondheim demonstration district of Knowledge Axis (Kunnskapsaksen) with the three demonstration areas of Sluppen, Brattøra, and Campus NTNU. Sluppen and Brattøra make up Positive Energy Blocks (PEBs), and are the demo areas focused on in this report.

The Trondheim PEBs (balance between local generation and consumption) are obtained as the sum of:

energy efficiency measures + local energy generation + local energy (flexibility) market

Figure 3.2 uses the term Local Flexibility Market (LFM), because local end-user flexibility makes up an important part of the total volume of energy traded. Throughout the report Local Energy Market (LEM) is consequently used covering all local trade/exchange of locally generated energy.

The LEM is a key ingredient in the Trondheim PEB set-up, as it makes it possible to substantially increase the utilisation of locally available energy. The LEMs at Sluppen and Brattøra also add significantly to the PEB value creation in Trondheim, and are specifically addressed in this report. Important to note is that the Brattøra LEM comprises a series of buildings other than the PEB buildings, in order to obtain sufficient volume of energy traded.

See section 3.2 for the specific demonstration projects performed in Trondheim, and which demonstration projects that are specifically related to sustainable investment and business concepts and models, and thus addressed in this report.

Table 3.1 Details on the LHC Trondheim PEBs of Sluppen and Brattøra.

PEB [buildings] [m² SFA]	Initial consumption [kWh/year]	Remarks
Sluppen [5] [39426]	4.350.299	Four commercial buildings and one health care centre [1)]. Buildings are mixed-use comprising offices, wholesalers, restaurant, cultural venue, climbing centre, and local industry. Virtual PEB (figure 3.1) due to import of thermal energy from seawater heat pump system at Brattøra and PV from remote PV farm at Byneset. Sector-coupling EL - thermal is performed here, with dynamic utilisation of heat pumps (using both grid and locally generated EL) - and district heating, based on a new dynamic DH pricing model de-coupled from the EL spot price Interventions included: PV, heat pumps, battery storage, EV batteries/V2G, energy efficiency measures, waste heat recovery, Local Energy Market (LEM). LEM comprises all PEB buildings.
Brattøra [3] [35176]	2.286.636	Three commercial office buildings. Dynamic PEB (figure 3.1). Sector-coupling is not demonstrated at Brattøra, although thermal energy makes up an important share of the energy supply. A large seawater heat pump system serves all 3 PEB buildings. Interventions included: PV, heat pumps, battery storage, EV batteries/V2G, Local Energy Market. Buildings are initially very energy efficient; no efficiency measures are performed. LEM comprises 5 more buildings/ installations than the PEB ones in order to have a sufficient selection of buildings and assets for the market: pedestrian bridge w/heat cables, E-Bus charger, museum, additional office building, cold storage facility.

[1)] Health care centre is a replication case w/PV, heat pump, energy efficiency measures; part of Sluppen Local Energy Market.

The PEBs are connected to the city district heating grid, and have connected EV batteries and the Local Energy Market through V2G chargers. The battery storages (540 kWh/500 kW) are connected to the grid and individually metered.

3.2 The LHC Trondheim demonstration projects

Eleven demonstration projects are being performed in Trondheim, now undergoing monitoring and evaluation, and early stages of scaling and replication as presented in figure 3.3.

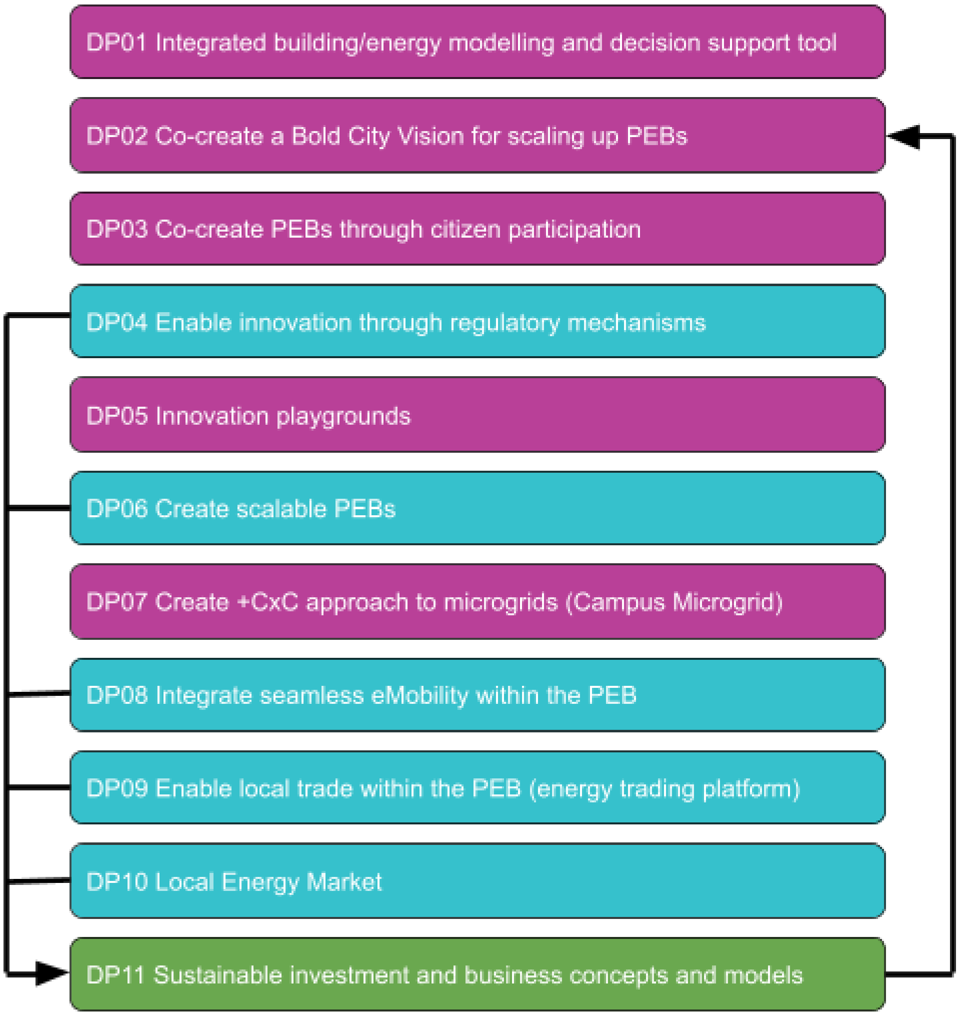


Figure 3.3 The 11 LHC Trondheim demonstration projects (DPs), including the demo projects that relate to the investment and business model developments and implementation.

Five of the demonstration projects provide inputs to the sustainable investments demonstration project. DP04 provides inputs through energy regulatory barriers and opportunities for investments. DP09 with its deployed energy trading platform/solution is mainly an enabler for performing energy trades in the local energy markets at Brattøra and Sluppen. The main inputs for developing the DP11 concepts and models emerge from the PEB (DP06), EV sharing/EV batteries w/V2G, and Local Energy Market (DP10) provide the most crucial frameworks and inputs to establishing viable investment and business models.

Developed, deployed, tuned, and verified investment and business models will provide inputs to the roadmap on how to move towards the LHC Trondheim Bold City Vision of *Trondheim Positive Energy City 2050*.

Important input factors are the set-up, design, and content in terms of specific interventions and inclusion of RES of the DPs 06, 08, and 10; the most important ones are PV, battery storage, and heat pumps. Additional key input are: energy prices (EL and district heating), grid tax for EL, values/prices (price models) on energy, capacity, and system services sold to the buildings/local market under different conditions (time of day/year + possible grid bottlenecks, willingness in the market to pay a certain price for the traded energy, etc.), Capital Expenditure (CAPEX) and Operational Expenditure (OPEX) of the single interventions and investments, type of financing (loan - and type of loan, cash), interest rates, depreciation times and depreciation rates and schemes, and degree of external funding.

Based on the *value network analysis* and the innovative value chain as identified in the framework of Trondheim PEBs in the report D2.4 on *Bankability of the demonstrated innovations*, subtask *Business Models Monitoring* is focused on an in-depth analysis of each player's current business model to identify or propose potential improvements linked to PEB/LEM implementation. This is described with an overview in figure 3.4.

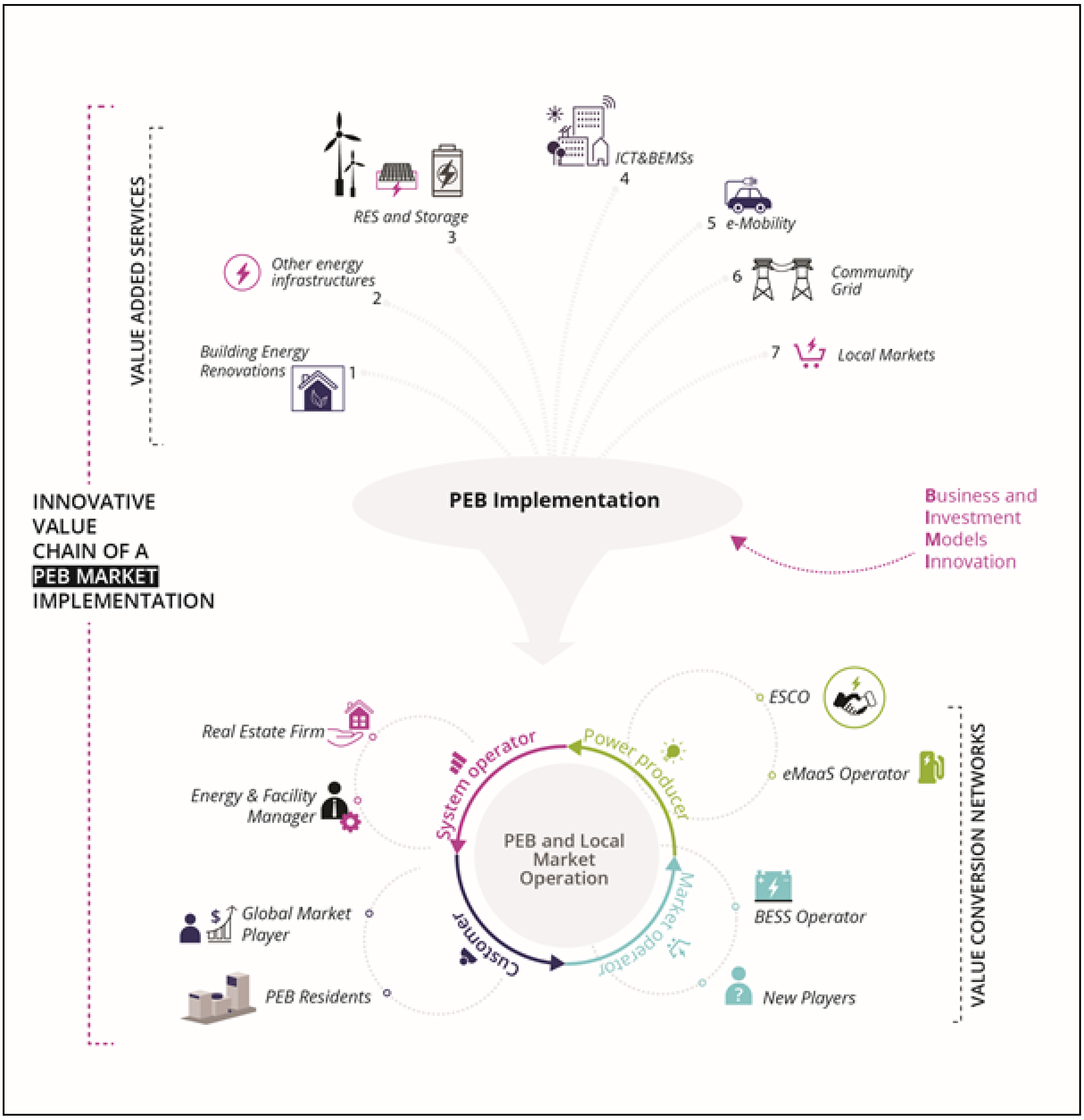


Figure 3.4 The value chain of PEB implementation and operation through Business and Investment Models Innovation. Source: Source: +CityxChange report D2.4 - Report on the bankability of the demonstrated innovations (Cimini, Giglio, Carbonari, 2019)

The methodology chosen to analyse LHC Trondheim PEB actors' Business Models includes:

- An online survey, with questions on both BaU and PEB business models (questionnaire available in Annex 4)

- One-on-one online interviews, for in-depth analyses of responses to the questionnaire by the following key +CxC partners/PEB players:
    - Trondheim municipality (TK)
    - Trønderenergi (now Aneo)
    - ABG
    - RK
    - ABB
    - SV
    - NHP (now Relog)
    - 4C
    - Volue
- Identification of links and interdependencies among the PEBs/local market players, visually represented in some pictures, on the basis of a "complete" ecosystem depicted *ex-ante*

Improvements have been analysed through a qualitative approach and considered as if the norms would allow a local trading and flexibility market to prosper through trading and flexibility services. This has been performed with the aim to analyse not only the improvements in the specific demo case, but also those derived by the future dissemination of PEBs and local markets as a consequence of the wider application of EU directives on energy communities. This is a key for replication activities and for the evaluation of potential improvements against the required investments on a longer time scale and wider client segments.

Additional barriers, risks, and opportunities have been identified (financial, technological, market, etc.). In particular, improvements have been checked against the needed investments to let the "net" improvement easily emerge.

Methodology and Tools applied:

- BM monitoring (baseline)
- Ideal BM
- Survey on financial benefits from building certification (BREEAM, Well, etc.)
- Financing Risk Sharing Model (FRSM)
- Green Investment Evaluation Model
- Investment and revenue analyses incl SPP times and ROI calculations
- Analyses of BM improvements
- ESG indicator assessments.

3.3 Required input for costs and investments

The inputs for costs and investments (as described in the FRSM) for Sluppen have been used to find and categorise business models for energy production, energy savings, and PEB implementation and management. After selecting buildings to be included in the PEBs and mapping existing RES in Sluppen PEB, OV and TK started evaluating costs for investments and related revenues and total annual savings. As stated in the +CityxChange D5.11 report on Trondheim PEB Demonstration: "*The local markets are based on innovative, project-developed energy trading and flexibility market solutions. Innovative energy solutions, services, and products claim the development of new investment and business models*".

The demonstration includes implementation of a business case in 5 buildings in Sluppen (39.426 square metres), including external thermal energy from heat pump and electricity from external PV farm, extensive sector coupling EL - thermal. The energy resources include PV, building integrated heat pumps, battery storage, V2G charging, and waste heat recovery (serverparks). Investments costs, revenues, operational costs and Financial KPIsFor have then been calculated for all these energy assets.

The demonstrations at Sluppen and Brattøra both also include an eMaaS case within its boundaries. The costs shown in tables 3.2-3.5 are expected to be lower for fully commercial cases. For the eMaaS case, all personnel costs are standardised work and development work occurred mainly in an earlier phase. Table 3.2 presents an overview of all cost elements for the deployed PEBs and eMaaS case. In a commercial PEB case, person month efforts will be substantially lower; investment costs are supposed to be pretty similar for a prototype and a commercial case. Table 3.5 presents indicative PEB case total costs, based on an assumption that personnel costs are 90 % lower for a commercial case.

Table 3.2 Total PEB and eMaaS case costs, funding, financing and annual OPEX (€).

Demonstration	Total cost [€]	EU funding [€]	In-kind financing [€]	3. party Financing [€]	Annual OPEX [€]	OPEX share of total cost (%)
PEB Sluppen	4.124.703	1.347.445	2.769.758	7.500	48.000	1,2
PEB Brattøra	3.683.800	487.000	3.100.400	96.400	51.000	1,4
eMaaS case	651.426	133.600	517.826	0	78.500	17,4

Worth noticing is the much higher OPEX share of total project cost for the eMaaS compared to the PEB cases. Rental costs for parking spaces alone make up € 54.000 of the OPEX per year; then comes washing of cars, vehicle service costs, and costs of charging the EVs. The rather high OPEX for the eMaaS case will strongly affect the final business case and business model for eMaaS. The OPEX in the eMaaS case falls on Zipcar as the EV sharing scheme owner. If another actor could cover parking space costs or the EV sharing provider could get special agreements on parking costs, this would have substantial impacts on whether an eMaaS is commercially viable or not. The costs distributed on funding type and investment/personnel are presented in table 3.3.

Table 3.3 PEB and eMaaS costs distributed on investment and personnel costs, and how much investments, personnel, and type of financing/funding constitutes of the PEB total cost.

Cost elements	PEB Sluppen	PEB Brattøra	eMaaS
Investment cost [€]	2.919.603	2.719.200	635.176
Personnel cost [€]	1.205.100	964.600	16.250
Investment cost share of total cost [%]	70,8	73,8	96,4
Personnel cost share of total cost [%]	29,2	26,2	3,6
Funding source share of total cost			
EU funding [%]	32,7	13,2	20,5
In-kind financing [%]	67,1	84,2	79,5
3. party financing [%]	0,2	2,6	0

While the investment cost (table 3.3) share of the total cost ranges from 70-75% for the Trondheim PEB cases, the same number for the eMaaS case is 96 %. The real-estate company owning the Brattøra buildings, as opposed to the Sluppen building, is not an official +CityxChange partner and explains why the in-kind financing share is as high as 84.2 % for Brattøra. The Powerhouse building in Brattøra received 3,65 M€ (8 % of total building cost) of national funding from Enova[8] for the building and solutions. Table 3.4 presents costs per m^2 for realising the PEB buildings in Brattøra and Sluppen separately.

Table 3.4 PEB costs per m^2 serviceable floor area (SFA) of the PEB buildings.

PEB	SFA [m^2]	Cost/m^2 SFA [€]
Sluppen	39.426	105
Brattøra	35.176	105

Both PEBs have a total cost of €105/m^2. When combining with the numbers in table 3.5 for a commercial PEB case, the experiences give the following conclusions:

- Moving from a prototype to a commercial PEB case where the prototype entails high personnel costs, benefits from moving to a commercial phase
- The registered cost of €77-80/m^2 serviceable floor area (SFA) points to economic opportunities for establishing financially viable PEB projects; especially when substantial external funding and possibly risk reduction actions are applied
- When taking shared risks and investments into consideration in a Financing Risk Sharing Model (FRSM) as presented in section 5, the conclusion is that the PEB cases in Trondheim are profitable.

[8] https://www.enova.no/om-enova/om-organisasjonen/teknologiportefoljen/powerhouse-brattorkaia/

Table 3.5 Calculated PEB cost and cost reductions for a commercial vs prototype case.

PEB	Total cost commercial case [€]	Cost/m² SFA commercial case [€]	Cost reduction commercial vs prototype case [%]
Sluppen	1.989.804	77	45,2
Brattøra	2.815.660	80	23,6

3.4 The PEB in a local energy market - an ecosystem

Doing business in a PEB as a part of a local energy market means providing energy services with the objective of guaranteeing the locally generated energy necessary to meet the local demand. This can be done through improving the energy performance of involved buildings and processes, local generation and storage of renewable energy, active management of energy operations by means of automation, management of internal flexibility, and participation in the local energy market. Value added services can be offered within the PEB beyond the energy services supply, including e-mobility. This local energy system could be looked upon as an ecosystem.

Figure 3.5 represents the "complete" overview of the local PEB ecosystem with its possible stakeholders/players/actors/roles. It includes a rather complex map of interactions between all involved parties. A main finding from the mapping is that it is complex and requires many integrations, and most probably it will be difficult to operate it efficiently without deep understanding of incentives, and business models in addition to clarified roles.

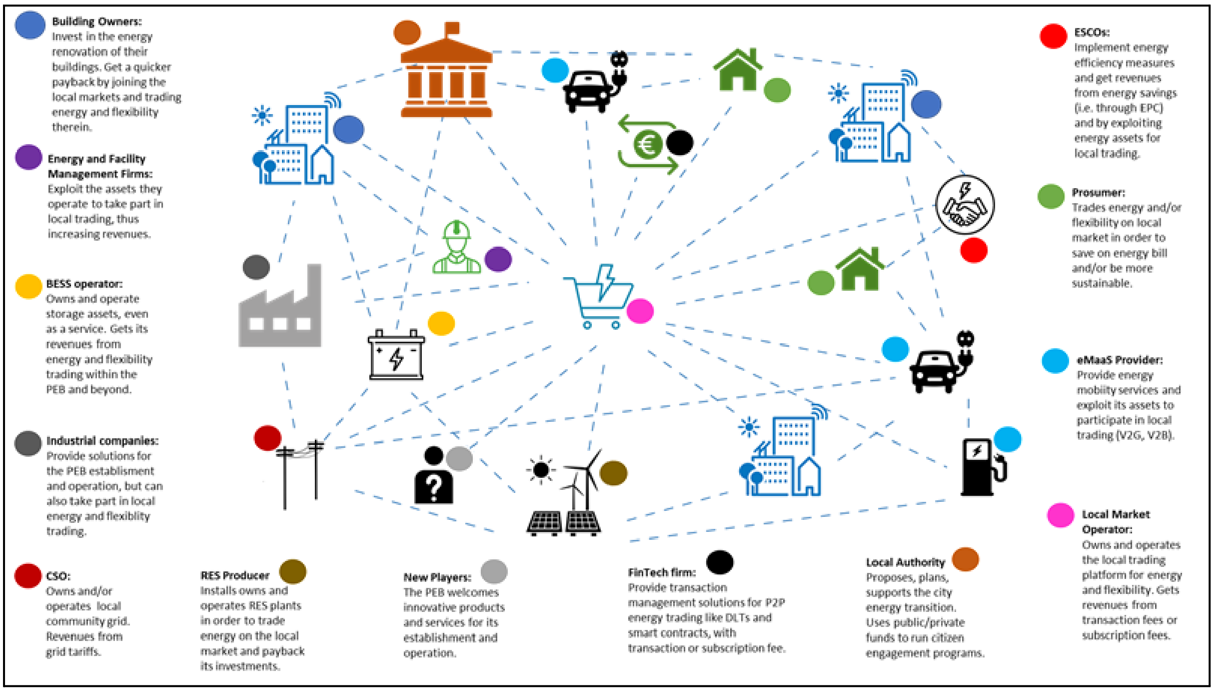


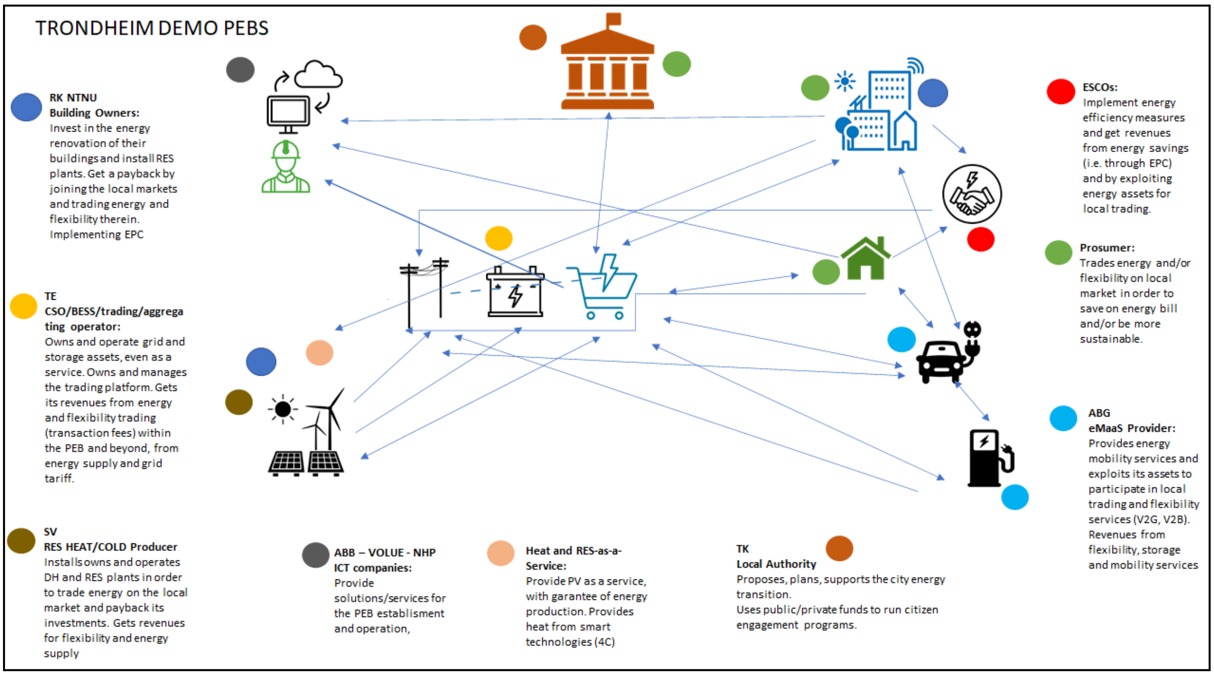
Figure 3.5 A complete overview of a PEB ecosystem. Source: OV

The overview in figure 3.5 outlines specific energy market roles within the PEB ecosystem presented in table 3.6. This represents actors participating in the local energy market including the operation of the PEBs. The reason is that new business opportunities and cooperation models keep flourishing as long as the local energy market (LEM) operates, expands and attracts more players, and with regulatory changes likely to occur in the near future.

Table 3.6 Revised overview of roles in local energy systems and markets in Trondheim PEBs.

Market role	Activity	Roles	Actors in Trondheim
Producer	Produce and sell	Consumer, real estate manager, eMaas provider, BESS owner, aggregator, prosumer	RK, TE, 4C, ABG, households
Customer	Consume and buy	Consumer, DSO, energy supplier, Balance Responsible Party (BRP), Aggregator, eMaas provider, BESS company, prosumer	RK, TE, SV, 4C, ABG, households
System Operator	Operates electricity system and secure quality of supply	DSO, (CSO)[9]	TE, SV
Market Operator	Operates local marketplace and correctly clear and settle local supply and consumption.	LMO	TE

Figure 3.6 displays the refined PEB ecosystem with roles and players implied. It shows a much simpler interconnection system than presented in figure 3.5 due to the fact that it is one single market operator acting as a central node for energy coordination, sharing, and trade which excludes the need for peer-to-peer trade options.



[9] Trondheim has not deployed the Community System Operator (CSO) role as developed and described in the report https://cityxchange.eu/knowledge-base/d2-6-framework-for-community-grid-implementation/. Aneo (Trønderenergi) as LMO fills the main/basic roles of a DSO locally, on behalf of DSO Tensio.

Figure 3.6 Overview of the market operator centric PEB ecosystem in Trondheim demonstrations. Source: OV

The set-up and realisation of the PEB ecosystem as described in figure 3.6 trigger the following considerations experienced in Trondheim:

- The dedicated roles required to enable the local market with PEB needed to be refined during the course of the demonstrations
- "Energy neighbourhoods" linking PEB residents, both domestic and commercial, are not being formally settled yet, nor dedicated companies as market operators
- Potential new players from finance, energy industry or others are not involved at this stage with the result that new business models have not been fully explored
- The market operator (LMO) has indeed experienced becoming the basic hub in both establishing and operating the demonstrations
- The market operator has a close link to the energy industry and their skills and know-how have indeed been factors for success in the demonstrations
- One player (4C), investigated starting a new business line, aiming at exploiting the waste heat generated by data servers

3.5 PEB challenges, constraints, and opportunities

The most common barriers being faced by businesses trying to effectively implement a PEB ecosystem appear to be:

- **Technological:** Local energy market and related technology are not mature. Many new solutions are being developed to address similar problems
- **Financial:**
    - Lack of incentives and funding, lack of private investment, lack of monetization of energy and flexibility services
    - Existing external funding instruments and funding schemes are not designed and fit for the PEB/area level approach
- **Market:** Lockdown (eg. for eMaaS)
- **Regulatory:** National Tenancy Act, National Energy Act, National Finance Act, GDPR regulation (which data can be controlled/managed), norms on local energy trading (Norway lags behind on this topic). On the latter, one of the project's most important achievements was Trondheim receiving full acceptance and permit (28.02.2022) from the national regulatory authority RME for coordination of open energy and flexibility markets at Brattøra and Sluppen. It is running indefinitely, pending TE's continued participation, and thus allows continuous experimentation and testing
- **Political:** Consistency of political commitment
- **Social:** Market not mature, consumers' and tenants' awareness, social acceptance, difficulties for new players to enter the market
- **Governance and organisational and cultural aspects:** Local/Regional public authorities are not set for taking the role as driver and facilitator for a green energy shift. Municipalities/Counties/Regions are indispensable in this context and processes

Table 3.7 presents the barriers identified by the key players in Trondheim's PEB, based on a survey.

Table 3.7 Barriers in implementation of business strategies identified by players.

Company	**Trønderenergi**	**ABB**	**KJELDSBERG**	**STATKRAFT VARME - District Heating Operator**	**VOLUE (ex POWEL)**	**ABG**	**4C**
Company type	Power Producer	HW/SW development and production-	Building Owner / Real estate developer /Facility Manager	District Heating operator,producer and distributor	Software for the energy industry (Energy Trade Platform)	Rental Cars / Car sharing - Shared eMobility provider	Software provider/Smart heat provider
Barriers in implementation of business strategy	Legal and Technological barriers linked with methodology to split the energy values coming from smart metres between locally and globally sourced energy	- Market: find commercially viable projects and funding - Technological: Local energy market and related technology are not mature. - Financial: lack of incentives and private investment - Regulatory: GDPR regulation -Norms on local energy trading - Political: the energy transition is not seen in the same way by different political parties	- Legal: Regulatory - Economic - Social: tenants not aware of energy changes	- Economic: Competition with electric heating, where the prices are regulated and the costs of different sources equalise. - Economic: define a value of flexibility - Legal barrier: behind the meter Assets control is not in place yet. Have to compete with FM companies that manage the plants on behalf of building owners	- Legal: regulations not allowing local energy markets - Economic: lack of incentives to kick start LEMs - Economic: excess production not well incentivised nowadays - Social: market not mature	- Economic: High investment in vehicles (rental vs purchase), primary vs secondary revenues - Social/economic: market situation - Technical: Maturity - Legal: Not able to deliver intended grid services to the local market	- Market: Low energy price - Economic: competition from big ICT players installing big data servers - Legal/market: National incentives to bigger data servers - Political: Public entities not used to innovate

The regulatory framework has a fundamental role in the context of local energy market development. To make the framework future-proof and as an enabler for the energy transition, changes and updates of existing regulations are needed in order to remove barriers. There is a need for a "shift of paradigm" for enabling a distributed and customer-centric energy system that should be available in an *energy transition* scenario. The improvement of business models for players involved in a local energy system characterised by renewables, storage, flexibility and local system operation and trade is affected by regulatory aspects such as (as a subset of what is defined in the report D.5.9[10]):

- Revenue incentives for the natural monopolies within a local energy system
- Structure of tariffs for local transport of electricity
- Metering and data management for local energy assets operating in a local market
- Trade of local flexibility - standardisation of products and contracts
- Feed in tariffs and rights to connect renewables
- How to achieve maximum value from local storage
- Investments, funding and incentives for renovation and energy efficiency at building level.

It is experienced that local renewable assets cannot be shared between neighbours within the block of apartments, and a neighbourhood cannot buy PV installation and share the generated electricity between them. Surplus energy can not be used in a local flexibility market without dispensations from national legislation as per today.

Table 3.8 shows how different regulations affect the key players' business models and how it could represent an opportunity in the process of establishing and operating a PEB as demonstrated.

[10] https://cityxchange.eu/knowledge-base/d5-9-playbook-of-regulatory-recommendations-for-enabling-new-energy-systems/

Table 3.8 Impact of regulatory barriers on key +CityxChange partners' business models in a PEB establishment process.

Regulatory element	TE	RK	SV	ABB	ABG	VOLUE	4C	Customer
Revenue incentives for the natural monopolies within a local energy system			As a DH monopoly, coupling with electricity can result in a revenue reduction					
Structure of tariffs for local transport of electricity	Revenue as a manager of the local grid	Building owners might save money from lower tariffs			e-MaaS management might save from lower tariffs			Bill savings
Metering and data management for local energy assets	To improve the functioning of the LEM and flexibility services - to apply pay per use/volume		Management of private heat pumps, i.e. behind the meter thus reducing energy competition and unbalanced		Management of private cars energy consumption for flexibility and storage services	Provision of LEM software going to be paid as-a-service (based on volume or use)	Produce/sell energy in the local market	Produce/sell energy in the local market -
Trade of local flexibility - standardisation of products and contract	To be able to trade energy and to save on contracting functions (administration costs)	Standardisation of contracts for energy supply services	Standardisation of contracts for management of private heat pumps				Standardisation of contracts for energy supply services	Revenue from provision of flexibility services
Feed in tariff and right to connect		To push building owners installing PV	To push building owners to share the use					Revenues from excess energy production

Regulatory element	TE	RK	SV	ABB	ABG	VOLUE	4C	Customer
		systems to generate excess power to trade	of heat pumps at market level					
Max value for local storage	To cover/support storage investments costs	To push installation of storage services and cover investment costs			To monetise V2G and V2B storage services			V2B storage services
Investments, funding and incentives for buildings		To increase bankability of energy renovation investments and therefore ESCos interest in EPCs		To sell more software				To decrease individual investments.

3.6 How to improve business models within the PEB

The second step in the *Business Model Level Analysis* within the framework of the *Value Network Analysis* aims to define how each player does business in the local energy market. This is defined in terms of value proposition, products, required infrastructures, revenue models, and interactions between the players.

Customer (including prosumers) can choose between the following options:

1. Practice self-consumption only
2. Practice self-consumption and sell any excess production at the price charged by the market at that moment
3. Practice self-consumption, store excess production, and sell it to the market when the market price reaches the optimal value for the customer/prosumer
4. Practice self-consumption, store surplus energy, and sell it to the market when the market demands it

Needed additional investments:

- Option 1 requires the BESS
- Option 2 requires a national/local grid to transfer power to the grid
- Option 3 could require a BESS, a platform for the "sorting" of energy to the grid and a national/local grid for the transfer of energy to the grid
- Option 4 could require a BESS, a platform for the "sorting" of energy to the grid, and a national/local grid for the transfer of energy to the grid

The cost for smart electricity metering is excluded from the investment cost list because all buildings/installations have smart meters in operation.

The additional costs connected to the grid, platform, and battery storage are attributable to maintenance and management. Revenues can be determined on the basis of the price charged in the various options and the quantities of energy traded.

For each option it is possible to determine the value of Total Revenue, Total Costs, Profit/Loss, Payback Period for the investment, IRR, NPV, and it is also possible to consider profitability indicators that incorporate the volumes of CO_2 saved.

Option 2 has the following risk:
The prosumer (in the absence of storage) will sell the excess production at the very moment in which production exceeds consumption. In this way it does not manage to create revenues in any way. In fact, it does not affect the price which is defined by the market and the prosumer must take it for granted, and it does not affect the quantity of sales as it is subject to and conditioned by the consumption of the same prosumer.

Option 3 has the following risk:
In view of the investment, the prosumer decides whether to sell the excess heat/electricity production at a favourable market time or to keep it for later self-consumption. This decision can also be supported on the basis of the definition of historical consumption statistics - trends and projections for the future. This analysis could be done directly by the

prosumer (this will claim time/money), or it could be bought from a service provider. This is the option that best manages the prosumer's revenues and lowers their risk.

Option 4 has the following risk:

The flexibility of the market that buys heat/energy based on supply/demand needs increases the risk of the prosumer compared to option 3. The prosumer does not manage the price and does not decide when to sell the stored quantities. A situation could also arise in which the store is full, storage costs increase, the market does not purchase energy/heat, and the simultaneous excess of production compared to consumption cannot be stored further and is therefore "lost" with economic losses for the prosumer.
This could be remedied with a further investment of a new and additional storage battery by the prosumer, which in turn increases its investment/costs/risk.

Precisely for this reason the prosumer reasoning in terms of economic/financial optimization should request an additional fee to accept this request for market flexibility.

The analyses have been carried out through questionnaires and interviews, which highlights:

- The presence of interesting opportunities and innovations able to improve business models, even beyond what initially foreseen
- A consequent need of further financial/economic analyses, also by exploring interdependencies among players
- The shared need for regulatory adaptations, possibly anticipated by dispensations for testing or a regulatory flexibility to adjust norms for a fluid and ongoing sector (local energy markets) to flourish
- A simplified overall structure in terms of players, roles and services due to a non-mature context

In terms of business models improvements, common opportunities are based on:

- Wider target customers - reaching households
- New service offering (grid services, flexibility, system coupling, etc.) - eg. SV offering DH coupling with private heat pumps and flexibility services or ABG offering grid services based on storage
- New product offering (renewable energy, software, etc.) - eg. VOLUE offering an adapted version of the software for Local Trading
- Revenue systems: as-a-service (subscription fee and volume prices) vs. direct investment or single sale - ABB applying subscription fees for using their software
- Staff increased capacity - e.g. for ABB staff

Table 3.9 presents the improvements identified by key commercial players in Trondheim.

Table 3.9 Business Models Improvements from participation in PEB and Local Markets.

Business Models Improvements from participation in PEB and Local Market	
TE	New technologies: Storage, integration and smart metres New revenues: LEM Usage fees (based on volume, % tbd); new service for current customers (business segment) New customers: Households
ABB	New revenues: Subscription fees to services such as asset management and connection to local market (not applied in BAU, as normally Single sale for hardware components and software licences and system integration are used) New customers: Municipality, university, households Other opportunities: Capacity building for staff
RK	New technologies: PV installation or PV as-a-service New revenues: Market flexibility; energy trading; margin on PV energy supply based on tax avoidance in a LEM, Special Purpose Vehicle for HPs management/trading New customers due to lower energy bills
SV	New services: Sector coupling, optimization, flexibility in heat provision; managing households facilities behind the metres; provision of summer cooling through use of excess heat in summer
Volue	New revenues: Platform Hosting and Software as-a-service; usage fees based on volume of energy traded/numbers of trades or a combination; sell of expertise. New customers: Building Owners - Residential, Building Owners - Commercial, Industrial companies, Commercial companies - interesting for future developments in other places
ABG	New revenues coming from mobility as a service, grid services, capacity/storage New customers: grid operator, building owners
4C	New technologies: Data servers waste heat exploitation to heat buildings New revenues: Buildings as new customers; companies for servers supply

Revenues deriving from PEB participation are used in the calculation within the FRSM.

3.7 Infrastructure ownership and governance

The ownership structure in Trondheim appears to be much simpler than foreseen in the *ex-ante* analysis, thus showing a limited need of a FRSM. Each asset is owned by one single operator and sometimes asset-as-a-service is going to be preferred to direct purchase where available (eg. photovoltaic as-a-service). This is presented in table 3.10.

Table 3.10 Ownership of implemented PEB assets in Trondheim PEB.

PEB implemented assets	Ownership
Energy Renovation	Buildings, BMS, energy management and integration systems for buildings: building owners (RK, households, etc.)
RES Generation	ESCO: PV rigs
	Building owners: Buildings, PV panels, heat pumps in buildings
	SV: District heating network; exchange HPs with DH (reduce EL consumption - dynamic solution); flexibility services
	TE: Larger and local el. grid and belonging infrastructure. Battery storage(s) - BESS
	IOTA: Tangle (ledger tech)
	ABB: Site EMS (Optimax) and ABB Ability
	PV leasing/as a service company: PV rigs
	NTNU (outside being building owner): Local energy system and energy management systems
	4C: waste heat from servers cooling system supplied to buildings (delayed delivery of components - implementation status uncertain
Storage	TE: Larger and local el. grid and belonging infrastructure. Battery storage(s) - BESS
	Building owners: Buildings
	ABG: Electric vehicles, V2G chargers
	ABB: Site EMS and ABB Ability
e-MaaS	ABG: EVs + charging infrastructure
	AtB: Public transport system
	Trh City Bike: Shared bikes, racks, and bike stations
	4C: Seamless eMobility backend (platform) and APP for booking (integrating micropayment solution at later stage)
	IOTA: Tangle
	ABB: Optimax ® and ABB Ability
Community Grid	TE: Larger and local el. grid and belonging infrastructure. Battery storage(s) - BESS
	ABB: Site EMS and ABB Ability

Local Energy and Flexibility Market (LEM/LFM)	TE: Battery storage(s) - BESS, LEM solution and belong set of algorithms
	VOLUE: Energy Trading Platform
	Buildings
	DH
	ABB: ABB Optimax ® and ABB Ability

In particular:

- Asset as a service allows for avoiding both investment and risk - e.g. a building owner (RK) might go for PV-as-a-service to avoid investment and to be guaranteed a performance level no matter the climatic conditions affecting PV energy production, free of risks
- Full ownership allows one to avoid asking for permission to manage - i.e. the district heating provider (SV) is preparing to manage private heat pumps to be coupled with district heating
- Individual ownership might help overcome regulatory limitations as with the "ownership" of the LEM which cannot be shared

Even though the full impact of an FRSM will emerge when also investments are shared, section 5 will verify that a FRSM is important in order to have a full inventory of a PEB case in a financial sense.

4 Innovative funding solutions

Innovation in funding has been comprehensively covered in D2.4 *Report on Bankability of the Demonstrated Innovation*[11]. Here we summarise key funding solutions (section 4.1) to contextualise those implemented in Trondheim (sections 4.2 and 4.3)

The +CityxChange innovative funding models represent a "shift" from traditional public financial resources such as grants, national and EU Structural Funds to other public funds (for example Green Bonds or Revolving Funds); or contractual models. The new funding solutions will be represented by green bonds, revolving funds, public private partnership (PPP) and tax increment financing (TIF). Innovative financing schemes will be able to attract private capital from ESCOs (Energy Service Company) and other commercial players. It is considered as business innovation, i.e. new value creation from innovative business lines or revenue sources connected to PEB specific characteristics, such as technologies or governance.

Innovative funding solutions not only provide further sources of financing, but contribute to bringing innovation into a PEB ecosystem development. The "shift" towards innovative funding can also be partial, generating an integrated solution composed of a mix of different funding sources (eg. grants + other more innovative funding) where public subsidies help bankability and are considered as a "guarantee" on an investment.

4.1 Overview of innovative funding solutions

In order to raise capital to fund the required high-tech and system solutions for the energy transition, close collaboration and continuous interaction between involved parties and the financial sector is required; with the aim to leverage private investment. Such collaboration is based on the following involved issues:

- New financial schemes
- Innovation in business modelling
- Standardisation of projects and underlying contracts
- Reduction of investment risks
- Projects clustering to increase size and bankability and reduce administrative costs, and reduce risk
- Mechanisms for investment that fall off the balance sheets via Special Purpose Vehicles (SPV) and Public Private Partnerships (PPP) [12]

The innovative financial and support schemes can be green bonds or Energy Performance Contracting (EPC) where an ESCO provides various services, such as finance and guaranteed energy savings for energy investment and is generally repaid through energy saving. Tax Increment Financing (TIF) allows local governments to invest in public infrastructure and other improvements up-front and pay later for those investments. They can do so by capturing the future anticipated increase in tax revenues generated by the project. This financing approach is possible when a new development is of a sufficiently large scale, and when its completion is expected to result in a sufficiently large increase in

[11] https://cityxchange.eu/knowledge-base/report-on-bankability-of-the-demonstrated-innovations/
[12] Paragraph taken from D2.4 Report on bankability of demonstrated innovations, chapter 5.2

the value of surrounding real estate; such that the resulting incremental local tax revenues generated by the new project can support a bond issuance.[13]

Alternative finance includes instruments and channels in the market that differ and at the same time derive from the traditional banks/financial institutions and capital markets. This list represents some alternative financial instruments:

- Soft loans, loan guarantees, and portfolio guarantees. Financial tools where public funds invest in Energy Performance Contracting. Public portfolio covers any potential risk for ESCOs including any delay on payment.
- Revolving funds. These are set up by either private or public lenders for a specific typology of energy efficiency or environmental sustainability projects . As soon as borrowers start repaying the debt, money is put back in the fund pot and can be lent to new applicants. Such funds can be financed from European Structural and Investment (ESI) funds.
- Cooperatives, citizen based financing and crowdfunding platforms. A crowdfunding scheme often uses an internet based platform to raise funds from a variety of lenders, usually in small to medium amounts, for a specific project. In exchange lenders get equity in the implemented assets or financial guarantees. It can be used in combination with, or in alternative to, cooperative models where citizens get together and self-fund projects with shared ownership of the infrastructure.
- On Bill Financing: A method of financing energy efficiency improvements that uses the utility bill as the repayment vehicle. Energy suppliers collect the repayment of a loan through energy bills.[14]
- Peer-to-peer (P2P) lending. Through dedicated platforms, citizens can exchange money with no official financial institution involved in the process in order to lend and borrow. This is often used when borrowers need access to financing that they cannot get elsewhere. This approach can be suitable under specific circumstances, particularly small contexts, where trust is ensured between peers due to their geographical or social belonging.

Innovation in business modelling refers to value creation from new business lines or new revenue sources. Among these, one business innovation is the income generated by flexibility in a PEB ecosystem.

Regarding project clustering, a PEB in itself can be considered a clustering demonstration where multiple interventions are integrated and aggregated to both energy and financial/funding aims. In the framework such clusters could be further developed by the potential creation of a Renewable Energy Community, thanks to the recent ad hoc regulations and incentives that are being promoted throughout Europe. The EU Clean Energy for all Europeans Package[15] and the EU Directive on common rules for the internal electricity market[16] are especially important in this context. However, other collaboration solutions are possible.

Public-Private Partnership (PPP) is a mechanism for the government to procure and implement public infrastructure and/or services using the resources and expertise of the private sector and in which the private party bears significant risk and management

[13] Tax Increment Financing - The Works Bank https://urban-regeneration.worldbank.org/node/17
[14] Source: Covenant of Mayors, Funding Guide https://eu-mayors.ec.europa.eu/en/resources/funding_guide
[15] https://energy.ec.europa.eu/topics/energy-strategy/clean-energy-all-europeans-package_en
[16] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2019.158.01.0125.01.ENG&toc=OJ:L:2019:158:TOC

responsibility. The term is used to describe a wide range of types of long term agreements between public and private sector entities, and different countries have adopted different definitions of PPP.[17]

The reduction of investment risks will be treated in-depth in section 5, presenting an application in Trondheim based on a Financial Risk Sharing Model, a calculation model developed by OV in the framework of the +CxC project, which can be used for upscaling and replication by other players and other cities.

4.2 Leasing scheme for PV on commercial buildings

An ESCO solution with a specifically designed leasing scheme is being deployed for PV investments for two commercial buildings at Sluppen. The directly involved contract partners are the operations company of +CityxChange official partner RK (R Kjeldsberg Property), Kjeldsberg Eiendomsforvaltning/KEF, and Aneo (former Trønderenergi - official +CityxChange project partner).

Aneo rents 3,312 m^2 of roof space at Sluppen for installation of a PV rig with a certain annual production of PV electricity. Aneo uses a subcontractor for the delivery of PV panels and necessary additional equipment including concrete installation, and covers all costs for engineering, investment costs for all PV parts, operations, and maintenance. Aneo then provides PV electricity as a Service to KEF for a specified fixed price for the PV electricity over a contract period of 30 years. The PV electricity is redistributed to the corporate tenants, and the electricity cost is invoiced as part of the common costs for the tenants.
KEF must also establish a +Customer[18] contract with a power supplier and sell surplus PV electricity to the supplier according to the Norwegian +Customer scheme. The scheme includes a buy-out clause for the rig after 10, 15, or 20 years, based on the agreed remaining value of the rig.

4.3 Flexibility as business innovation

The consumers with their own power generation tend to see the possibility of producing excess electricity as an opportunity to gain revenues. In this context, the consumer as a prosumer and/or a producer adopts an entrepreneur's approach, seeking the maximisation of revenue/profit. They could therefore evaluate the electricity production capacity also in the logic of capital budgeting, which can support an investment (in tangible and intangible assets) if it proves profitable.
As an example, a prosumer could evaluate an increase in their investment in photovoltaic panels by purchasing a battery system to "store" energy, in order to be able to transfer the excess production to the electricity grid at the time of maximum economic benefit, or at the moment of the peak purchase price by the market (it is assumed a market with variable prices over time).

The prosumer will therefore need to cover the purchase, maintenance, and management costs. The prosumer will get the maximum of the revenues resulting from the formula:

Revenue = Price (expressed by the market) * quantity stored and transferred.

[17] The World Bank, PPP Legal Resource Centre, https://ppp.worldbank.org/public-private-partnership/about-public-private-partnerships
[18] https://www.nve.no/reguleringsmyndigheten/regulering/nettvirksomhet/nettleie/tariffer-for-produksjon/plusskunder/

The differential between revenues and costs will represent the Operating Income (OI) which, compared to the Investment, will allow us to calculate the relative Return On Investment (ROI = Operational Incomes/Investment).

If the local energy market (the energy demand) requires flexibility from the prosumer (energy supply), or to store energy instead of selling it freely on the market to cover the market's needs (peak of demand or low production), the prosumer's availability to offer flexibility should be remunerated. Not only because it is a service offered, but also because this availability has a "green deal" and a definite social value.

If the energy market (the demand for energy) requires the prosumers to orient towards energy flexibility or asked to store energy (battery) and not sell it freely based on the economic evaluations of the prosumer (presumably at times of peak price), but sell it according to the needs of production (peaks of demand and lack of production), flexibility should be remunerated to the prosumer as this gesture has an energy/economic/ecological value. The value of flexibility could be calculated by paying the quantity sold by the prosumer at a fixed price similar to the peak price value of energy.
Such a choice would allow on the one hand the prosumer to lose interest in the development and analysis of market prices, as well as to see the flexibility adequately repaid in relation to potential free market opportunities.

However, in the case of a PEB development with a local energy market, the value of flexibility should be calculated considering the general local benefit - which is supposed to be the main target. In this case the single prosumer, being part of the local energy community, could accept other (lower) values in exchange of services and other savings. Additionally, the local energy market has further flexibility value negotiation potential towards the global energy market.

5 Model for financial risk sharing

5.1 Financial Risk Sharing Model application

The Financing Risk Sharing Model has been designed and created for the equipment needed in a PEB and has been developed during the project, involving all Task 5.11 partners and stakeholders, with the aim to enable the PEB and share the financial risk-benefits of the energy assets and related flexibility in a LEM (Local Energy Market).

The FRSM defines and considers the allocation of finance-investment risk among different stakeholders (tech producers and investors) for the energy asset infrastructures: PV, BESS, heat pumps, and EV chargers needed (especially applicable for V2G charging).

Application of the FRSM gives guidance/overview to prepare and advise investors and tech providers in the decision making process before and during the investments in the Sluppen PEB. The FRSM approach and methodology are useful to support financial analysis to better understand the profitability of the investment. This process is a helpful and viable approach to gaining knowledge for assessing the investments' profitability, evaluating strengths and weaknesses, and perceiving the main factors which determine value.

Energy efficiency (EE) and RES projects present numerous risks, starting from political and regulatory risks, to grid and transmission risks, up to liquidity and refinancing risks. The first mitigation measure deals with the role of policy makers which can drive and support energy communities and potential investors to overcome barriers, acting as an intermediary to avoid investment risks and allow access to capital for investments in RES and EE projects and programs.

In addition to financial risks, the following issues could impact investments:

- *Change in regulations:* During a project/investment development or implementation, financial support can be blocked due to new rules/policies
- *Changes in the market*: Operational costs can vary; costs of equity and costs of debt for RES can change
- *Technological changes:* The technology can become obsolete and in some cases can largely impact while some renewable energy technologies quickly enter into the market

The model assesses the financial terms and how they affect the value of a project. The FRSM has been developed with the main purpose to:

- Assess/calculate potential benefits and/or financial and investment risks distributed among a cluster of stakeholders achieving a common goal
- Give guidance on how to avoid potential investment losses and reduce financial exposure risks

The analysis measures the risk of the investment in quantitative and qualitative terms. A major driving force in the decision making process is related to risks that investors perceive in the Local Energy Market (LEM).

The methodology to measure risks foresees that after estimating financing parameters, information will be provided that influences investments. Risks and potential revenues depend on uncertainty of future events and play a prevailing role in investment decisions.

The Financial Risk analysis starts with collecting inputs such as:

- Energy data
- Calculation methods such as financial KPIs and ESG indicators/impacts/benefits
- Risk assessment analysis aiming to address actions and measures in an innovative way
- Methodology to calculate investment risk and opportunities for potential investors in RES and related flexibility in the PEBs

By using the collected input, the analysis puts in relation each stakeholder with local market assets and flexibility, and measures the financial value of each asset of the project.
The method and its results has been used for various business cases and energy investments within the PEBs in Trondheim.

5.2 FRSM main features

The FRSM (Financial Risk Sharing Model) is contained in a Tool - Excel file named "+CxC_D 5_16_Financial Risk Sharing Model_PEB_Trondheim" check it on +CxC website at the following link: https://cityxchange.eu/knowledge-base/d5-16-trondheim-sustainable-investment-and-business-concepts-and-models/
The tool contains information, energy data, calculations, and provides results on a "project-investment" phase for financial, economic, and analysis for PEB creation. It is a guide which supports potential and targeted investments, helps investors to manage the energy assets, incomes and expenditures, with the goal to make it profitable. It gives information on the leverage effect between costs and revenues. The tool aims to measure the financial sustainability and the environmental and social performance.
Phase 1, 2 and 3 as described in table 5.1 are not included in the FRSM while they are preparatory to the financial-economic analysis.

Table 5.1 Phases to implement an energy project and apply the FRSM

Phase	Description	Excel spreadsheet section
1	Project identification-definition	
2	Partnership and third party investors (participants, shareholders to involve directly and indirectly)	
3	Legal entity (subject) establishment	
4	Partners' role (in the PEB/LEM) and companies-business type	1.Stakeholders & BMs
5	Required/needed investment (€) - total investment value	2.PEBs Inputs & data
6	PEB Business Plan - Financial scheme	1.Stakeholders & BMs 2.PEBs Inputs & data
7	Benefits/risk sharing	3.PEBs Outputs KPIs & Fin. Risk
8	Total PEB Value and KPIs/impacts	3.PEBs Outputs KPIs & Fin. Risk

Main functions, outputs and results of the FRSM are:

- Financial risk analysis support improving skills of users and knowledge on financial techniques with practical results
- Gives guidance and information on the quality of involved stakeholders, supplier and related solvency
- Collects and identifies PEBs (and related infrastructures) costs, revenues and financial KPIs
- Calculates the percentage of risk related to costs and revenues and to capital participation
- Explores the analysed business cases giving info on accounting information and financial-economic analysis

The FRSM structure, contents, and sheets:

1. *Intro_Guidelines*: This *Sheet-part* describes how tool's main features and objective, provides guidance on Financial Risk Model application and how to use it.
2. *Stakeholders & BMs:* This *Sheet-part* of the tool contains information on each player/stakeholder involved, related company's profile, core business and area, role in the PEB/LEM, business model and strategy, related improvements from PEB to Local Energy Market. It also contains and describes possible "implementation barriers" related to business strategy.
   In Chapter 5.1 of this report, *barriers & obstacles* (*change in regulations, in the technology and in the market)* are mentioned and described and this part of the tool, compiled in cooperation with each stakeholder by questionnaires and interviews, describes how to potentially overcome PEB challenges and barriers. The sheet also includes collected information on potential funding and funds.
3. *PEBs Inputs & data:* This *Sheet-part* needs input data on energy production and or/saved (kWh/yr) and multiplies it with the cost of energy. This calculation is based on a standard process: Energy produced (thermal, electric, coupling) or saved x the cost of energy (see next paragraph table 5.2). The cost of energy can be set and chosen by the user, as we did in the project, taking into consideration three periods to finally calculate an average cost of energy. It also contains needed capital investments and related total value, Revenues, O&M (Operation and maintenance costs).
   This section is composed of all the energy assets and softwares foreseen in the PEB, owned by all involved stakeholders/investors, and all the investment data. In this part one can choose energy prices related to the period of interest and, by changing this, revenues and related calculations/outputs data in sheet 3. *Financial_KPIs* change as well. This section includes the possibility to do a sensitivity analysis playing with more than one energy price.
4. *PEBs Outputs KPIs & Fin. Risk:* This *Sheet-part* is the core of the model since it automatically elaborates and calculates data and numbers from inputs *Sheet* (2.*PEBs Inputs & data*) elaborating incomes/operational profit and the following Financial KPIs:
   - Payback period
   - ROI (Return on investment)
   - Financial Risk (Cash flow)

The first two KPIs have been described in the KPI section (Annex 3). The Financial Risk is an indicator that measures how each player/investor, in terms of percentage, risks to lose money on its own business or investment decision.

The risks related to finance refers to a potential financial loss on investment decision, in particular on how the total PEB operational profit/incomes for each stakeholder participates in the risk in terms of percentage.

5.3 Application of the FRSM in Trondheim

5.3.1 Payback and revenue analyses using the FRSM

In Sluppen PEB 6 investors for 16 investments are included. The investors include the real estate company/building owner, LMO/DSO, and district heating operator. The results of the analysis and the market consultation are combined in a model to quantify risk costs.

The first step of the model is a common approach which estimates risks and impacts of the project by calculating the PayBackPeriod (PBP) with the energy prices as presented in table 5.2.

Table 5.2 Applied average electricity prices [€/kWh]

2022 March	2022 September	Average
0,15	0,53	0,26

The current price of electricity is an average price from March 2022 to September 2022[19], while the future price of electricity due to fluctuating changes is difficult to estimate.

The model considers the expected outputs of the project in terms of kWh, and related costs for operation and maintenance. FRSM measures the minimal price which investors want to obtain from the market (in the lifetime of the project) and demands regarding financial returns are met and the investment is feasible. The price is calculated from the cash flow of the project, in which all relevant factors are included such as O&M costs.
An estimation of the minimal price is useful in markets where the financial support for renewable energy is not fixed by the government (e.g. through feed-in tariffs), but depends on the market. The result of a cash flow calculation is usually the rate of return of a project. When the potential income is given over the lifetime of the project, the attractiveness of the project can be measured through the Return On Investment (ROI).

Another aspect to consider is to assess the risk in the different stages of the project/investment. The risk of a renewable energy project depends strongly on the stage of its development. At the starting phase, the investor faces a risk of failure due to (environmental) the permitting process and acceptance by authorities in addition to financial conditions. This implies that, even if the project may succeed, the investor faces additional risks because the available information is not complete. At a certain point in time, however, more information will become available if project development continues.
Permits to build and operate will be given, removing the risk of failure due to regulatory restrictions. Investments, operation and maintenance costs will become clear when a supplier has been selected and contracts have been closed. These steps will also remove

[19] https://www.lifeinnorway.net/electricity-bills-in-norway/

parts of the risk for the investor. Some issues still may remain uncertain. For instance, the expected price for produced energy sales, energy production level, inflation rate, and maintenance in the long run. Some of these risk elements may be removed when the project starts to operate. Key data and information for planned investments (for example PV and batteries) during different phases of the project development are fundamental to estimating the potential risks/failure of the investments. The calculation and mitigation of investment risks and building up structured financial schemes can be a starting point for policymakers to scale up the investments in a PED and a city. Innovative policies and financial and investment solutions are necessary to attract large-scale investors.

The final goal is to give policymakers, project developers, and investors guidance on how to prevent risks by the implementation of a pilot project from small to large scale. The PEB is a physical place where actors need rules in order to share business opportunities and related financial risks. This means that the PEB should be considered a common area of business (Strategic Business Unit - SBU). For this reason, each of the parties involved in the Trondheim PEBs should avoid evaluating it independently. In facts, each of them:

- Has its own business history prior to the PEB project
- Plays a new role (or in some cases roles) in the PEB
- Will make investments in PEB
- Finances its participation in the PEB project with an ad hoc financial structure. In practice a single form of funding is not defined to finance the individual participation in the PEB by each player, but each party finances its participation with a funding made up of own capital and ad hoc debt capital
- Each party bases its involvement on business plan hypotheses aiming to future revenues deriving from a new market and/or new customers, and elaborates future hypotheses for related typical and particular management costs
- Each party has its own strategy and faces barriers and constraints linked to its specific business

Risks are related to the possibility to recover invested capital, remuneration for the invested capital, and a probability to reach future revenue goals. Risks related to management and operational cost should also be considered.

This part of the report demonstrates potential profitability and related financial risk of each subject stakeholder participating in the PEB as investor. The analysis includes the following financial KPIs:

- Investment + Revenues + O&M[20]costs + Operational profit + Payback Period + Return On Investment
- Financial Risk

[20] Operation and Maintenance costs

Table 5.3 PEB total costs and investment and financial KPIs

	ANEO (Trønderenergi)	ABB	KJELDSBERG	STATKRAFT VARME	VOLUE (POWEL)	ABG	TK	GRAND TOTALS
Investments' value[€]	751.400,00	314.250,0 0	674.553,00	500.000,00	65.000,00	27.400,00	458.500,00	**2.791.103,00**
Investments[%]	27	11	24	18	2	1	16	**100**
Revenues[€]	69.729,60	18.527,08	185.387,44	100.800,00	37.054,16	2.600,00	41.340,00	**455.438,28**
Revenues[%]	15	4	41	22	8	1	9	**100**
O&M Costs (Opex, Personnel)[€]	55.570,00	15.000,00	116.182,95	16.500,00	15.000,00	1.000,00	20.000,00	**239.252,95**
O&M Costs [%]	23	6	49	7	6	0	8	**100**
Payback Period[yr]	11	17	4	5	1,8	10,5	11	**6**
Operational Profit[€]	14.159,60	3.527,08	69.204,49	84.300,00	22.054,16	1.600,00	21.340,00	**216.185,33**
ROI (Return On Investment)[%]	1,88	1,12	10,26	16,86	33,93	5,84	4,65	**7,75**
Financial Risk (Cash flows)[%]	**6,55**	**1,63**	**32,01**	**38,99**	**10,20**	**0,74**	**9,87**	**100**

Total Costs + Investment	3.030.355,95 €

Table 5.3 with PEB total costs + investments & financial KPIs is a synthesis extrapolated from the Financial Risk Sharing Model showing the investors participating in the PEB, their related pro-quota investments, revenues from the ownership and/or assets' management, financial risks, and main KPIs.

PEB total CAPEX Investments is around 2,8 M€. It measures the payment to acquire the needed equipment, physical or fixed assets in Sluppen/PEB Business operations. This amount of investment is needed for making the PEB exist in Sluppen even if some elements are not included, for example new properties to purchase, big plants, or other equipment, products, or technologies because they already exist or are co-financed by the project. Another element/component not included in the calcs is the licence purchase for ABB Optimax/SiteEMS - HW/SW and the cloud use. As mentioned by the FRSM thanks to the PEB implementation there could be potential new revenues for subscription fees to service. In the FRSM sheet *2.Sluppen_PEB_Revenues* the typology of investments for each stakeholder participating at the PEB supported by another file compiled by TK named *Annex 7 - Detailed PEB and mobility CAPEX and OPEX* is detailed.
OPEXs are 239.252,95 €, O&M (costs + investment 3.030.355,95 € and **total revenues 455.438,28 €.**
PEB Payback Period = Total Investment/Revenues shows a short time to recover the cost of the investment - within **6 years.**
PEB Revenues and O&M are calculated on an annual basis and consequently related operational profit (= Revenues - O&M).
A significant indicator that gives information on PEB viability and profitability is the ROI (Return on Investment). The ROI is a significant financial KPI and it shows how market players make money on different energy assets: ROI = (Net profit-incomes/Investment) x 100, so positive ROI means profitable risk investment. It measures the efficiency and the profitability of the investments and it also compares the positive Return On Investments of a total of 16 investments/assets as it is in the PEB case. The ROI is positive and useful as an indicator only if the investment will pay for itself within its expected asset useful life.

In the tech sector, for example, the useful life of a technology investment is around 3 years. For plants/infrastructure the ROI is calculated over 5-10 years. With our calculation method in the FRSM, while revenues are constant x year, the ROI has a positive incremental value in a range-frame of 3, 5,10 years.

Total PEB average ROI (annual basis) performance is **7,75 %**, which is definitely positive.

Total PEB average ROI on 3, 5 and 10 years of time span has a positive incremental value as shown in table 5.4 below.

Table 5.4 Total PEB Return On Investment - ROI (annual, 3, 5 10 years)
OV source: Financial Risk Sharing Model

	ROI [%]
ROI (annual basis)	7,75
ROI (3 years)	23,24
ROI 5 (years)	38,73
ROI (10 years)	77,46

The ROI is positive for most investors/stakeholders participating in the PEB, although it varies quite a lot among the actors. The total PEB ROI is the ratio between PEB total revenues = 455.438,28 €/PEB total operational profit = 216.185,33 €.

Trøndenergi (TE) is the main investor in the PEB with a total CAPEX-investment of 751.400 €, revenues equal to 69.729,60 € coming from PV (on site), BESS, flexibility and reduced grid tariff costs due to BESS as shown in table 5.5.

Table 5.5 PEB Total revenues

	Energy Asset	Energy Production/ Savings [kWh]	Revenues [€]	Total [€]
TE	PV (from site)	84000	21.840,00 €	**69.729,60 €**
	BESS	28980	4.057,20 €	
	Flexibility	94740	24.632,40 €	
	Reduced cost of grid tariff due to BESS		19.200,00 €	
ABB	Software	71258	18.527,08 €	**18.527,08 €**
RK	Energy Renovation Sluppen	151363	39.354,38 €	**185.387,44 €**
	PV Sluppenvegen 11	150075	39.019,50 €	
	PV Sluppenvegen 17B	75256	19.566,56 €	
	PV Sluppenvegen 19	120950	31.447,00 €	
	HP Sluppenvegen 19	400000	56.000,00 €	
SV	Thermal energy import from seawater HP Brattøra	400000	56.000,00 €	**100.800,00 €**
	Exchange HP with DH	320000	44.800,00 €	
VOLUE	Energy trading platform	142516	37.054,16 €	**37.054,16 €**
ABG	EV CHARGER	10000	2.600,00 €	**2.600,00 €**
TK	PV Tempe Health Care Centre	112000	29.120,00 €	**41.340,00 €**
	Energy Renovation Tempe HCC	47000	12.220,00 €	
Grand Totals				**455.438,28 €**

NOTES	
Opex have been calculated considering also the Asset depreciation, so total Opex are around 0,05% of the investment	
Computer waste heat for hot water production	Not feasible (not considered in the calcs)
ABB Optimax integration	We have considered the total cost of the platform as an investment in Human Resources.
Local Flexibility Market (TE)	We have considered 134.000 for the equipment

As illustrated in table 5.3, the payback period for TE is 11 years, meaning that the investment takes 11 years to be recovered. The result is positive and it represents the time to get the money back from the cash flow generated by those assets. This result/quotation is constant if the cash flow and related energy price is the same from year to year and long payback period means higher risk an investor is assuming.

The ROI (Return On Investment) for TE is 1,88 %, while total returns are higher than related costs. TE, with its investment and related revenues in the PEB, participates in the PEB with a financial risk (cash flows) of 6,55 %, as the result-ratio of the TE operational profit on the total PEB operational profit.

For ABB (Energy system integrator manager - ABB Optimax ®), O&M costs are for maintenance, service, and operations. Revenues are influenced by business and also on the number of different assets/protocols to integrate. Revenues are still low but the objective is to have new revenues and new customers due to PEB and LEM implementation and improvement. ABB payback period is the highest value in the whole PEB, 17 years (see also comments in this paragraph above on ABB). In a commercial case, revenues and payback periods are expected to be higher/lower due to incomes from other PEB actor(s) on sales of services and Optimax licence.

A key player/stakeholder in the LEM-PEB of Sluppen is R Kjeldsberg (RK) with a percentage of 29 % on total investments. RK is a prosumer in the LEM (PV energy) and a building owner/real estate developer and facility manager (owner of 5 corporate/industry buildings at Sluppen PEB). Annual revenues are 185.387,44 € with a payback of 4 years and an ROI of 10,26%.

5.3.2 Sensitivity analysis

The PEB Sluppen business model, as mentioned above, considers an average cost of energy of 0,26 €/kWh. However, the FRSM, is a dynamic model/tool, able to simulate different "business scenarios" at various costs of energy. Considering the costs of energy in three different periods, numbers and results and related revenues for investors/stakeholders strongly change. The Sensitivity Analysis, summarised in table 5.6 (extrapolated from the FRSM), considers two further options based on costs of energy equal to 0,15 €/kWh and 0,20 €/kWh.

Option 1: Energy tariff 0,15 €/kWh

- Effect on the overall PEB: SPP becomes 8 years, while revenues become € 338.930 and ROI annual basis 3,57%
- Effect on single stakeholders: in this case for TE and ABB operational profit and ROI become. negative.

This option shows that the financial/economic return on investments does not satisfy all stakeholders'/investors' expectations.

Option 2: Energy tariff 0,20 €/kWh

- Effect on the overall PEB: the payback reaches 7 years, revenues become € 391.888 and ROI on annual basis 5,47%
- Effect on single stakeholders: In this case the operation profits are positive for all stakeholders, but for TE the Single Payback Period reaches 13 years.

This option is the threshold value, beyond which PEB investments are profitable for all stakeholders and below which the investment is not attractive for key stakeholders/investors.

Table 5.6 Sensitivity Analysis based on different costs of energy. Source: OV

Sensitivity 1 Energy Price 0,15 €/kWh										
Stakeholders Involved		**Trønderenergi**	**ABB**	**KJELDSBERG/ RK**	**STATKRAFT VARME - District Heating Operator**	**VOLUE (ex POWEL)**	**ABG**	**Trondheim Municipality**	**GRAN TOTALS**	**Total Costs + Investment**
Total Investments	€	**751.400,00 €**	**314.250,00 €**	**674.553,00 €**	**500.000,00 €**	**65.000,00 €**	**27.400,00 €**	**458.500,00 €**	**2.791.103,00 €**	**3.030.355,95 €**
Total Investments	%	27%	11%	24%	18%	2%	1%	16%	**100%**	
Revenues	€	**50.068,20 €**	**10.688,70 €**	**130.646,60 €**	**100.800,00 €**	**21.377,40 €**	**1.500,00 €**	**23.850,00 €**	**338.930,90 €**	
Revenues	%	15%	3%	39%	30%	6%	0%	7%	**100%**	
O&M Costs (Opex, Personnel...)	€	**55,570,00 €**	**15.000,00 €**	**116.182,95 €**	**16.500,00 €**	**15.000,00 €**	**1.000,00 €**	**20.000,00 €**	**239.252,95 €**	
O&M Costs (Opex, Personnel...)	%	23%	6%	49%	7%	6%	0%	8%	**100%**	
Payback Period	y	**15**	**29**	**5**	**5**	**3.0**	**18.3**	**19**	**8**	
Operational Profit	€	**- 5.501,80 €**	**- 4.311,30 €**	**14.463,65 €**	**84.300,00 €**	**6.377,40 €**	**500,00 €**	**3.850,00 €**	**99.677,95 €**	
ROI (Annual basis	%	-0,73%	-1,37%	2,14%	16,86%	9,81%	1,82%	0,84%	3,57%	
ROI (3 years)	%	-2,20%	-4,12%	6,43%	50,58%	29,43%	5,47%	2,52%	10,71%	
ROI (5 years)	%	-3,66%	-6,86%	10,72%	84,30%	49,06%	9,12%	4,20%	17,86%	
ROI (10 years)	%	-7,32%	-13,72%	21,44%	168,60%	98,11%	18,25%	8,40%	35,71%	
Financial Risk (Cash flows)	%	-5,52%	-4,33%	14,51%	84,57%	6,40%	0,50%	3,86%	100,00%	

Sensitivity 2 Energy Price 0,20 €/kWh										
Stakeholders Involved		Trønderenergi	ABB	KJELDSBERG/ RK	STATKRAFT VARME - District Heating Operator	VOLUE (ex POWEL)	ABG	Trondheim Municipality	GRAN TOTALS	Total Costs + Investment
Total Investments	€	751.400,00 €	314.250,00 €	674.553,00 €	500.000,00 €	65.000,00 €	27.400,00 €	458.500,00 €	2.791.103,00 €	3.030.355,95 €
Total Investments	%	27%	11%	24%	18%	2%	1%	16%	100%	
Revenues	€	59.005,20 €	14.251,60 €	155.528,80 €	100.800,00 €	28.503,20 €	2.000,00 €	31.800,00 €	39.889,80 €	
Revenues	%	15%	4%	40%	26%	7%	1%	8%	100%	
O&M Costs (Opex, Personnel...)	€	55.570,00 €	15.000,00 €	116.182,95 €	16.500,00 €	15.000,00 €	1.000,00 €	20.000,00 €	239.252,95 €	
O&M Costs (Opex, Personnel...)	%	23%	6%	49%	7%	6%	0%	8%	100%	
Payback Period	y	13	22	4	5	2.3	13.7	14	7	
Operational Profit	€	3.435,20 €	- 748,40 €	39.345,85 €	84.300,00 €	13.503,20 €	1.000,00 €	11.800,00 €	152.636,85 €	
ROI (Annual basis	%	0,46%	-0,24%	5,83%	16,86%	20,77%	3,65%	2,57%	5,47%	
ROI (3 years)	%	1,37%	-0,71%	17,50%	50,58%	62,32%	10,95%	7,72%	16,41%	
ROI (5 years)	%	2,29%	-1,19%	29,16%	84,30%	103,87%	18,25%	12,87%	27,34%	
ROI (10 years)	%	4,57%	-2,38%	58,33%	168,60%	207,74%	36,50%	25,74%	54,69%	
Financial Risk (Cash flows)	%	2,25%	-0,49%	25,78%	55,23%	8,85%	0,66%	7,73%	100,00%	

5.4 Innovative risks analysis based on ESG and CSR

Innovative risk analysis of a PEB should go beyond the classic pure financial assessment to consider also other indicators, such as ESG factors.
Such wider risk analysis can lead to a lower cost of capital, as described in the extract below, which refers also to Norway:

"Legal regulation of ESG and sustainability is constantly evolving and may be relevant to the company. Norway has in the Act relating to the Publication of Sustainability Information introduced rules corresponding to the EU Regulation 2020/852 (Taxonomy Regulation) and the EU Regulation 2019/2088 (Sustainable Finance Disclosure Regulation), imposing new ESG-related disclosure and reporting obligations on large companies and financial market participants. A key requirement under the Taxonomy Regulation is the reporting obligation, which stipulates that certain large undertakings (including banks) are obliged to report on how and to what extent each activity of such undertakings is associated with economic activities qualifying as ESG-aligned. Even if the company is not required to report, the "Taxonomy status" of the company may nevertheless have an impact on access to- and costs of external financing. Such effects are likely to be strengthened due to banks' and investors' preferences and associated terms, as well as potential regulatory developments, changed capital requirements etc. It must therefore be expected that the company will have to assess the company's taxonomy status, which will entail additional costs that are difficult to estimate at present[21]."

Specifically, we can clarify how ESG indicators can be taken into account within a financial risk assessment through their impacts on the rating.

We can assume that financial risk is expressed by cost of capital/W.A.C.C.[22] which discounts the expected future cash flows.

The WACC is obtained by the formula:

W.A.C.C.=- Kc= Ke%+Kd%

The Kd[23] components of the W.A.C.C. is influenced by the Rating issued by independent rating Agencies or by the banking system which evaluates the loan request.
The Rating is a score which measures in terms of quality and quantity, or some combination of both, made of two components:

1. Financial component (financial score) issued, for example, by rating companies such as S&P and Moodys
2. Ethical/environmental/social component (ethic score) issued, for example by the Standard Ethics Agency

[21] "RISKS ASSOCIATED WITH INVESTING IN PROJECT FINANCE STRUCTURES" Pareto Securities Chapter 2.4 Risk related to regulatory ESG (Environmental, Social and Governance).

[22] https://www.bdc.ca/en/articles-tools/entrepreneur-toolkit/templates-business-guides/glossary/weighted-average-cost-of-capital#:~:text=The%20weighted%20average%20cost%20of,the%20proportion%20of%20each%20component.

[23] Kd = Cost of debt before taxes. D% is the % of debt/Total value. Ke is the equity cost and e% the percentage of equity/Total value

Therefore:

Rating = Financial Rating % + Ethic Rating (ESG Rating) %

A company/business with a higher ethical rating value will gain a higher overall rating. This company receives an ESG score from a rating institute.

"An ESG score is an objective measurement or evaluation of a given company, fund, or security's performance with respect to Environmental, Social, and Governance (ESG) issues. Specific evaluation criteria vary between the different rating platforms that issue ESG scores; however, they all fall within one (or more) of the E, S, or G categories[24]".

The overall rating influences the cost of debt (Kd)[25] and affects the W.A.C.C. (Kc)
Therefore:

- Ethical rating increasing improves the overall rating
- To increase-improve the overall rating can reduce the cost of debt
- The cost of the debt reduction causes overall cost of money reduction and related financial risk.

In this way, an "ESG oriented" business/company has easier access to the financial capital market. Lower debt cost of capital means lower cost debt and lower financial risk.

"*The growing attention paid to ESG issues has led to an increase in lending institutions' awareness of reputational risk imposed by borrowing firms in addition to default risk. This means that lending institutions* can *be perceived by society as facilitators of negative ESG practices conducted by borrowing firms, resulting in adverse: ESG performance (ESG-perform) and ESG disclosure (ESG-disclose)" [26].*

By doing this, a company business can increase the Economic Value Added (EVA)[27] and have higher corporate stability. If a company increases its ESG CSR score by 1 point (i.e. they add an additional strength in one of the areas of ESG - CSR or are no longer engaging in an activity deemed as a ESG CSR concern), there should be a cost debt reduction of around 0,5 points. The cost of debt (and the related cost of capital) of a company "not ESG oriented" should be higher than a "ESG oriented". On the other hand, the Bank is more confident to borrow-lend money to a solid company instead of a less solvent once.

Such approach, although not applied yet in the framework of the Trondheim case, is based on new financing models starting to spread across Europe and is recommended to be taken into consideration in replication contexts. Besides, the recently approved (Dec. 2022) EU Corporate Sustainability Reporting Standard Directive modifies the previous regime of non-financial reporting, expanding the responsibility of companies in terms of sustainable economy and will generate consolidated info on companies' non-financial reporting that could be used for such innovation in the risk analysis.

[24] https://corporatefinanceinstitute.com/resources/esg/esg-score/
[25] Cost of debt = method of cost of capital. It's calculated on the debt, bonds, loan or by multiplying interest rate with given amount of debt. The rate can be calculated This rate is called Kd.
[26] Thomson Reuters and Bloomberg ESG ratings.
[27] https://www.investopedia.com/terms/e/eva.asp

5.5 Risk terms for PEB integration

PEB creation is a shared project, sharing potential benefits and avoiding financial risks.
It is an ecosystem which needs a strategic and coordinated management organisation, and above all rules to define an overall governance. Contractual rules should be established and agreed among the PEB members. Risk allocation is a policy to define inside the PEB, it means to decide how parties' contracts could stand costs or benefits for a change or a sudden event in the energy project outputs or results caused by risk factors. The first step and objective is to provide motivation and incentives to manage and foresee risks by reducing costs and increasing potential benefits.

There are key questions connected to risk allocation, such as:

- Who assumes the risk of the entire investment? That is, who finds the funding?
- Who assumes the task of estimating expected costs & revenues?
- Who assumes the risk of non-realization of revenues and negative ROI?
- Who assumes the business failure risk?

A general contractor might assume part of the risks beyond being solely a programme manager. Another option could be a sort of temporary business association with codified rules and a coordinator.

If all the entities participating in the PEB merge into a new entity (cooperative/association/commercial enterprise), the business risk is transferred to the third party who is the only one facing it. If the third party is made up by the various players, the financial and business risk is shared based on the % of participation in the third party's assets.

After the investment/project has been completed, the situation A or B may occur:
Situation A: Each party enters on its own into the examined, evaluated, and approached new Business.
Situation B: All parties contribute with capital to a new economic entity which builds and manages and bears the risk of the entire project, and all parties share the risk for the % of capital subscribed and paid, also in the form of contribution of goods/services.

It is important to avoid underestimating ESG liability risks because they can put the company's profitability at risk. Every director/administrator needs to integrate ESG risks into strategic decision making and operational processes. Ideally, financial and ESG risks are two sides of the same coin to be monitored and managed efficiently, possibly also creating new business opportunities. All KPIs related to ESG can reduce the cost of debt and for it the cost of capital.

The more the ESG variables of the matrix are considered in strategic decisions, the lower the financial risk of the single company operating on the PEB will be. Data reported and presented in table 5.7 consider the financial risk of each player operating on the PEB according to each one's industry area of competence. The average value can express the average financial risk of the PEB. The values in the table must be adapted according to the financial structure (Debt/Equity) of the single company/building participating in the PEB.

An advantage of joining forces into a single PEB operator/structure is made evident by the average value which is lower than each specific industry's financial risk.

Table 5.7 Financial risk per industry.

Industry	Cost of Capital [€]	D/E [%}
Engineering/Construction	4,2 %	69,11
Green & Renewable Energy	3,9 %	48,2
Real Estate (Development)	3,4 %	82,06
Average	**3,8 %**	**66,45**

Source: http://www.damodaran.com, Useful Data Sets (nyu.edu) , Country Europe

Governments, policy makers, and local authorities should encourage and create the conditions to push banks, lender/financial Institutions to apply and implement this practice/policy aimed at reducing the cost of debt, thus favouring the introduction and the application of ESG indicators. By doing so, ESG KPIs could reduce the cost of debt and consequently related cost of capital. In January 2023, the EU published the Corporate Sustainability Reporting Directive (CSRD) that will introduce more detailed sustainability reporting requirements for EU companies, non-EU companies meeting certain thresholds for net turnover in the EU, and companies with securities listed on a regulated EU market. With the CSRD, companies will be required to demonstrate how sustainability measures and ESG impacts are integrated into their business and how risks and opportunities are identified and managed on the basis of Sustainable Finance Disclosure Regulation – SFDR 2019/2088 and EU Directive 2022/2464. Companies should ensure that their business models and strategies are compatible with the goal of limiting global warming to 1,5 °C in line with the Paris Agreement and the EU's own European Climate Law, which aims to achieve climate neutrality by 2050[28].

[28] EC COP27: EU calls for concrete steps to limit global warming

6 PEB value capture

As a PEB's total value we define the global value created by summing up and integrating all assets and interventions in a single economic, financial, environmental, and social assessment process, based on indicators suitable to measure the investment against its global direct and indirect impacts. The indicators and their values can become a reference baseline for benchmarking future replication attempts.

6.1 PEB total value: OV approach

The PEB total value approach analysis starts with a bibliography research at EU level on this topic.

The PEB total value could be defined as the sum of the benefits that stakeholders, investors, prosumers, and energy communities and other potential beneficiaries could potentially perceive in PEB participation. A TOTEX (total expenditure) cost approach is recognised as the best way to understand the total cost of a scheme[29], as it combines capital and operation costs thus allowing to better understand and assess long term costs of an asset during its life cycle of an asset.[30] In this way, better informed, more detailed information, and financially viable investments decisions can be made. Besides, in order to calculate and capture the total value of an asset, life cycle analysis is required also to make investments and interventions socially and environmentally acceptable. Such a total value approach is especially recommended for infrastructures and the green built environment investments.

PEB total value can be summarised through the following formula:

Total Value = Financial Value + Economic Value + Societal Value + Natural Value.

- Financial value is the value to investors (profit, essentially the net present value of future cash flows)
- Economic value is the value to the public purse (value for money, essentially the cost-benefit ratio)
- Societal value is the value to society (the benefits accruing to stakeholders, local communities and end users, such as jobs creation, social inclusion, partnership development, increased comfort, etc.)
- Natural value is the value to the environment (the benefits accruing to environmental assets and their stocks and flows)

The calculation of the Total Value using the formula above is however not easy, as it combines both quantitative and qualitative values and a specific methodology to develop standard parameters able to sum those values has yet to be fully developed.

Therefore, **in the Trondheim case we chose to use another approach that combines PEB and ESG impacts, based on a kind of logical framework,** where we assess how investments generate outputs (the tangible assets such as implemented technologies or

[29] Total cost of a scheme:
[30] CAPEX + OPEX: The traditional approach considers purchasing costs from a capex (capital expenditure) budget separate from running costs which are considered within an Opex (operating expenditure) budget.

refurbishment works), outcomes (that we are able to analyse also in terms of ESG effects), and impacts (wider and longer term effects).

By considering ESG effects together with PEB financial/economic indicators since the beginning of an investment process, the decisions could be changed to better deal with local contexts and needs. This approach can be of interest for local authorities when approving private investments.

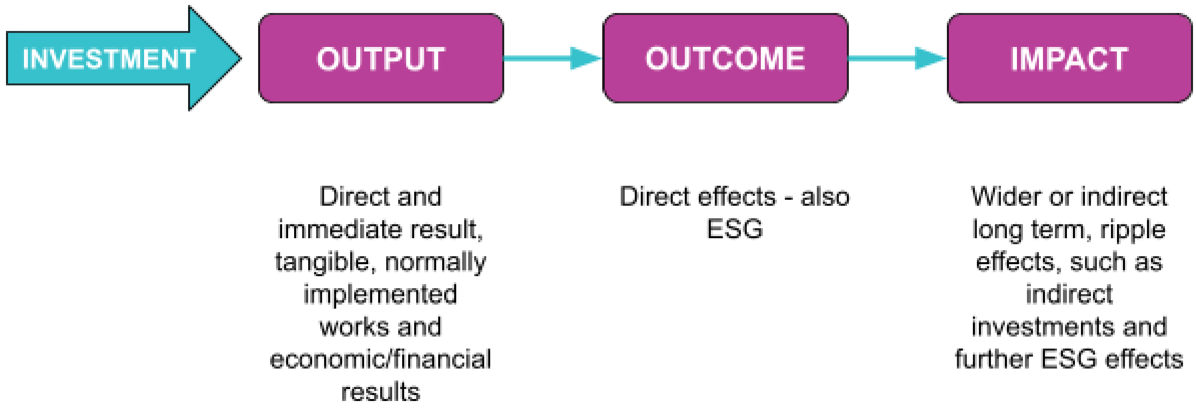


Figure 6.1 Total value assessment approach for Trondheim PEB. Source: OV

In this framework, we manage to link the investment done to the ESG effects in a relationship model, so that the investment is seen as “seed money” and a precondition for the ESG impacts achievement.

This approach allows to capture total value both across linear PEB development (ie. from implementation to impact generation) and across themes (economic-financial aspects + ESG).

The relationship can be set between the initial PEB investment and the achieved direct outputs/outcomes, and the impacts as for example in terms of induced further investment and the related further outputs/outcomes/impacts to be analysed on the basis of indicators.

In this way it is possible to assess the total investments/impacts (cause-effect) and the potential for each specific investment to generate further, broader impacts on the ground, thus capturing the total value of that investment and assessing its overall potential.

As an example, we know that the initial global +CityxChange PEB investment in Trondheim of € 2.791.103 has generated 96 direct jobs. However, we also know that the initial investment has generated further € 28 million in cascade investments with linked 181 jobs. From these figures we can say that:

- Initial investments have a leverage factor equal to 1:10 (€28 million/€2,7 million).
- Initial investments can be seen as “seed money” i.e with a potential to generate further investments and impacts
- This leverage ratio might not be applicable for all kinds of impacts, for example concerning job creation, which only doubles while the investment is increasing by 10 times

The same reasoning, if data were available, could be performed for ROI and then for SPP, or for CO_2 emissions reduction and ESG factors.

6.2 Value creation from certification of buildings

An investor survey in Norway in 2019 performed by the bank DNB[31] shows significant increased willingness to pay for new, certified buildings. A main topic has been willingness of payment related to a BREEAM Excellent vs a non-certified building according to BREEAM-NOR[32], the Norwegian adaptation of the international environmental certification tool. A substantial number of developers have a payment willingness of 50 bps (0.5 %) lower net yield[33] for a BREEAM Excellent building. This is related to a belief that certification will reduce operational costs, increase return on investment, and increase the buildings' values. Updated numbers from the 2021 DNB investor survey shows a further increase of close to 14 % in the willingness to pay (calculated as decrease in the number of net yield basis points) for a BREEAM Excellent building compared to a non-certified building.

Analyses and calculations have been performed by partner NHP (now *Relog AS*), based on the conclusions from the 2019 investor survey, in order to quantify what this might mean for the value of the building itself and the value of the equity.
Numbers are based on a new building (e.g. office/industry) with a total cost of 50 M€, funding half of the cost through equity (25 M€), and a net yield of 4,5 % (down from 5,0 %). Value increases are summarised in table 6.1.

Table 6.1 Potential value increases and impacts due to BREEAM Excellent certification of buildings in Norway.

Value type	M€	% increase
Initial property	50	
BREEAM certified property	55	10
Initial property equity	25	
BREEAM property equity	30	20

A BREEAM certified building with - among a variety of other factors - strongly improved energy performance and innovative energy solutions, may contribute to substantially increase in real-estate company's building value and equity.

The value increases are related to

- Increased attractivity towards potential tenants (tenants are continuously becoming more environmental/ESG conscious)
- The risk/fear of upcoming, stronger environmental standards and regulations related to buildings
- Improved funding conditions (banks/capital market) - lower interest rates/green bonds

[31] https://www.dnbnaringsmegling.no/no/miljosertifisering-lonner-seg/
[32] https://www.byggordboka.no/artikkel/les/breeam-breeam-nor
[33] https://support.easyproperties.co.za/support/solutions/articles/13000072716--gross-yield-vs-net-yield-#:~:text=%E2%80%9CNet%20yield%E2%80%9D%20is%20the%20yield,purposes%20of%20the%20yield%20calculation

- A larger number of potential buyers when/if the building is to be sold

A survey among Norwegian real-estate companies, banks, and financing institutions has been performed through the +CityxChange project focusing on the importance of building certification, sustainability, innovation, and governance for value creation in the real-estate sector. 62 companies were asked, with a response rate of 35 % (22 companies) distributed to 45 % large real-estate companies, 32 % small real-estate companies, and 23 % banks and finance companies. The response group covers important actors nationally and regionally.

The outcomes from the survey are important to include as factors influencing business model improvements. The complete results are presented in Annex 6. The main outcomes and results are presented and discussed below.

The main observed trends from the survey, across all companies are as follows:

- 82 % consider it very important/important to certify their own/funded properties
- 56 % consider certification to be very important/important for the value of the developed buildings
- 73 % states that focus and work on sustainability is high when developing/funding properties; no one answered no/little focus on this question
- No clear trend, but 64 % consider it to be a strong relation between innovation and sustainability
- More than 70 % of the respondents answer that they have a conscious relation to social sustainability; no company considers sustainability of low importance when it comes to the development of new projects

More detailed trends and outcomes from this survey are as follows:

- All banks and finance companies: Important to certify buildings/properties; this trend is not valid for real-estate companies
- A majority of banks and finance companies and large real-estate companies say that certification has an impact on the value of the developed properties
- All large real estate companies state that they have a large focus on sustainability; this trend is nor clear for small companies, banks, and financial institutions
- All banks and financial institutions state that innovation is important/very important for setting the value of developed buildings/properties; no clear trends for real-estate companies. Innovation seems to be of low importance for small real-estate companies
- Large real estate companies: A clear connection between innovation and sustainability; not a clear trend for small companies
- Banks and finance companies: Connection between governance among real-estate developers and value of properties
- 80 % of banks and finance companies and large real-estate companies state that social sustainability is highly important for them as companies. However, social sustainability thinking and approaches are not significantly important when developing individual properties/projects

Building certification (BREEAM, WELL, etc.) may contribute to significant value creation for the real-estate company and will contribute to substantially decreasing the payback time for the building/building upgrading. This implies that value creation due to the building certification itself may trigger innovative and efficient energy measures, and for instance improve the overall energy performance of smart energy neighbourhoods.

6.3 Rooftop PV

Generation of electricity from local PV represents a key to succeed with energy smart neighbourhoods (incl PEBs); especially in combination with battery storage. However, there are a series of factors influencing the total economy of PV installations. It is important to underline the reality that PV generation at Norwegian latitudes suffer from very low production during winter months, which strongly influences the economy as presented in figure 6.2. However, as shown below, there is also revenue potential from PV systems at Norwegian latitudes, and even in Trondheim - Central Norway.

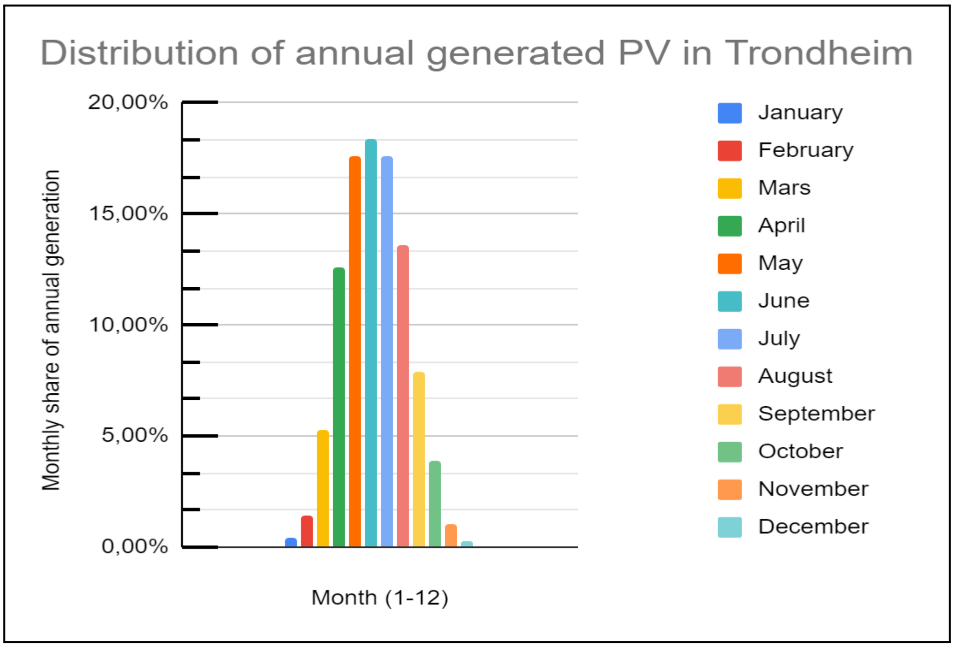


Figure 6.2 Registered monthly distributed generated PV production in Trondheim. Source: Trondheim Municipality (TK).

Important factors experienced to influence the economy of rooftop PV installations:

- Finance costs for the installation including interest rate, depreciation and depreciation time, and lifetime of the installation. Green bonds and incentivised interest rates are of course of utter importance. A longer payback period on the loan is also a highly important factor here
- External funding through either local, national or international schemes and funding instruments. Funding may also be local price guarantees or price securing for the PV electricity, for instance through public funds
- The need for battery storage (battery storage is investment intensive) to buffer surplus production
- The difference between energy costs for a PV rig compared to power market prices including grid taxes and energy taxes. Given the present grid tariff structure, the opportunities of cutting or shifting peaks through local PV production may have substantial impacts on the savings
- The opportunity to sell either production (kWh) or capacity (kW) in local or larger, commercial flexibility markets
- The opportunities for selling system services to the DSO
- Having a contract on “PV electricity rollover” with your energy supplier, where you can put surplus PV production into the supplier’s “bank” and use it later on, for

instance during peak price periods. This is a type of product offered in the private household PV market in Norway today, but not for the corporate market.

The complexity and vast number of factors influencing the economy of PV investments in relation to monthly variations in PV production, makes it difficult to perform detailed calculations and analyses comprising a large set of parameters and possible outcomes. Low PV production during winter months makes it especially challenging to obtain economic benefits from PV in winter periods with high electricity prices combined with a high demand. This makes it more challenging to obtain a good economy out of a PV rig, thus risk of increasing simple payback times.

The analyses have focused on a PV installation financed through a loan, and a proposed model for external funding. The proposed external funding scheme is developed by the +CityxChange project in Trondheim.

The exemplified analyses are based on the PV installation at Brattøra PEB building Brattørkaia (BK) 16, with an electricity consumption of 308.000 kWh/year. Basic numbers for the case are presented in table 6.2.

Table 6.2 Basic numbers for the analysed PV case in Trondheim. The PV installation at PEB building Brattørkaia 16 in the Brattøra PEB is used as an example.

Parameter	Value
Investment cost	319.200 €
Yearly production	122,660 kWh
Depreciation time	15 years
Type of loan	Serial loan
Yearly interest rate	5 %
Yearly depreciation	21.280 €

The monthly PV production during the Winter months in Trondheim is very low and strongly restricts the revenue potential. This is further underlined when looking at the monthly PV production in % of monthly electricity consumption visualised in figure 6.3.

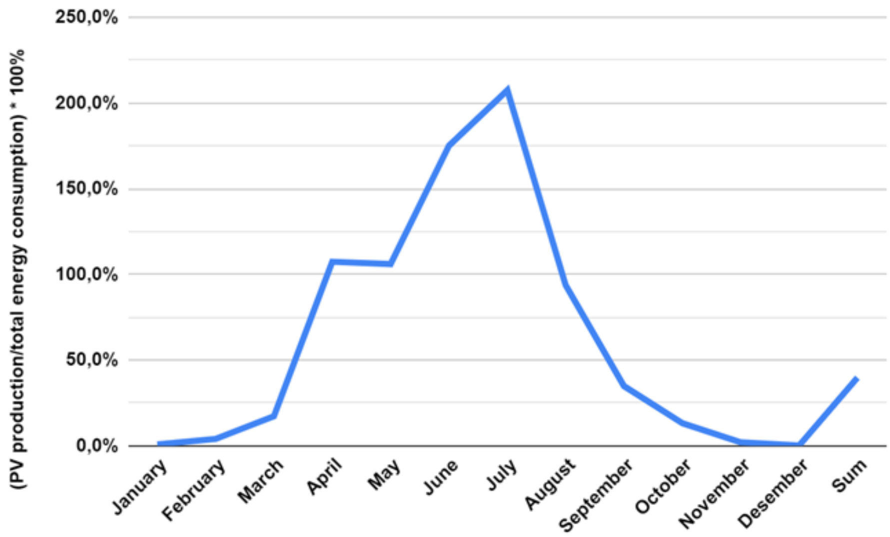


Figure 6.3 Monthly PV production as a share of electricity consumption for the building Brattøra BK16. Source: Trondheim Municipality (TK).

Only 4 months of the year (April - July) have a PV production higher than the actual building's (BK16) electricity consumption. 80 % of the total annual PV production is happening during 5 months a year. This PV production example from BK16 building is a part of the Brattøra PEB and analysed regarding revenue in Part 1 case. Part 2 discusses financing issues for the same installation.

<u>Part 1 of the BK16 PV case: Selling electricity to a local energy market and including variable monthly depreciations.</u>

- Selling PV electricity to a local market during April - July at a price of € 0.005 lower than the electricity cost when buying electricity from the grid
- Monthly depreciation dependent on monthly share of annual PV generation calculated: *(PV investment cost x monthly share in % of annual PV production) / total depreciation time.*

Note that the total annual depreciations are constant over the full depreciation time of 15 years. Details and basic values for this scheme are shown in table 6.3. See Annex 8 for detailed data and results.

Table 6.3 Monthly electricity prices as averages over all 5 price areas in Norway, including grid tax of € 0.052 each month, monthly PV production, and share of production sold per month. Valid for the BK16 case at Brattøra PEB. Case: Sales are average, and not performed at peak price times (€0.005 lower than average price for bought electricity).

Month	Electricity cost - bought from grid (€/kWh)	Electricity price - sell to local market (€/kWh)	PV production (kWh)	% PV production sold to local market
Jan.	0,1750	0,1700	261	0
Febr.	0,1566	0,1516	1282	0
Mar.	0,2062	0,2012	5320	0
Apr.	0,2040	0,1990	18 479	20
May	0,1886	0,1836	21088	20
Jun.	0,1850	0,1800	22060	50
Jul.	0,2086	0,2036	23149	60
Aug.	0,3439	0,3389	16925	0
Sep.	0,3537	0,3487	8992	0
Oct.	0,1415	0,1365	4282	0
Nov.	0,1571	0,1521	762	0
Dec.	0,2186	0,2136	63	0

All sales of electricity to the local market is executed during months with occasional/no specific consumption/capacity peaks and it is a moderate price for the PV electricity sold to the local market.

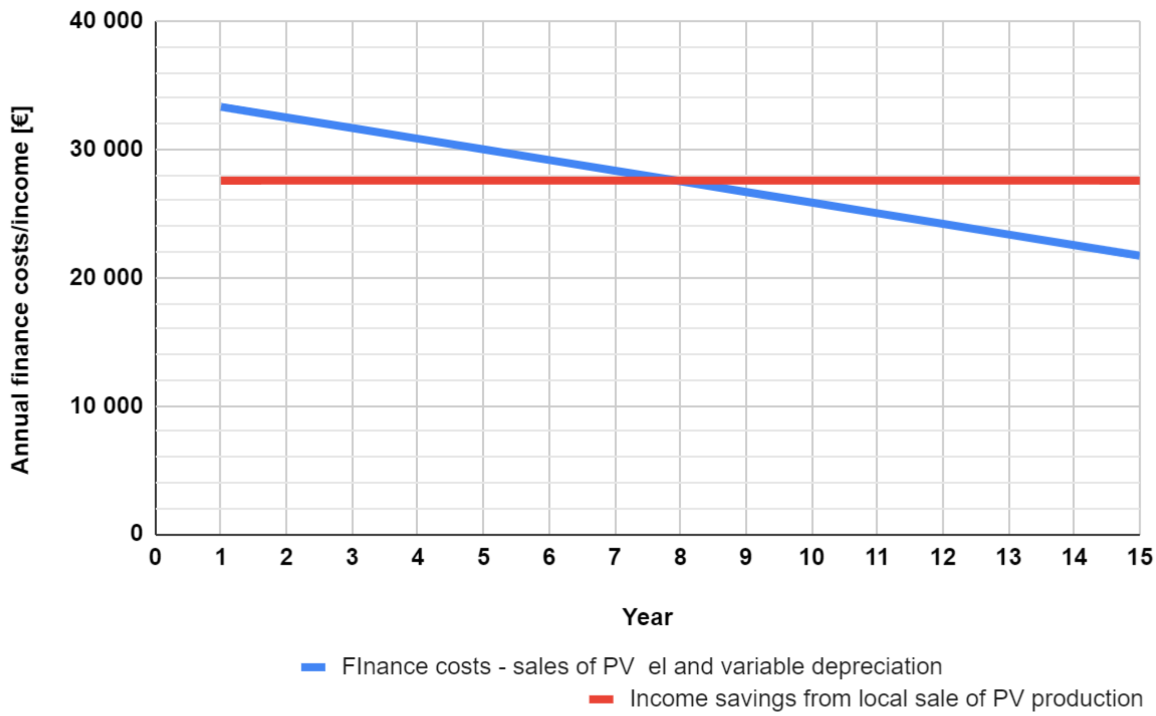


Figure 6.4 Annual finance costs (blue) and income from sales of PV production in the Local Energy Market (red).

Conclusions:

- Considering only sales during April - July and applying variable monthly depreciation is sufficient for having a net positive revenue from year 8 on.
- The main factor contributing to a net positive revenue at year 8, is the new depreciation scheme with variable monthly depreciation varying with monthly PV production.

<u>Part 2 of the BK16 PV case: The impacts of external funding on the revenue.</u>
This case involves analysis of two different, external funding schemes, both considered provided by the Norwegian national funding instrument/organisation Enova:

- A one-off funding of € 50.000 per PV installation.
- Interest rate subsidy of 3 % points per year.

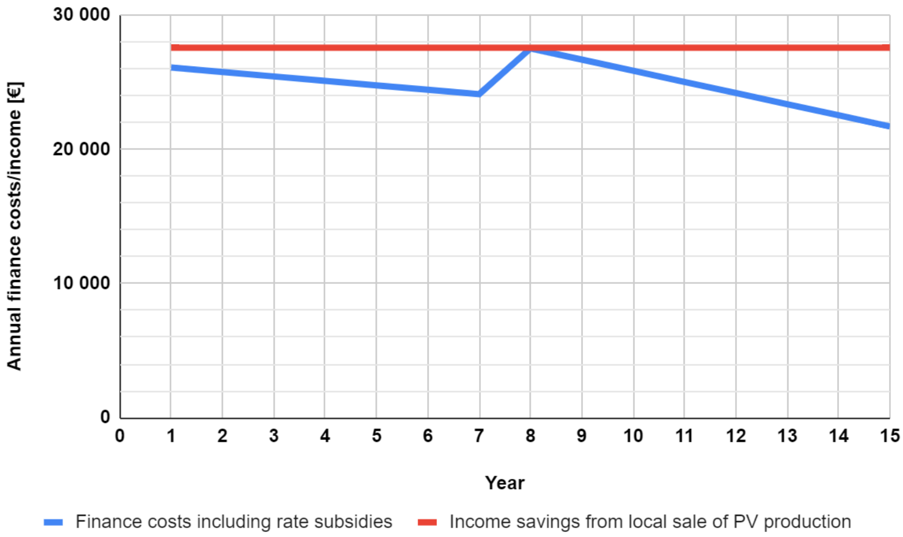


Figure 6.5 Depreciation + cost of interest with external funding (blue) and income savings (red); funding based on interest rate subsidy of 3 % (remaining interest rate of 2 %). Depreciations and interest costs include the Norwegian standard tax exemption of 22 %.

External subsidies are removed from year 8 on, when the PV rig has net revenue without external funding. Costs increase when external funding is removed, before they gradually decrease due to increased revenues during years 8-15.

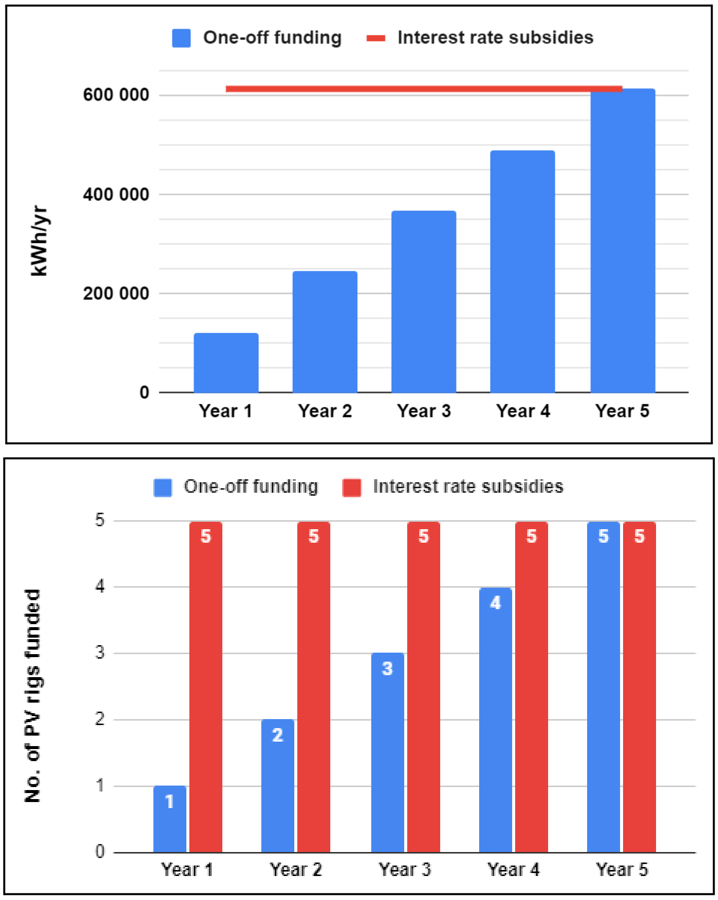


Figure 6.6 Comparisons of one-off funding and interest rate subsidies for the Brattøra PV case showing improved possibilities for funding PV systems with interest rate subsidies.

Figure 6.6 shows that interest rate subsidies are much more powerful than one-off funding regarding opportunities for funding. At approximately the same cost, funding institutions can fund 5 times more PV systems with interest rate subsidies compared to a one-off funding scheme. Said in another way, one can get the full impact of funding already from year one on.

Conclusions and key factors for boosting this PV case in a financial perspective:

- A PV scheme for the BK16 case including a) sales of energy, b) monthly variable depreciations, and c) interest rate subsidies of 3 %, will be financially beneficial already from year 1
- The PV case will anyway be financially beneficially, without external funding, from year 8
- Using energy prices for the Norwegian price area Southeast/Oslo (50 % higher than in the prevailing use-case), the Brattøra BK16 PV case would have been financially beneficial from year 1 without interest rate subsidies
- The PV case with external funding (interest rate subsidies) will be financially beneficial already from the first year on
- External funding through interest rate subsidies are much more powerful than a one-off funding scheme. Using a scheme with interest rate subsidies will result in the opportunity of funding 5 PV installations compared to one one-off funded PV project - for the same sum of funding. Interest rate subsidies will strongly increase the number of PV rigs to be funded, proving a net positive impact already from year one
- If loan financing is used: Analysis of the Brattøra BK16 case shows clearly that an annual serial loan with monthly depreciation proportional to the monthly PV production (annual depreciation is however constant over all years), should be the preferred scheme
- Calculations shows that annuity loan financing will not provide positive revenue within the 15 year depreciation period
- Set up a variable monthly depreciation profile based on monthly PV production (but for all years perform the same annual depreciation of € 21.280)
- Strongly increased impacts in terms of PV SPPs and ROI and increased risk sharing will be obtained with external funding. Private financing institutions could work together with public funding schemes on reduction of PV investment interest rates through interest rate subsidies/green bonds. This would imply reduced public funding due to private funding contributions, and give incentives to an increased number of publicly funded PV installations.

6.4 Battery storage - a value proposition

Local energy generation is to an increasing degree linked to local storage where batteries are used for storage of surplus generation. The stored energy is normally used in periods with a lack of local generation or in situations with overload in the local grid. However, the following value proposition for battery storage is expanded to an energy landscape that includes consumption patterns, power price variations and forecasts, grid tariff price structure, and local demand for locally generated renewable power. This approach concludes that the value of a local battery is significantly higher than typically is addressed and communicated.

6.4.1 Background and some basic principles of usage

In a local energy system perspective the battery must be defined as a short term storage of generated electricity energy [kWh]; a storage that on request delivers both electric energy [kWh] and electric capacity [kW]. The deliveries may either be part of a short term (daily) plan for supply of energy or a more instant (minutes) supply of demand [kW]; or simply speaking charging and discharging. However, the most interesting topics and basic questions that must be answered of the operator for the battery are:

- When shall the battery be charged - and how much?
- When shall the battery accept to be discharged to cover a planned energy [kWh] demand for the next day?
- How much should the battery accept to be discharged in a situation where the price next day is known to be doubled?
- How should the battery combine a demand for energy [kWh] from consumers and capacity [kW] from the DSO at the same time?
- Who in a flexible local energy system has interest in selling energy to a battery?

This list of questions is probably not complete, but it addresses the complexity of setting up a value proposition that maximises the value of a local battery.

6.4.2 A battery centric local energy system

The value of a battery is closely linked to its several degrees of freedom as an energy resource in the energy system. By looking at the energy system as a local market with well-defined roles for sellers and buyers of energy [kWh] and power [kW], it is easier to fully understand and communicate the value of the battery. Figure 6.7 presents an almost complete overview of how the battery can play active roles to maximise its value. The example covers a customer side (left side in figure 6.7) that represents local PV and consumption. This customer side responds to the batteries' capabilities either by charging or discharging the battery.

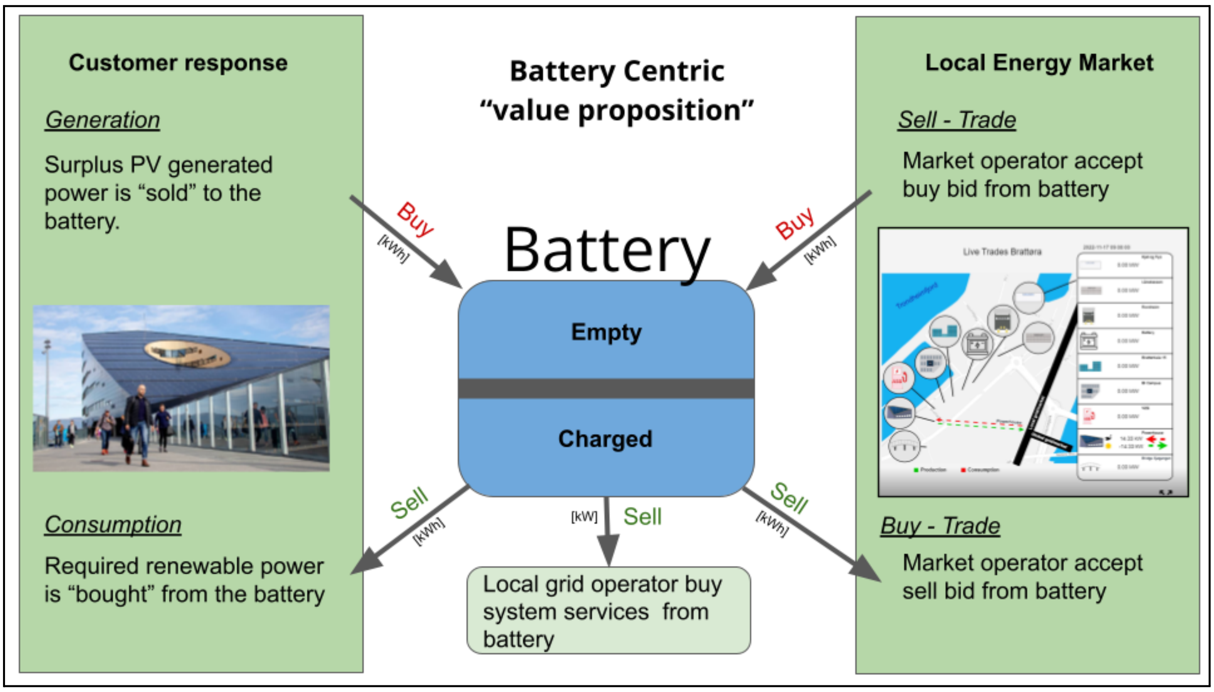


Figure 6.7 Value proposition for a stationary battery storage behind a smart meter. Source: Trondheim Municipality (TK).

The battery can act as a participant in a local energy market (right side in figure 6.7) that could be operated by a market operator and/or managed as smart coordination of an energy neighbourhood. Active participation in the local market will open up for adding value to the battery both through sale and buy due to price variations from hour to hour during a day - or a longer period of time. Local trade of imbalance could be included in this use of the battery. With local generation and flexible consumption, there will continuously appear some deviation between generation and consumption. This deviation from planned generation/consumption will be managed by active and instant use of the local battery.

The local grid operator has complete responsibility for the quality of supply to the local energy system/neighbourhood, independent of connected renewables and demand/ consumption. In an evolving energy transition as we see today and which will evolve further with the grid operator turning more and more into a system operator (DSO) role, the grid operator will ask for local system services, defined as near real-time use of capacity purchased from a local battery as an example (figure 6.7 bottom of the figure) on how the battery may sell capacity [kW] to the local grid operator for the purpose of securing the quality of supply. The price of this sold capacity is typically bilaterally agreed upon.

6.4.3 Battery storage value proposition

When it comes to the overall value proposition for a battery within a local energy system/neighbourhood as discussed above, it is crucial that all degrees of *operational* freedom are understood and analysed. If not, the value will typically be underestimated. All battery centric transactions will add value, however, the following external variables will influence the outcome of the estimates of total value achieved from operation:

Surplus of locally generated non-flexible power (PV, wind)
+ Price variations *during a day* in the power market
+ Load curve characteristics for the consumers in the area
+ Balance management for local market/neighbourhood
+ Structure (time of use etc.) of the grid tariff
+ Free capacity in the local grid
+ Prices in the local market cleared by the local market operator

---

= Total value creation for the battery
===

These variables are not individually independent. The dependency is a function of degree of simultaneity of the variations in the main parameters such as power price, consumption, generation, and grid tariff. For this reason a selection of use-cases for a local system are defined and described, as are some examples of calculations applicable to the Trondheim cases.

6.4.4 Battery and PV Use-cases

A prerequisite for setting up an example of total value creation from a battery is a detailed presentation of the local demand and local generation it is supposed to serve. In this example real metered data for a factory that processes food are chosen. The peak demand for the metered period of two weeks is close to 2000 kW. The rooftop for PV covers 3500 m^2 with an estimated peak of 740 kW and annual generation of 450.000 kWh. The battery is simulated with a capacity of 500 kWh/500 kW. The power price variations during the exemplified period in addition to the tariff structure of the grid tariff are included as fixed operational cost elements.

Figure 6.8 presents the load curve for the period from 14.10.2022 to 13.11.2022 with an hourly time resolution. The load profile is characterised by daily peaks with a demand of approximately 2000 kW. During night time the load level is down to approximately 1000 kW, while on weekends a typical load level is slightly above 500 kW.

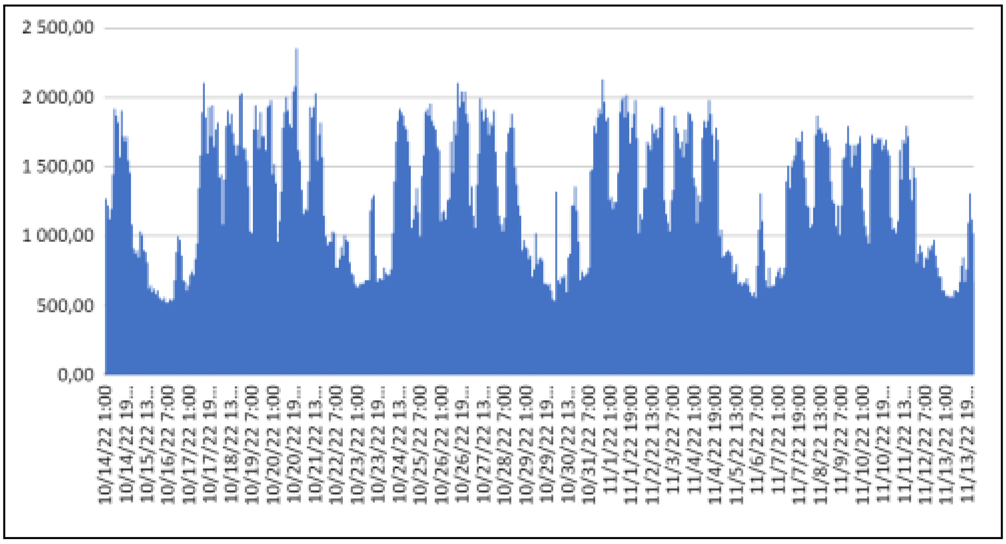


Figure 6.8 Load curve [kWh/h] for the period from 14.10.2022 to 13.11.2022. Source: Trondheim Municipality (TK).

The load time duration curve for the same metered load period is presented in figure 6.9. The curve is characterised by being relatively steep for the first approximately 50 hours; for the rest of the period, the duration curve becomes more horizontal, ending up with the period's lowest metered demand of 500 kW.

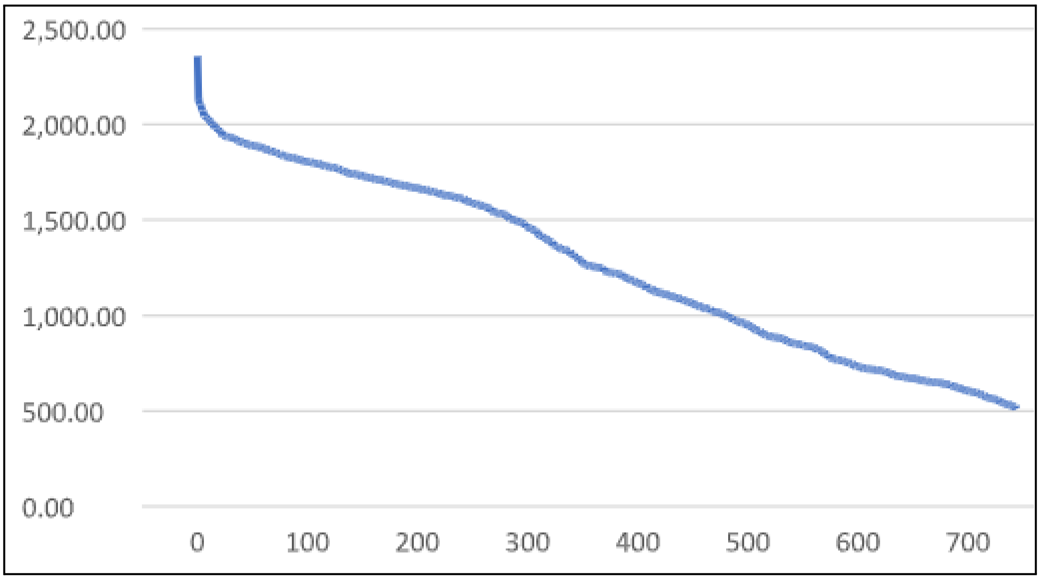


Figure 6.9 Load [kW] duration curve for the period [h] from 14.10.2022 to 13.11.2022 presented as hours. Time resolution is one hour. Source: Trondheim Municipality (TK).

The real power prices from NordPool[34] during the metered period are presented as an example of a typical day in figure 6.10.

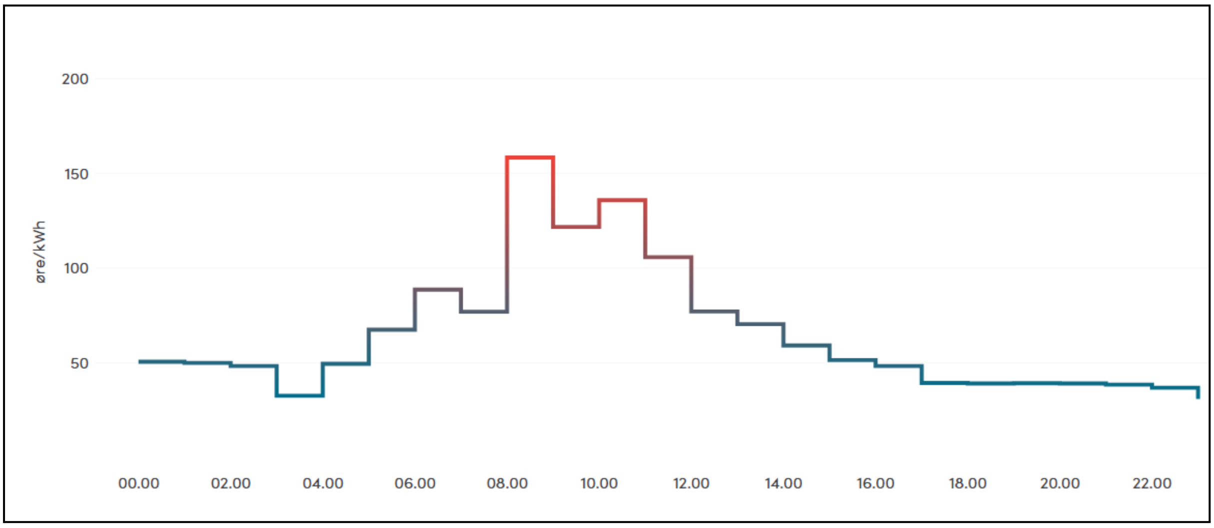


Figure 6.10 Power price [øre/kWh] for a typical day during the metered period. 1000 øre = 1 €. Source: NordPool.

It is assumed that the power prices as presented above are representative for summer and winter periods in the use-case calculations.

The grid tariff is dominated by a cost focus on the demand [kW] variable. For industrial customers the tariff cost ex. VAT for a month is as described in table 6.4. It is important to underline that the cost elements come from the peak demand fee, not the energy fee which is mainly scaled from a marginal loss cost principle and is as low as 0,0059 €/kWh ex VAT.

Table 6.4 Cost elements included in the grid tariff (ex. VAT). Winter months comprise November - April; Summer months May - October. Source: Grid company Tensio[35].

Cost element	Value	Unit of measurement
Energy consumption fee	0,0059	€/kWh
Peak demand fee Winter	7,6	€/kW/month
Peak demand fee Summer	1,2	€/kW/month

Use case 1: Reduced cost of grid tariff

Based on the actual use case and available data, calculations have been performed that present the income by using the battery to reduce the monthly accounted *grid tariff* demand peak by 200 kW. The peak is observed to occur during the daytime. The reduction is made possible due to the fact that the battery is charged during nighttime. Based on the load duration curve in figure 6.9 it is identified that it is required to execute the peak shaving during a month of no more than 30 hours in order to guarantee a peak reduction of 200 kW. The use case is chosen to be split into winter and summer periods respectively.

[34] https://www.nordpoolgroup.com/en/
[35] https://tensio.no/

In the use cases the full year is defined as 6 months of winter and 6 months of summer. The differences between the seasons are the monthly peak demand price [NOK/kW/month] (76 in winter and 12 in summer) and the distributed generation from PV prices periods of each part of the year separately. This is a simplification, but the use cases are still valid for the calculation of how the battery and the PV will contribute to the reduced total annual cost, hence increased value creation.

The battery's efficiency is estimated to be 85-90 % due to energy losses during storage, charging, and discharging. The battery storage efficiency will equivalently influence charging costs.
Winter month: November 1. - April 30. (6 months)
No contribution from local PV.

Table 6.5 Reduced monthly costs for the battery storage during winter (October - March). Price per kWh = 0,17 € . Source: Trondheim Municipality (TK).

	Element	Calculation	Sum [€]
+	Charging cost for 30 hours/month	200 kW x 30h x 0.1€	600
-	Reduced grid tariff cost per month	200 kW x 7,6€/kW	1.520
-	Reduced energy cost in peak period	200 kW x 30h x 0,17 €/kWh	1.020
=	**Reduced monthly cost of grid tariff**		**1.940**

Summer month: 01.05-31.10 (6 months)
Conditions and basic figures:
3500 m^2 PV and a grid tariff demand price reduced from 7,6 €/kW to 1,2 €/kW.

Table 6.6 Reduced monthly costs for the battery storage during summer (April - September), and total annual reduced battery cost due to grid tariff based on monthly peak demand reduction of 200 kW and using the prerequisites in the use cases. Price per kWh = 0,17 € . Source: Trondheim Municipality (TK).

	Element	Calculation	Sum [€]
+	Charging cost for 30 hours/month (from PV)		0
-	Reduced energy cost from grid	200 kW x 30h x 0.0059€/kWh	35,4
-	Reduced grid tariff cost per month	200 kW x 1.2 €/kW	240
-	Reduced energy cost during peak period	200 kW x 30h x 0.17 €/kWh	1.020
=	**Reduced monthly cost of grid tariff**		**1.295,4**
+	Reduced cost during 6 winter months (1,940€ x 6 months)		**11.640**
+	Reduced cost during 6 summer months (1,295.4€ x 6 months)		**7.772**
=	**Total annual reduced battery cost due to grid tariff**		**~19.400**

The total yearly cost reduction of the battery regarding peak shaving incentives from the grid tariff and power prices is presented as the sum of summer and winter use-case examples. It is important to note that the reduced energy cost from the grid is the marginal cost price element - not the energy supply cost element which is 0,17 €/kWh.

Summary of use-case 1
The main conclusions from the summer and winter use-cases are as follows:

- A battery brings valuable flexibility to a PV asset
- A battery is in general well positioned to peak shave load profiles
- During the winter period (Trondheim area), the battery is not possible to significantly charge from PV generation
- Value of the battery storage depends heavily on the grid tariff structure and peak demand prices during the winter period
- Power price variations during a typical day is the key driver to obtain value from the battery storage during the winter period

In addition to the list of main conclusions it is important to add the following two factors:

- The battery size must be decided based on load pattern + load duration curve.
- The coincidence between peak load, peak grid tariff price and power market prices will strongly influence the added battery value. Coincident factor of 1,0 = maximum value.

The value of the battery will in addition to the use-case descriptions be influenced by sale of system services to local grid operator/DSO. This service could be managed as P2P with a price model that includes standby optional price and a price dependent on disconnections (number and duration).

Use-case 2: Reduced cost from sale of system services
It is a reality that the distribution and local grid, in general, is about to be filled up in peak hours (grid bottlenecks). The parties responsible for the quality of supply are more and more frequently facing situations where the need for system services and/or more permanent grid investments are urgently required. This model is applied to the transmission grid with large industrial consumers in many countries. However, addressing this possible system service product to customers in the local grid is not that common. With a digitalised infrastructure for metering and dispatch (in/out), this represents valuable win-win options for the operation of local grid systems.

System services have traditionally been managed and operated as production reserves accessible for up/down regulation by the TSO (Statnett[36] in Norway). From a DSO perspective local bottlenecks and/or disturbances situations with local grid operational challenges due to introduction of more flexible loads, local generation, and lack of grid capacities are about to evolve.

To make such services available from consumers and/or local energy resources a digitalised infrastructure for metering and dispatch (in/out) and related settlement and invoice routines is required. With automated operation of digitalised system services, this represents valuable win-win options for end consumers/local energy assets and the local, regional, and central system operator(s).

[36] https://www.statnett.no/

The value for system operators to have the option to purchase demand disconnection is significant. A Norwegian example shows that during a 400 hour summer period, an amount close to 50 €/MW/hour is available to be instantly disconnected for not more than 30 seconds and available for repeated disconnects after 15 minutes. This was experienced in a real situation where a DSO asked for a local system service in a critical situation for their quality of supply/outage obligations.

With a battery with a capacity of 200 kW, a 30 second sale (discharge) will need only 1 % of the energy capacity in the battery. By using the battery, it is not required to cut the power supply to the factory (or building).

For the case used in the examples, this will bring the following income for a period of 400 hours/year for a battery storage of 200 kW capacity used in the system service market:

Income per 400 hours/year = 50 €/MWh x 0,2 MW x 400 h = 4.000 €

This example is from a demonstration project managed by Norwegian TSO Statnett in 2021, and is in principle possible to be operated by the local system operator as well.

Use-case 3: Reduced cost from participation in local trade

A complete value proposition for the battery storage should include income from participation in the local energy/flexibility market. In such a market the battery will act as a highly flexible participant that benefits from variations in power prices, peak priced grid tariffs, and the need for energy storage in periods with a surplus of locally generated renewable power. The total added income from such trade will mainly be a result of calculations similar to described use cases. However, there will be mark-ups for each trade and fees linked to buyers' demand for renewables (PV) during nighttime and other buyer specific occasions where renewables are requested.

A prerequisite to calculating the income due to preferred renewables is to know the size of a possible "green mark-up". This is so far not possible to get any numbers for, but with an estimated will to pay 0,01 €/kWh and 10 €/kW, the battery income during a year will emerge from 500 nighttime hours asking for 100 kWh/h renewable energy and 200 times asking for 100 kW capacity for some minutes each time. Based on this assumption the annual income from a 200 kWh/200 kW battery could be:

Income - energy sale for 500 h: 100 kWh x 1000 x 0,01 €/kWh = 1.000 €

Use-case 4: Battery income from daily charging/discharging

The power market price has daily variations as described as an example in figure 6.10. This is a variation that is possible for the battery to explore through daily charging and discharging operations. The charging is executed during the nighttime with low prices, while the discharging is executed during daytime when the power prices are the highest. By using the price variations as described in figure 6.10 as a typical day, the price level during nighttime (charging) is 1 €/kWh, while during daytime the price is 1,5 €/kWh. The price difference is 50% between day and night. In the example the price difference will then be (0,15-0,1) = 0,05 €/kWh. For a battery of 200 kWh with an efficiency of 80 % which is 160 kWh, the annual potential for income by selling during daytime and charging during nighttime will then be:

Income - from sale in peak price hours: 160kWh x 365 days/yr x 0,05€/kWh = 2.920€

Summary of use-cases: Total added value to the battery during a year

Table 6.7 summarises the different financial components and their exemplified yearly numbers for a battery storage in a local energy system that includes consumption, battery and PV.

Table 6.7 Summary of battery storage use-cases: Total added value for the battery storage over one year. Source: Trondheim Municipality (TK).

	Element	Sum [€/yr]
+	Reduced cost from grid tariff (*use-case 1*)	19.200
+	Income from sale of system services (*use-case 2*)	4.000
+	Income from trade in local market (*use-case 3*)	1.000
+	Income from daily sale at peak hours (use-case 4)	2.920
=	**Total added value to a 200 kW battery during one year**	**27.120**

Due to the fact that all use cases are not independent of each other, the total value proposition will not be the sum, but must be reduced due to which operational strategy is used for the battery. ***Even with a factor of 50 % revenue reduction caused by the dependencies, the value of the battery storage of 200 kWh could be 13.560 €/year which is close to 70 €/kWh of battery storage capacity***.

6.5 Vehicle-to-Grid EV charger

A 2-way (V2G) EV charger is in a local energy system an enabler for utilising EV batteries as a power bank for surplus local electricity generation and/or a secondary supplier of electricity to local consumption or a local energy system. Due to the relatively small number of kWh in an EV battery, sales of energy to local consumption/local energy systems are not an especially viable product. Sales of capacity/peak shaving (kW) to a local flexibility market and system services to the DSO (e.g. reducing temporary grid bottlenecks, and frequency correction) are more viable and may create value for car/EV fleet owners. The Parker project[37] showed that system services are a viable product in this context. More details are presented in +CityxChange report D5.13 - *Trondheim eMaaS Demonstration*[38].

The demonstration utilises EV batteries from an EV-sharing provider/company (Zipcar, the EV-sharing brand of Avis Budget Group) primarily as an integrated part of the local flexibility market. Brattøra and Sluppen as per today include only one V2G charger per location, connected to 40 kWh EV batteries. The value of one EV battery is pretty low, even though the capacity of the chargers is 11 kW. However, with for instance 10 EV batteries connected via the ABB Terra Nova 11 J[39] V2G chargers used in Trondheim, the total simultaneous capacity of 110 kW becomes a viable contributor in a local flexibility market/local energy system. The calculations are based on 10 EVs/EV batteries using ABB V2G chargers. The total capacity for 10 EVs taking the above considerations into account is 400 kWh.

[37] https://parker-project.com/
[38] https://cityxchange.eu/knowledge-base/d5-13-trondheim-emaas-demonstration/
[39] https://www.chademo.com/products/v2g/abb-terra-nova_11_j

A number of EV batteries integrated and included in a local energy system should be managed and operated as a local storage system and must in the future be looked at as an alternative to stationary battery storages or a supplement to storages; not the least due to cost issues.

The stationary battery storage value proposition is developed by Trondheim Municipality as a battery centric; focused on increased revenue for the battery owner. According to the Trondheim eMaaS Demonstration report,[40] there are 3 core actors that could benefit from EV batteries through V2G charging: The EV owner (in this case Zipcar), the building owner where EVs are connected, and a parking company that operates the parking spaces on contract with the local building owner. The revenue calculations are performed in order to analyse values for all these 3 types of actors.

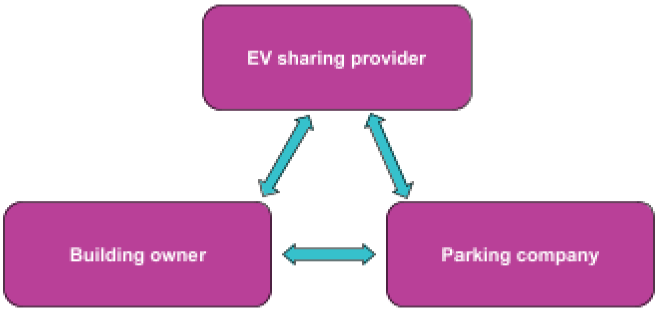


Figure 6.11. Actors involved in the Trondheim mobility and V2G cases.

The revenue/value proposition calculations for EV batteries are based on the calculations and assumptions done in section 6.4 for the stationary battery storage.

- Use case 1: The same parameters are used, only 110 kW capacity instead of 200 kW
- Use case 2: 200 hours are used instead of 400 hours
- Use case 3: 50 kWh is used instead of 100 kWh
- Use case 4: 200 kWh total battery capacity is used: 50 % of the EV battery total capacity is used since there needs to be remaining EV battery capacity in order to have driving range for the EVs at any time. Calculations are used solely for winter situations (performing calculations for 182 days and not 365 days) as in the stationary battery storage case.

Table 6.8 presents a summary of added value of the EV batteries from the four use cases.

Table 6.8 Summary of EV battery storage use-cases: Total added value for 10 EV batteries at 40 kWh/EV battery + 11 kW capacity for the V2G chargers for charging/discharging. Source: Trondheim municipality (TK).

	Element	Sum [€/yr]
+	Reduced cost from grid tariff (*use-case 1*)	10.674
+	Income from sale of system services (*use-case 2*)	1.100
+	Income from trade in local market (*use-case 3*)	500
+	Income from daily sale at peak hours (use-case 4)	1.820
=	**Total added value to 10 EV batteries during one year**	**14.094**

[40] https://cityxchange.eu/knowledge-base/d5-13-trondheim-emaas-demonstration/

This total annual income for an EV fleet owner or EV sharing scheme owner when integrating 10 EVs into a local flexibility market. Note that the building owner could have this income if they for instance rent the shared EVs for certain periods when energy prices for selling energy/capacity/system services are high. This is explored as part of the analyses and calculations shown below.

The deployed solution and investment and business models at Brattøra and Sluppen within the +CityxChange project are that The EV sharing actor Zipcar rents the parking spaces from the building owner, they sell electricity/capacity to the local market, and will themselves get the revenue from sales of electricity/capacity ("EV sharing company centric model" shown below). The model mentioned thus represents the actual deployed case in Trondheim.

The +CityxChange case is somewhat special compared to a fully commercial case, since Trondheim municipality invested in the V2G chargers, and Trondheim Parkering AS (Sluppen) and Entra Property (Brattøra) covered the investments for the 1-way chargers. Car sharing actors are usually reluctant to cover the investments for charging infrastructure. Our calculations below show that both the building owner and the EV sharing company will have positive revenue streams through selling energy and system services from the EV batteries, even when taking the investment costs for the chargers.

As for the revenue analyses above (table 6.8), the analyses below are based on 10 shared EVS per location. The revenue generated from sales of energy and system services in table 6.8 (€ 14.000) is used throughout the following analyses and calculations.
Note that car costs (CAPEX/OPEX) are not included in the calculations. Nissan Leafs are used in this project. For 10 cars: CAPEX: € 192.000 / OPEX (including holding costs, administrative costs, and charging costs): € 9.000.

The first part worth mentioning, is the cost reduction for the EV sharing company if they choose to let the building owner get the revenue from sales of electricity and system services. In this case the building owner rents the EVs for certain periods of time, when electricity/capacity/system service prices are high. This will reduce the operational costs for the EV sharing actor.

Table 6.9 Parking space cost reductions for the EV sharing company due to renting EVs to the local building owner.

	Element	Sum [€/yr]
+	10 parking spaces for one year	-24.000
+	Rent 10 EVs to building owner 20 times (hours) per year	2.000
=	**New total parking space cost**	**-22.000**

This generates a 8,3 % cost reduction for the EV sharing company only for making EV batteries available for the building owner, so this actor can benefit from selling electricity/capacity/system services to the local market/DSO.

Case 1: EVs w/V2G charging - Building owner centric model
Cost per V2G charger: € 4.000
Financing of V2G chargers: Annuity loan over 7 years / 5 % interest rate / 22 % tax exemption. Total costs for 10 chargers and loan financing: € 42.000
Technical lifetime of charger: 10 years

Table 6.10 Investment and revenue model for building owner centric model for year 1-7, and year 8-10. All numbers are annual figures.

	Element	Sum year 1 [€/yr]	Sum year 10 [€/yr]
+	Income from sales of energy and system services	14.000	14.000
+	EV rental cost	-2.000	-2.000
=	***Gross income***	***12.000***	***12.000***
+	Funding of chargers	-6.867	0
+	Operational costs and service on chargers	-600	-600
=	**Net income**	**4.534**	**11.400**
	Total income over 10 years	**65.939**	
	Total charger cost	**42.000**	
	Annual ROI %	**10,8**	

After the loan is paid back (from year 8), net income rises abruptly, resulting in a substantial net income over the total technical lifetime of the chargers.
An ROI above 10 % for this case is very good, and above the +CityxChange KPI #25 goal for project interventions of 10 %. From year 8 on, the ROI % increases to 27.1.

Case 2: EVs w/V2G charging - EV sharing company centric model
Basic parameters are the same as for the building owner centric model (Case 1).

Table 6.11 Investment and revenue model for EV sharing company centric model for year 1-7, and year 8-10. All numbers are annual figures.

	Element	Sum year 1 [€/yr]	Sum year 10 [€/yr]
+	Costs for renting parking spaces	-24.000	-24.000
+	"Lost" income from renting EVs to building owner	-2.000	-2.000
+	Income from sales of energy and system services	14.000	14.000
+	Funding of chargers	-6.867	0
+	Operational costs and service on chargers	-600	-600
=	***Net cost for renting of P-spaces***	***-19.466***	***-12.600***
-	Full costs for renting parking spaces	-24.000	-24.000
=	**Net income**	**4.534**	**11.400**
	Total income over 10 years	**65.939**	
	Total charger cost	**42.000**	
	Annual ROI %	**10,8**	

The parking space rent costs make up a large difference compared to the building owner centric model. However, the net parking space costs (€ 19.466) are, due to sales of energy and system services to the local market lower than the original parking space costs of € 24.000. Thus, there will be a net income for the EV sharing company as well, in fact equal to the net income of the building owner case. This means that the ROI% for this case equals the ROI for the building owner case, with 10.8 % per year during the first 7 years, and 27.1 % for the years 8-10.

Position number 2 in table 6.11 with "lost income" refers to the fact that in this case, the EV sharing company is not renting EVs to the building owner for the building owner to have the income from selling energy to the local market.

This case is the one deployed at Brattøra and Sluppen, except for the fact that EV charger investments in Trondheim are made by others than the building owner and the EV sharing company.

Conclusions:

- As for the battery storage, it is important to take a subject/stakeholder centric perspective when analysing the value creation potential of V2G chargers as part of a local energy and flexibility market
- For both a building owner and an EV sharing company, the net revenue is positive from year 1, with an ROI of close to 11 %; ROI from year 8 on is 27,1 %
- Total revenues over the assumed technical lifetime of the V2G charger of 10 years are close to € 70.000 for both the building owner centric and the EV sharing company centric models

6.6 Sector coupling

Sector coupling involves the interconnection and optimised utilisation of the electric and thermal energy sector. Figure 7.9 describes how sector coupling between heating/cooling (Sector A) and electricity (Sector B) is technically linked.

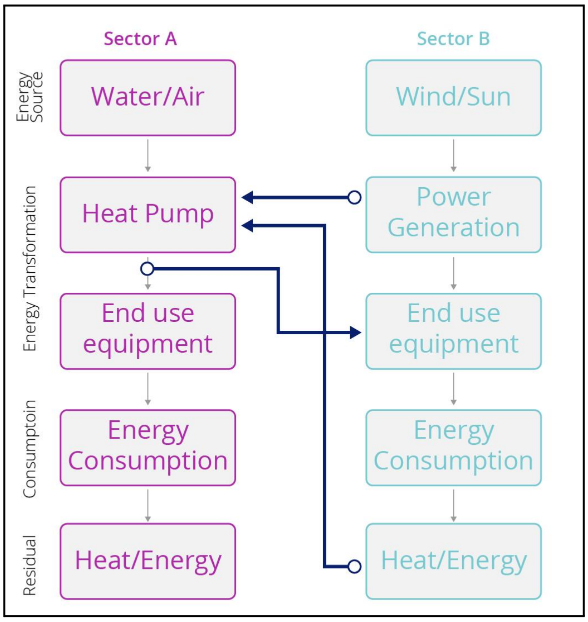


Figure 6.12 Technical local sector coupling between Sector A - heating/cooling and Sector B - electricity.
Ref: D5.9: Playbook of regulatory recommendations for enabling new energy systems.

In total 8 PEB buildings in the two Trondheim PEBs have heat pumps with individual annual net production ranging from 50.000 to 554.000 kWh. The total annual net thermal production equals approximately 2,6 GWh, and a substantial share of this thermal production at Brattøra comes from a large local seawater heat pump system (see Annex 11 for detailed production).

The heat pumps represent definite values for the buildings and building owners in terms of reduced energy costs by decreasing the electricity from the local grid. The heat pumps are important cost wise concerning the existing grid tariff structure[41], contributing to reduced grid tax costs, and reduced risks of exceeding grid tariff capacity thresholds.
One obvious conclusion is that heat pumps integrated with local generation systems (PV) and battery storages, will contribute strongly to decreased energy costs - not the least grid tax costs. This implies that heat pumps may be important, even crucial components and sources of local production in PEBs, as they definitely are in Trondheim.

Heat pumps may also be an integral part of a local sector coupling scheme, being deployed at PEB Sluppen. Below, the design and solution itself is described, including energy savings we expect to obtain. Not all cost elements for this case are available. This means that profitability analyses have not been performed for this case. Analyses, however, include cost optimisation, and expected energy savings.

[41] https://www.nve.no/reguleringsmyndigheten/kunde/nett/ny-nettleie-fra-1-juli-2022/

The specific PEB Sluppen sector coupling scheme includes one building and is visualised in figure 6.13.

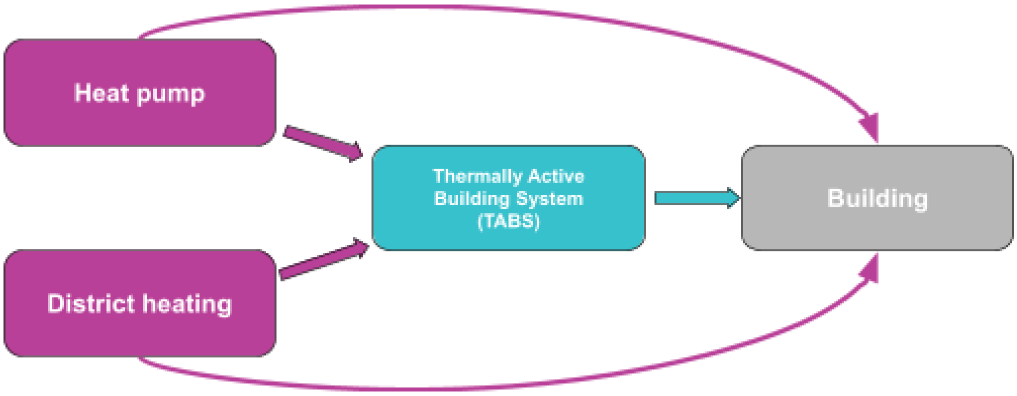


Figure 6.13 PEB Sluppen sector coupling scheme.

Table 6.12 A selection of basic parameters for the Sluppen sector coupling demonstration building.

Element	Value [kWh/yr]
Energy consumption	1.028.870
Net heat pump production	268.480
District heating	104.759
PV production	75.300

The Sluppenvegen 17B TABS[42] system has a capacity of 200 kW (total storage capacity in kWh is not certain since this depends on a series of factors).
This case is also based on a project developed (SV and TE/Aneo) dynamic pricing model for district heating, decoupled from the electricity spot price (figure 6.14).

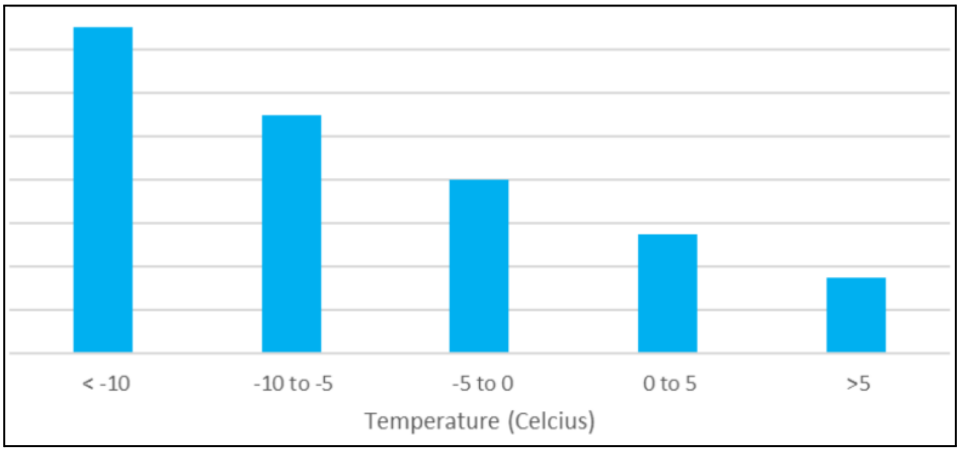


Figure 6.14 Dynamic price model for district heating based on outdoor temperature, decoupled from electricity spot price. Source: SV

[42] https://www.linkedin.com/pulse/thermally-active-building-systems-tabs-explained-canis-fung/

District heating is priced based on the monthly spot price for electricity in Norway today[43]. With soaring electricity prices, actions such as DH price models decoupled from electricity spot price are important in order to secure affordability, and optimise energy supply with e.g. sector coupling.

Both the heat pump and DH is used for warming of the building (figure 6.13). In addition thermal energy (surplus or based on price considerations/signals) from the heat pump and DH can be fed into the thermal storage (TABS), which later on can be fed into the building.

A large number of advanced analyses have been performed in order to find the best possible integrated use of all sources/assets in this system. The analyses are based on both the prevailing DH price model, and the new, spot price-decoupled, price model. The analysis has been performed as part of a Bachelor thesis, for Trønderenergi (Aneo), Energiemanagement Howest, and +CityxChange (Tancré, 2021).

The new dynamic DH price model will give high prices, thus high energy costs, during winter times and low temperatures in Norway because electricity and/or gas is used for the DH peak load production (figure 6.14). A low DH unit price with the new price model during Summer will make DH favourable then (figure 6.14). When we also take into account that there is a high share of waste heat from the district heating grid during Summer and opportunities of using this instead of a heat pump, we conclude that - with a new DH prize model - the best solution is to use the heat pump extensively during winter time, and feed in as much as possible of DH during Summer. This is also favourable in sustainability terms, since a larger share of the DH grid waste heat then can be utilised.

The latter is the actual deployed sector coupling scheme and model at PEB Sluppen.

A longer time of operation is needed in order to assess whether this scheme is financially beneficial or not, and to what extent. Optimisation of the use of TABS (thermal storage) is a key factor in increasing revenues.

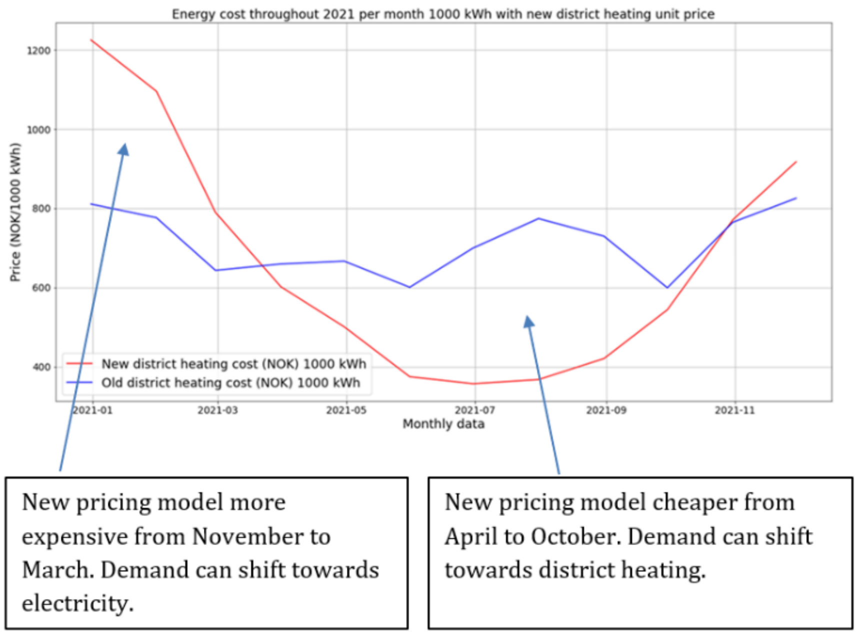


Figure 6.15 Annual price curves for DH for prevailing and new DH pricing (Tancré, 2021).

[43] https://lovdata.no/dokument/LTI/lov/1986-04-18-10

6.7 Local Energy Market

A local energy market in the +CityxChange context, is a smaller area where you optimise sales of local production/capacity and user flexibility (kWh/kW) between local actors, and sales of system services to the DSO. It is connected to the larger power system, and can also be seen as a submarket in the global market. There may be price differences for both electric and thermal energy between the global and the local market, since prices are set for the LEM. Trønderenergi (TE)/Aneo is the local market operator, and the market works as a down-sized power market; only that the market actors are individual assets, such as a PV rig, battery storage, and heat pump, with automated trades at high time resolution.

Section 5.3.1 and in particular table 5.3 shows that the PEB case in Trondheim is financially profitable (FRSM calculations); especially for the building owner. However, the Local Energy Market is the one factor and system that enables the sales of energy in the Trondheim PEBs; that contributes to the revenues generated by the different single assets, and the aggregated revenues generated, as assessed in the FRSM. Thus the building owner's revenues relies on having the market as the main “instrument” for selling and buying energy, strongly contributing to the building owner’s and EV sharing company’s revenues.

Main actors in the Trondheim LEM and main investment and revenue elements in the LHC Trondheim LEMs are presented in table 6.13.

Table 6.13 Overview of main actors and cost/revenue elements in the Local Energy Market in Trondheim.

Actor	Cost (CAPEX/OPEX)	Revenue
Local Market Operator (TE)	Battery storage Local Energy Market	Sale in local market including battery Sales of system services (DSO)
Building owner (RK/Entra)	RES Energy efficiency measures	Sale of energy/capacity Peak reduction/shift
EV sharing company (ABG) [1)]	V2G + other infrastructure Parking space rents	Sale of capacity & system services

1) Vehicle investments, holding costs, etc not included

Analyses performed by Officinae Verdi (OV) show that system integration is costly, and have a long payback period. However, this report also concludes that system integration is necessary in order to have a functional PEB and LEM. In the prevailing project, system integration licence and cloud/storage costs are covered in-kind by partners (ABB, Volue, TE). In a commercial scale PEB or similar measure, who to cover these costs, and will that make the whole PEB/LEM case non-profitable? What financial mitigating measures can be taken in order to ensure profitability? Grid tariff costs for a battery storage in the grid is another issue. Originally and worst case, grid tax must be paid 3 times for the same electricity: When charging the battery, discharging the battery, and for the building owner buying the electricity from the battery. TE has got acceptance that grid tax in this case is being paid only once. But who to pay the grid tax in a commercial scale measure? These are issues that need to be solved in scaling and replication.

6.8 Energy efficiency measures

Two different cases of efficiency measures have been applied to PEB Sluppen buildings:

1. State-of-the-art system management and ICT measures (primarily software measures) in 3 buildings (average specific energy consumption: 124 kWh/m^2, yr)
2. Traditional retrofit in terms of roof insulation and new exchanger on the HVAC system at replication building of Tempe Health Care Centre (specific energy consumption: 175 kWh/m^2, yr)

Case no. 1 energy efficiency measures were selected and performed based on an energy report from TK (Ness et al., 2021).

Table 6.14 Calculations of energy savings, efficiency measure savings, SPP, and ROI% for the two types of energy efficiency measures. Measures are considered financed through annuity loans at 5 % interest rate. Energy price per kWh is the same as the PV case in section 6.3 (€0.153 excl grid tax).

Element	Case no. 1	Case no. 2
Intervention cost [€]	83.916	210.000
Energy savings [kWh/year]	151.363	47.000
Energy cost savings [€]	23.159	7.191
SPP [year]	3,6	29
ROI [%]	27,6	34

The lower SPP and higher ROI in the case of advanced ICT based energy efficiency measures (case no. 1) compared to the traditional retrofit case (case no. 2) can of course not be regarded as increased impacts due to the project. The state of many buildings is such that retrofit/deep retrofit measures are necessary in order to obtain adequate energy savings (kWh).

The calculations underline that for buildings where new/newer BMS and/or EMS are not in place, there is a huge potential for highly cost efficient efficiency measures. In fact, one should seek and map opportunities for (advanced) ICT based solutions before moving to high cost, retrofit based measures anyway. Trondheim municipality is continuously seeking opportunities for such/similar measures for their own buildings, in order to obtain their annual energy consumption reduction goal of 2 %. This strategy will probably also be chosen and made into operational efficiency measures within the revised Energy and Climate Action Plan for Trondheim (2023).

7 Investments and replication monitoring

7.1 Investments monitoring

The innovative applied business models and risk analysis should be monitored to check and assess their actual performance over time.

The implemented and foreseen investments will therefore need to be monitored in their economic/financial performance by collecting yearly information and checking them against the identified KPIs and current baselines, as well as against ESG, impact & stakeholders benefits and efficacy of identified solutions. It is recommended that each investor/prosumer monitor their PEB related activities within the normal business operations and will check how far reality matches the forecasts. The public institution (i.e. Trondheim Municipality) should collect all data to perform detailed and verified inventories bi-annually for the overall picture and its global evaluation, as well as detailed numbers for the core financial KPIs including +CityxChange official KPIs. The financial monitored KPIs are revenues/savings, annual return on Investment and simple payback periods (years).

Replication/scaling can represent a consolidation of PEB financial performance and at the same time provide further monitoring and evaluation results in terms of feasibility and bankability of the investments.

7.2 Replication monitoring

The +CityxChange replication monitoring is partly based on the original (Grant Agreement) Roadmap 2050 (table 7.1). In addition replication and replication plans are set up for short term replication (throughout 2023).

LHC Trondheim has set up a specific action along with a brand for the short term replication - *CityxChange By Trondheim*[44], which, in addition to the decided scaling/replication happening within +CityxChange, involves scaling and replication beyond the scope of +CityxChange itself (figure 7.1).

CITYXCHANGE
By Trondheim

Figure 7.1 The LHC brand for the scaling and replication beyond the scope of +CityxChange commitments.

[44] https://cityxchange.eu/knowledge-base/d5-14-trondheim-project-documentation-repository-including-project-status-reports-4/, section 2.4

Table 7.1 Original +CityxChange replication plan and roadmap towards 2050 (Bold City Vision: Positive Energy City), including prevailing status

Year, plan	Replication activity	Buildings	Status
2020	Nidarvoll School and Health Centre (TK, investments secured - 78,1M€)	School + sports hall + rehabilitation centre 24.800 m²	Under construction; completed early 2024 - Replication
2021	Interconnecting the Trondheim PEBs + Campus Gløshaugen Microgrid		Not realised
2023	PEB Sluppen - remaining buildings	Sluppenvegen 23 (ALO) w/15,000 m² completed in 2023	Replication - Well Platinum / BREEAM Outstanding / Paris Proof
2023	PEB Brattøra, adding E-Bus charger and shore-to-ship facility		E-Bus charger being replicated as per early 2023
2023	Trondheim Station Centre (new terminal for trains + bus + apartments + commercial area		New terminal + offices completed in 2025
2025	PEB NTNU Campus Gløshaugen Stage 1		Not decided
2025	PED Brattøra completed	30 buildings 0,65 km²	Not decided
2027	PED Campus Gløshaugen completed	0,23 km²	Not decided
2030	PED Sluppen Stage 1	0,65 km²	Not decided
2032	PED Sluppen Stage 2	0,38 km²	Not decided
2037	PED Demonstration District of Knowledge Axis ("Kunnskapsaksen") completed	5,28 km²	Not decided
2050	Trondheim Positive Energy City	321,8 km²	Not decided Assumed: 255,9 MW peak load 2,2 TWh local production 539 MWh battery storage

Ongoing replication projects, energy:

- Tempe Health Care Centre, TK owned project, 2023 (extensive PV, 112.000 kWh/yr - beyond self consumption, system/asset integration, and inclusion in the Sluppen PEB and Local Energy Market)
- Development and implementation of a smart EV charging system for optimising EV charging (developed by Spark by Volue[45]), implemented in stages in for now cooperation with TK

[45] https://www.volue.com/spark

Ongoing/Started replication projects, mobility:

- eMaaS and the development and implementation of Mobee[46]; mobility backend and frontend developed by official partner FourC, Mobee brand developed and owned by TK. Almost full-scale MaaS solution with a large variety of mobility modes included
- Cargo bikes - cooperation TK - Studentsamskipnaden (student welfare organisation) - solutions for students
- Cargo E-Bikes and car sharing - cooperation TK - IKEA
- Car sharing at grocery stores - cooperation with international chain of grocery stores

Replication monitoring could be also useful to check how key performance indicators change across different investments, contexts, time, though seemingly directed to PEBs implementation.

In the table below the unit value for outputs in Sluppen PEBs investment in Trondheim are reported as reference, based on the initial investment, equal to € 2.791.103, divided by the implemented tangible results.

Table 7.2 Cost per generated output by the deployed investments in the PEBs.

Indicator	Amount achieved PEB Sluppen	Data Source	Average €/unit
CO_2 reduction	535 ton/y	D5.11 table 2.2	€ 5.217/ton
New RES installed	1,8 GWh/y	D5.11 table 2.1	€ 1,55/kWh
Energy efficiency	243.400 kWh/y	D5.11 table 2.1	€ 11,4/kWh
Total m^2 served by the PEB systems	39.426	Table A41 D5.11	€ 70,79/sqm
Energy traded in the local market (incl. system integration)	783.840 kWh/y	Table A41 D5.11	€ 3,5/kWh

[46] https://mobee.no/

8 Conclusions and recommendations

These conclusions and recommendations are the result of a four year project period. It is a result of extensive cooperation between partners, data sharing, development of models for technical, and economic/financial calculations based on a local energy system approach. Interviews and questionnaires shared with main stakeholders, investors and service providers have supported the work. Management costs, investments and revenues have been calculated and related financial risk has been measured for energy assets and investors in the Sluppen and Brattora PEBs.

Stakeholders including project partners have innovated on system thinking, cost efficient implementation of supportive technology and stakeholder incentives required to succeed finding the most profitable and convenient balance among energy production, energy efficiency measures, and flexibility.

There are financial and management factors influencing and driving PEB implementation and related success. The Trondheim PEB cases have identified success factors as well as implementation difficulties and factors or barriers which in any case are lessons learnt and valuable use cases for policymakers and market players. It identifies factors to be improved or implemented for developing sustainable investments and business models to be applied to PEB development and operation.

8.1 Conclusions

A variety of specific financial models involving project developed investment and business models and a Financing Risk Sharing Model (FRSM) have been tailored for the deployed PEBs in LHC Trondheim. The same models/tools can, however, be used and applied for other European PEB/PEDs.

The PEB solution includes a multi-stakeholder approach as well as efficient energy efficiency measures, local RES combined with a Local Energy Market, and user flexibility sold to the stakeholders of the PEB and the DSO. The involved actors/players share the total risk, the total revenues, and value creation of the PEB.

The model developments including the financial analyses prove that a combination of improved investment models and a financial risk sharing model (FRSM) covering the PEB as a system involving impacts of ESG indicators, are necessary for a complete value creation of a multi-stakeholder PEB. The individual investment models are crucial for verifying the value creation of the single interventions of the PEB. However, for a complete inventory and documentation of the value creation, an FRSM is required. The model is conceived to be a prerequisite to conclude whether a PEB is financially viable and profitable.

The project has executed a survey asking real estate companies, banks and financial institutions all over Norway about their experiences and opinion on how building certification (BREEAM, WELL, etc.) may contribute to significant value creation for the real-estate companies. The main finding is that it will contribute to substantially decreasing the payback time for the building/building upgrading, building market value will increase 10 %, and the building owners value of equity will increase by 20 %. This is important knowledge due to it strengthening the incentives to participate in PEB development and participation.

The PEB process combines building characteristics on how the energy is supplied and managed. Sector coupling between electricity, heat pumps, and district heating makes up important resource utilisation in order to gain maximum value from the PEB. This coupling contributes to postpone grid investments, optimise the flexibility of stored heated water, and minimise the electricity cost of heat pump operation. In total the value is maximised and the liquidity of the local energy market is improved.

The FRSM is developed and applied within a framework that includes building certification upgrades, sector coupling, and utilisation of local energy resources in an energy system approach - including sector coupling and sales of local system services. The PEB demonstrations at Brattøra and Sluppen have resulted in the following main conclusions:

- Rooftop PV systems may exhibit net positive revenues from year 8 on when financed through a serial loan at 5 % interest rate. This requires sales of surplus production in the LEM during 4 Summer months, and a depreciation scheme with a variable monthly (albeit fixed annual) depreciation dependent on the monthly PV production
- The PV case may be profitable from year 1 if, in addition to the factors above, the PV investment receives interest rate support of 3 %. Interest rate support for such a case could for instance be through a national/international funding instrument, or through a mix of public and private incentives (private for instance through a green loan)
- Interest rate support is a far more efficient use of money than one-off funding schemes, in the way that 5 times more PV systems can be funded from year one for the same cost
- The battery storage case is not itself economically profitable due to high investment costs. A battery storage is, however, crucial in PEBs/LEMs involving PV, and a local battery storage being part of a LEM will significantly improve the cost situation. The value of battery storage of 200 kWh can be 13.560 €/year which is close to 70 €/kWh of battery storage capacity
- V2G chargers may have net positive revenue from year 1 if charge/discharge is optimised, and energy/capacity from the EV batteries are sold in a LEM. ROI may be close to 11 % already from year 1, and 27 % from year 8. Total revenues over the assumed technical lifetime of the V2G charger of 10 years are close to € 70.000 for 10 EV chargers at one location, e.g. connected to a commercial EV sharing scheme
- Single intervention investment models are important for benchmarking costs and revenues in PEBs/green energy neighbourhoods. However, an FRSM is a crucial model and tool for concluding whether an area based approach to energy interventions (i.e. PEBs) is profitable or not
- FRSM calculations and analyses show that
    - The total revenue is positive for all actors of the Trondheim PEBs; the highest for the building owner (R Kjeldsberg in this case)
    - The cash flow is also positive for all actors
    - Simple payback times vary from 2 - 17 years, with an average SPP of 6 years
    - ROI varies from 1-17 %, with an average of 7,8 %; for building owner RK it is 10,3 %
    - For the Local Flexibility/Energy Market which is novel and important for the whole PEB solution in Trondheim: Investments take 11 years to be recovered (SPP), and the ROI for the market (TE) is 1,9 %

- Trondheim whole PEB is a profitable financial - economic investment where each investor/stakeholder shares a different financial risk related to the pro-quota invested and related revenues
- An ESG oriented company/business has more easy access to the financial capital market. Lower debt cost of capital means lower cost debt and lower financial risk
- If a company increases its ESG CSR score by 1 point (i.e they add an additional strength in one of the areas of ESG - CSR or are no longer engaging in an activity deemed as a ESG_CSR concern), there should be a cost debt reduction of around 0,5 points

The set-up and realisation for the PEB ecosystem trigger the following considerations experienced in Trondheim:

- The dedicated roles required to enable the local market within the PEB needed to be refined during the demonstrations
- "Energy neighbourhoods" linking PEB residents, both domestic and commercial, are not being formally settled yet, nor dedicated companies as market operators
- Potential new players from finance, energy industry or others are not involved at this stage with the result that new business models have not been fully explored
- The market operator has indeed experienced becoming the basic hub in both establishing and operating the demonstrations
- The market operator has a close link to the energy industry and their skills and know-how have indeed been factors for success in the demonstrations
- Central Norway (Trondheim) with electricity prices typically from 0,15-0,2 €/kWh, is at the low end in terms of profitability for PEBs/energy smart neighbourhoods. At Central Norway latitudes, the PV production is very low during the darkest winter months; still the PEBs are profitable.

The main barriers being faced by businesses trying to effectively implement a PEB ecosystem appear to be:

- **Technological:** Local energy market and related technology are not mature. Many new solutions are being developed to address similar problems.
- **Financial:**
    - Lack of incentives and funding, lack of private investment, lack of monetization of energy and flexibility services
    - Existing external funding instruments and funding schemes are not designed and fit for the PEB/area level approach
- **Market:** Lockdown (eg. for eMaaS)
- **Regulatory:** National Tenancy Act, National Energy Act, National Finance Act, GDPR regulation (which data can be controlled/managed), norms on local energy trading (Norway lags behind on this topic). On the latter, one of the project's most important achievements was Trondheim receiving full acceptance and permit (28.02.2022) from the national regulatory authority RME for coordination of open energy and flexibility markets at Brattøra and Sluppen. It is running indefinitely, pending TE's continued participation, and thus allows continuous experimentation and testing.
- **Political:** Consistency of political commitment
- **Societal:** Market not mature, consumers' and tenants' awareness, social acceptance, difficulties for new players to enter the market
- **Governance and organisational and cultural aspects:** Local/Regional public authorities are not set for taking the role as driver and facilitator for a green energy

shift. Municipalities/Counties/Regions are indispensable in this context and processes

During the PEB demonstrations 10 different parameters that influence cost of RES and PEB interventions have been analysed. In addition ESG variables that influence financial risk have been included in the work. In table 9.1 it is presented a list of lessons learned.
A major lesson learned from working with green energy measures on a PEB level claims novel thinking and new approaches, also generated by the close cooperation among the involved stakeholders.

Table 8.1 List of lessons learned

Topic	Explanation
Stakeholders	The stakeholder map will be quite different from, and more complex than, usual local building actions.
Stakeholders	Joint cooperation among private and public actors-local authorities is a fundamental success factor that can also grow into a formalised collaboration in the form of a cooperative or energy communities for the establishment of overall PEB profitability and the use of an innovative model such as FRSM is useful.
Stakeholders	Building Owner/Real Estate developer is a core player in the PEB implementation-success.
Funding	Several financing schemes have been analysed, but most interventions have been supported by EU funding, demonstrating that PEB implementation at an early stage needs public funding to design and test tailored business models in the research and experimentation phase. This is also a tangible conclusion and result from the Lighthouse +CxC project in Limerick.
Governance	Management/governance issues influence PEB development and success. The case has shown that a Public Body-local authority is needed as driver and facilitator for escalation to PED, replication and for overall profitability, being able to combine investors' needs as well as to look for further funding. A public body can take, and has a strong mandate, to face the societal perspectives and aspects of a green energy transition and to link it to a wider perspective, combining local work on sustainability with work on fulfilling UN Sustainable Development Goals (SDGs) and climate & resilience related ambitious plans.
Context	Replication is affected by the local context, but also the national and in fact international context. Context is for instance about frame conditions and legislation/regulations, the tax system, will to invest, local facilitation, and energy prices (which are both local, national, and internationally influenced), but also predictability in terms of frame conditions.
Complexity	Moving to a total value concept is a long and complex process that requires a long planning phase, strong dialogue among local stakeholders, system thinking and a collaborative mindset. This process has to be governed, preferably by a player that can be a recognised public authoritative stakeholder or a cooperative team.

8.2 Recommendations

The recommendations below are also based on and refer to outcomes and results from the PEB and regulatory tasks and final reports. The technical and system-wise PEB and LEM set ups, the Trondheim PEB ingredients, and regulatory conditions and framework are all directly connected to and providing important inputs to the development, set-up, and outcomes in terms of project developed investment and business models; and the outcomes in terms of profitability for the Trondheim PEBs. The main source to backbone in this case are the reports D2.1 - *Report on enabling regulatory mechanisms to trial innovation in cities*[47], D5.11 - *Trondheim dPEB Demonstration*[48], and D5.9 - *Playbook of regulatory recommendations for enabling new energy systems*[49].

To achieve a profitable PEB it is crucial to optimise and balance energy production, energy efficiency measures, and flexibility, on the basis of the available resources and stakeholders and on the basis of the local context.

In a PEB setup and ecosystem, it is recommended that *integration is pursued*, conceived in technical (energy related technologies), economic (sharing of savings, revenues, funding, etc.), and social terms, with multi-stakeholders involvement (public, private, residential, commercial, prosumers, citizens, etc). It is crucial to focus on:

- **Financial benefits and risks should be transferred and compensated among the different assets and stakeholders** to maximise global value and create a sustainable system in its entirety. Most of all, like in Trondheim, where currently a single stakeholder (TE) is playing many of the roles, the involvement of prosumers is a key to the success of a PEB (ref. report D 5.11 - footnote 46, and D 5.6 Trondheim Flexibility Market Deployment - to be delivered June 2023).
- **Total value creation should be preferred to BAU cost-revenue creation** for the establishment of a sustainable "system". In order to succeed with a green energy transition we need to shift from "total reduced costs" to "total added value". Total added value is understood as the sum of increased revenue including decreased SPP/increased ROI, increased values of assets/equity, value creation through ESG factors for the private stakeholders, societal outcomes for the city, and reduced investment needs for critical and important infrastructure.
- **Specific governance models for the PEB should be implemented,** such as Renewable Energy Community or Citizen Energy Community as defined by the Clean Energy Package[50] able to guarantee integration, coordination and cooperation not to mention long term perspective. Such structures could be promoted by local authorities and benefit from specific funding. Energy communities as legal entities can cover various parts of the value chain (incl. generation, distribution, supply, consumption, aggregation etc.). Often, energy communities are focusing on jointly investing in nearby RES projects, thereby participating in the simple investment opportunity and related returns[51].
- **Regulatory issues should be improved and revised,** where needed, to favour peer-to-peer exchange of electricity, flexibility and local energy markets, prices

[47] https://cityxchange.eu/knowledge-base/report-on-enabling-regulatory-mechanism-to-trial-innovation-in-cities/
[48] https://cityxchange.eu/knowledge-base/d5-9-playbook-of-regulatory-recommendations-for-enabling-new-energy-systems/
[49] https://cityxchange.eu/knowledge-base/d5-11-trondheim-dpeb-demonstration/
[50] https://energy.ec.europa.eu/topics/energy-strategy/clean-energy-all-europeans-package_en
[51] ASSET STUDY on Best Existing Positive Energy Block - EUROPEAN COMMISSION DG Energy

transparency as elements that enable a PEB deployment (ref reports D2.1 - footnote 44, and report D5.9 - footnote 45).

- **Incentives and subsidies** should focus on such integrated/collaborative interventions (this report, D5.16) showing that mostly a feed-in-tariff is a common and general asset to contribute to making a PEB bankable (and also a tariff for selling electricity back to the grid), or to generate a profitable business model.

Figure 8.2 represents the key steps in PEB development and it is retrieved from the PEB report (D5.11). In this report, we add the arrows coloured in orange to include the economic/financial steps needed to reach implementation.

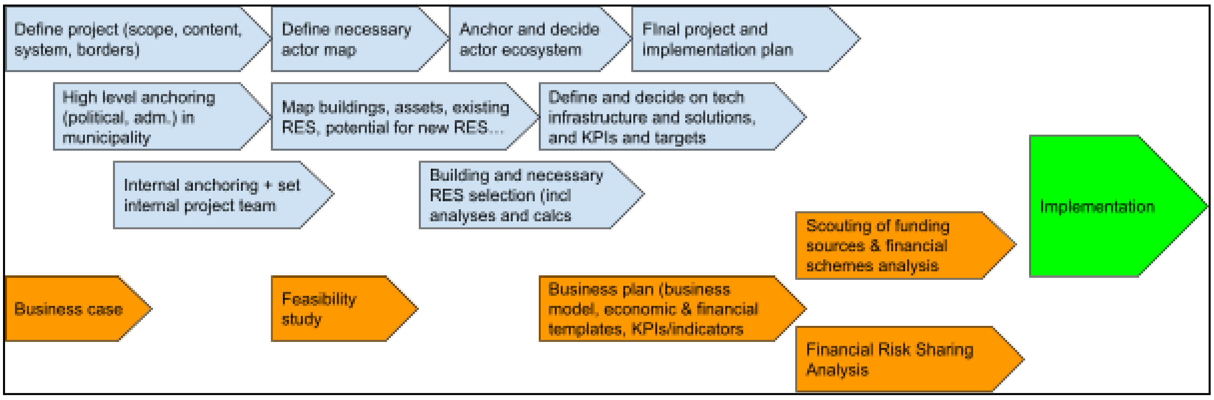


Figure 8.2 Generic pipeline for setting up, planning for, financing and implementation of a dPEB in a scheme initiated by and coordinated by the municipality. Update of fig. 7.1 in D5.11 Trondheim DPEB Demonstration

The business case is the preliminary business idea behind an investment where you identify its initial characteristics, such as costs, possible advantages/revenues and opportunities, needed resources.

The feasibility study, representing the second step, verifies the terms of the business case, through more detailed calculations on investments, revenues, costs, available resources. The third step covers business planning, i.e. the master document comprising details of the business model, economic and financial templates (balance sheet, cash flow, income statement), KPIs (ratios, etc.). In the final step we have a close interaction of two parallel activities which affect each other: one focuses on the research for funding, in terms of grants, equity or financial schemes; the other focuses on the financial risk sharing analysis, which provides profitability of each investment and related financial risk for all involved stakeholders and investors in the PEB ecosystem, thus helping to take the final decision on investment with subsequent implementation.

9 References

Bertelsen S., Livik K., Myrstad M. (2019)
D2.1 - "Report on Enabling Regulatory Mechanism to Trial Innovation in Cities". +CityxChange Project. Retrieved from: https://cityxchange.eu/knowledge-base/report-on-enabling-regulatory-mechanism-to-trial-innovation-in-cities/

Cimini, V., Giglio, F., Carbonari, G. (2019).
D2.4 Report on bankability of demonstrated innovations. +CityxChange Deliverable. Retrieved from: https://cityxchange.eu/knowledge-base/report-on-bankability-of-the-demonstrated-innovations/

Danielsen S.; Hendseth O.; Livik K.;Berthelsen B.; Sizov G. (2021, June)
D5.5: Energy Trading Market Demonstration. +Cityxchange Deliverable. Retrieved from: https://cityxchange.eu/knowledge-base/d5-5-energy-trading-market-demonstration/

Derkenbaeva E.; Heinz H; Stathopoulou E. (2021, Sep 19)
Business Models and Consumers' Value Proposition for PEDs Scenario-Based Foresight regional series of interviews. Smart-BEEjS project. Retrieved from: https://smart-beejs.eu/wp-content/uploads/2021/09/D6_3-Foresight-method.pdf

Dourlens-Quaranta S.; Desmaris R.; Decorme R.; Messervey T.; Torres P.; Zarli A.; Clerisse A.; Smit S. (2019, Nov 27)
D6.1 - Ecosystem analysis for Positive Energy Districts. Making City Deliverable. Retrieved from: https://makingcity.eu/wp-content/uploads/2021/12/MakingCity_D6_1_Ecosystem_Analysis_for_PEDs_Final.pdf

Giordano A.; Cassisi A.; Bolzicco M. (2020, Oct 01).
D7.1. Business Models and Financing Mechanisms for Wide Uptake of Smart City solutions. SPARCS Deliverable. Retrieved from: https://www.sparcs.info/sites/default/files/2020-11/D7.1_BusinessModelsAndFinancingMechanismsForWideUptake.pdf

Grabinsky, C., Riedesel, K., Haughslett, A. (2021, December 17).
D5.10 Trondheim Innovation Lab Solutions Catalogue. +Cityxchange Deliverable. Retrieved from: https://cityxchange.eu/knowledge-base/d5-10-trondheim-innovation-lab-solutions-catalogue/

Hackett S. (2019, December)
D2.3: Report on the Flexibility Market . +Cityxchange Deliverable. Retrieved from: https://cityxchange.eu/wp-content/uploads/2020/02/D2.3-Report-on-the-Flexibility-Market-v06-final.pdf

Handbook on Investment schemes for REScoop projects. RESCOOP 20-20-20 Project. (2014) Retrieved from: https://www.rescoop.eu/uploads/rescoop/downloads/Financial-Handbook-for-REScoops-English_2020-10-19-171323.pdf

Haugslett A., Rønningsen S., Riedesel K., Grabinsky C. (2021, Oct 30) D5.8 +Trondheim Citizen Observatory. +Cityxchange Deliverable. Retrieved from: https://cityxchange.eu/knowledge-base/d5-8-trondheim-citizen-observatory/

Haugslett A.; Riedesel K.; Berthelsen B. (2021, October) D5.7: +Trondheim 2050 Bold City Vision and Guidelines (Vision for Sustainable Urban Transition). +Cityxchange Deliverable. Retrieved from: https://cityxchange.eu/knowledge-base/d5-7-trondheim-2050-bold-city-vision-and-guidelines-vision-for-sustainable-urban-transition/

Hukkalainen M.; Jaeger A.; Ala-Juusela M. (2020, Nov) D1.3: Report on making PEB concepts part of local authorities planning instruments. EXCESS FleXible user Deliverable. Retrieved from: https://positive-energy-buildings.eu/fileadmin/user_upload/Resources/EXCESS_D1.3_29_10.pdf

Lauvland, M., Berthelsen, B.O., Gulbrandsøy, E.N., Gråberg, V.M., Leonhardsen, S., Fossum, M., Skoglund, T.R. (2022, October 31) D5.11 Trondheim dPEB Demonstration. +Cityxchange Deliverable. Retrieved from: https://cityxchange.eu/knowledge-base/d5-11-trondheim-dpeb-demonstration/

Livik K.; Danielsen S. ; Nati M.; (2020, October) D2.7: Local DPEB trading market demonstration tool. +Cityxchange Deliverable. Retrieved from: https://cityxchange.eu/wp-content/uploads/2020/02/D2.3-Report-on-the-Flexibility-Market-v06-final.pdf

Myrstad M.T, Livik K., Haugslett A. (2021) D5.9 Playbook of regulatory recommendations for enabling new energy systems. +CityxChange Deliverable. Retrieved from https://cityxchange.eu/knowledge-base/d5-9-playbook-of-regulatory-recommendations-for-enabling-new-energy-systems/

Ness, H.O., Stokke, V., Mortensen Gråberg, V. (2021, April 30) Energianalyse av Sluppenvegen 11/13 (Energy analysis of Sluppenvegen 11/13. 45 p. Internal report, +CityxChange

Petrick, K.; Fosse, J.; Klarwein, S. (2019, December) Principles for Prosumer Policy Options. Recommendations to strengthen prosumers and energy communities in NECPs and other EU, national and local policies. PROSEU Deliverable. Retrieved from: https://zenodo.org/record/3584746#.Y_eMrXbMKUl

Rood D., William Hynes W., Chiddarwar A., Gall T. (2019, October 31) D7.4: Monitoring and Evaluation Dashboard. +Cityxchange Deliverable. Retrieved from: https://cityxchange.eu/knowledge-base/monitoring-and-evaluation-dashboard/

Sunko R.; Sunko B.; Rutz D.; Mergner R.; Doczekal C; Pukšec T; Jensen L. L.; Redžić E.; Gjorgievski V.; Batas Bjelic I. (2017, October) Guidelines on improved business models and financing schemes of small renewable heating and cooling grids. CooHeating Deliverable. Retrieved from: https://www.coolheating.eu/images/downloads/CoolHeating_D5.1_Guideline.pdf

Sørum, A.B.; Berthelsen, B.O.; Skoglund, T.R.; Bratseth, E.; Nørbech, T. (2022). D5.13 +Trondheim eMaaS Demonstration. +CityxChange Deliverable. Retrieved from: https://cityxchange.eu/knowledge-base/d5-13-trondheim-emaas-demonstration/

Tancré, B. (2021). The modelling of district heating within a positive energy block. Bachelor thesis. Trønderenergi / Howest Energiemanagement / +CityxChange. 68 p.

Vandevyvere, H.; Ahlers, D.; Wyckmans, A. (2022). The Sense and Non-Sense of PEDs—Feeding Back Practical Experiences of Positive Energy District Demonstrators into the European PED Framework Definition Development Process. Energies, 15, 4491. https://doi.org/10.3390/en15124491

Sitography

(TIF) - The World Bank
"European Energy Efficiency
Platform (E3P)
About Public-Private
Adamodar Online
Association for project
Management
Bonkers.ie – Energy
buildings and communities
programme
Clean energy for all
COMMISSION Guidelines on
State aid for climate, environmental protection and
COMMUNICATION FROM THE
comparison website
consumer prices
Consumption and Energy
Communities CEER Report
Covenant of Mayors - Europe
Development Smart Villages
and Renewable Energy Communities
developments in and out of
the COVID-19 pandemic – from commodity prices to
DIRECTIVE (EU) 2018/2001 OF
Disclaimers and Disclosures
Distributed Ledger
Easy Property
ECB: Energy price

EIB Group Climate Bank
Electricity 'Prosumers'
Enabling framework for
energy 2022
ENERGY DISTRICTS - Urban
Europe
enova
EUROPE TOWARDS POSITIVE
European Network for Rural
European Parliament:
Europeans package
FACTSHEET
Funding & Tender
Gocardless
IAE-EBC: Energy in
INVESTING IN PROJECT
FINANCE STRUCTURES Pareto Securities,
Investopedia
Joint Research Centre
NAV
of the use of energy from
renewable sources
on Investment schemes for
REScoop projects
Opportunities - Smart
Cities and Communities
Partnerships - The World
Bank
Positive Energy Block (PEB)
Positive Energy Blocks
POSITIVE ENERGY DISTRICTS
Positive Energy Districts -
Regulatory Aspects of Self
Renewable energy directive
renewables
Rescoop project - Handbook
Retail market design service
RISKS ASSOCIATED WITH
Roadmap 2021-2025
SOLUTION BOOKLET
Tax Increment Financing
Technology (DLT)
The European Green Deal
THE EUROPEAN PARLIAMENT AND
OF THE COUNCIL of 11 December 2018 on the promotion
Trondheim Municipality
Welcome to the +CityxChange
M&E Reporting Tool (MERT)
+CityxChange (2019). Glossary - Positive Energy Block

Annex

Table A.1 List of appendices

Annex	Topic
A1	Project structure and task dependencies
A2	Sustainable investment tasks in +CityxChange Grant Agreement
A3	Business and value creation model KPIs
A4	Questionnaire to analyse business models and their improvements within the PEB
A5	Business Modelling Interview Guide
A6	Survey on sustainability vs value creation
A7	Detailed PEB and mobility CAPEX and OPEX
A8	Rooftop PV detailed calculations
A9	Financing Risk Sharing Model - FRSM
A10	Vehicle-to-Grid (V2G) detailed calculations
A11	LHC Trondheim BEST Table summaries
A12	Heat pump design and projecting tool

Annex 1 - Project structure and task dependencies

Local energy and flexibility markets are at the core of optimising local energy utilisation and the establishment of PEBs. This is an approach that claims exemption from Norwegian national energy legislation. Framework[52] and a practical approach and guidelines to this[53] thus make up important inputs to the building and verification of new investment and business models. A local energy market approach will lead to new revenue streams, business concepts and models. The development of the Local Flexibility Market concepts[54] and Energy Trading Platform[55] make up important inputs to the establishment of new investment and business models.

The foundation for the bankability of the LHC Trondheim demonstrations[56] including basic business concepts has been developed and is a precondition for the work on sustainable investment and business models. During the process of building and preparing for implementation on PEBs[57], local markets (delivery report D5.6), the deployed energy trade solution[58] and eMobility with V2G[59] exchange and flow of knowledge between these tasks and the development work on investment and business models have been of importance for the investment and business models.

Business opportunities within and based on the project have been extensively used and communicated through citizen involvement arenas and co-creation processes, and for establishing the Bold City Vision[60] [61] [62].

The sustainable investment and business concepts and models developed and verified for Trondheim will be fed into - and will make up crucial inputs to - upscaling, replication, and commercialisation of the Trondheim solutions, products, and services.
Sustainable investment models, and business concepts interact with several +CityxChange tasks, as shown in figure 1.1. Developed investment and business models will in addition form an important basis for the further work and development of the LHC Trondheim Bold City Vision (report D5.7): *Trondheim Positive Energy City 2050*.

[52] https://cityxchange.eu/knowledge-base/report-on-enabling-regulatory-mechanism-to-trial-innovation-in-cities/
[53] https://cityxchange.eu/knowledge-base/d5-9-playbook-of-regulatory-recommendations-for-enabling-new-energy-systems/
[54] https://cityxchange.eu/knowledge-base/report-on-the-flexibility-market/
[55] https://cityxchange.eu/knowledge-base/d2-7-local-dpeb-trading-market-demonstration-tool/
[56] https://cityxchange.eu/knowledge-base/report-on-bankability-of-the-demonstrated-innovations/
[57] https://cityxchange.eu/knowledge-base/d5-11-trondheim-dpeb-demonstration/
[58] https://cityxchange.eu/knowledge-base/d5-5-energy-trading-market-demonstration/
[59] https://cityxchange.eu/knowledge-base/d5-13-trondheim-emaas-demonstration/
[60] https://cityxchange.eu/knowledge-base/d5-7-trondheim-2050-bold-city-vision-and-guidelines-vision-for-sustainable-urban-transition/
[61] https://cityxchange.eu/knowledge-base/d5-8-trondheim-citizen-observatory/
[62] https://cityxchange.eu/knowledge-base/d5-10-trondheim-innovation-lab-solutions-catalogue/

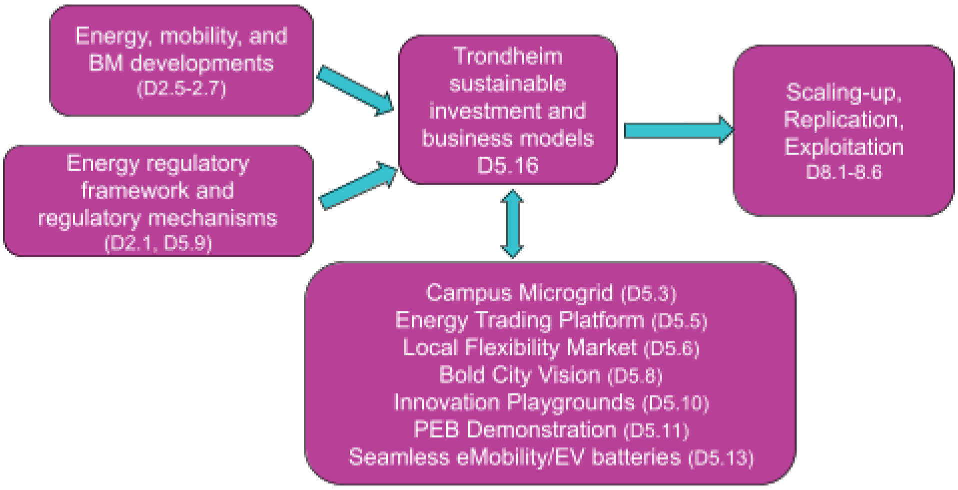


Figure A1.1 Dependencies between Sustainable Investments - and other +CityxChange co-projects (tasks). D.X.Y refers to +CityxChange deliverables (reports); source: https://cityxchange.eu/article-categories/deliverables/ .

Annex 2 - Sustainable investment tasks in +CityxChange Grant Agreement

Minor deviations and adaptations to the +CityxChange Grant Agreement (GA) were necessary in order to have implementable and functioning PEBs. They are listed and described in table 1.1.

Table A2.1. Deviations from (D) and adaptations to (A) the original plan (Grant Agreement). See also section 9.1, Experiences gained and lessons learnt.

Deviations and Adaptations	Description
D	EPCs in its original definition have not been used. Reason: This type of approach and model did not prove viable for the involved real-estate partners. ESCO with a specially designed leasing scheme has been deployed for PV investments for commercial buildings.
A	There was no need for NTNU to contribute to this; price models and pricing data were obtained from Trønderenergi (TE), Statkraft Varme (SV), and external, public sources.
D	A new dynamic pricing model for district heating decoupled from the electricity spot price has been developed by SV and tuned by TE. This is used for the electric - thermal sector-coupling at Sluppen.
D	Cash-flow and revenue improvement analyses and models are developed and verified for PV, battery storages, V2G charging, and local energy and flexibility markets.
D	Specific, new business models for battery storage, PV, V2G, and local energy and flexibility markets are developed and verified
D	A methodology for calculating overall PEB status/rating concerning simple payback times are developed and deployed
D	TK and NHP have developed and performed an extensive survey among real-estate companies and financing institutions focusing on sustainability vs value creation, the importance of building certification for the value of buildings, and the implications and values of innovation for value creation within the real-estate sector.
D	A business modelling interview guide and questionnaire is developed (Annex 2) and used for business model mapping among core partners and stakeholders in the project

Most deviations are positive: The Sustainable Investment project task has delivered beyond the commitments in the EU Grant Agreement. Energy Performance Contracts (EPCs) were not developed and used in the +CityxChange project in LHC Trondheim. EPC processes were started both together with Frost Property (residential area) and official partner RK (KJELDSBERG (commercial buildings) related to renewable energy source (RES) measures. In both cases the process and final solutions were impractical, time consuming, and not financially viable.

Annex 3 - Business and value creation model KPIs

The six +CityxChange KPIs listed and described in table 1.2 are directly related to investments, and business and value creation, and they reflect the investment and business model improvements obtained during the +CityxChange project. KPIs no. 24 and 25 are the most important indicators of improvements in the bankability of demonstrated solutions. Table 1.3 describes KPIs listed in table 1.2 and details the significance of KPIs for the prevailing work on sustainable investment and business models.

Table A3.1 Sustainable investment related KPIs. See +CityxChange Monitoring and Evaluation Reporting Tool (MERT)[63] and Hynes et al (2019)[64] for details on the KPIs.

No.	Name of KPI	Unit	Impact targets project/Trondheim
4	Number of new /PEB/PED enabling prototypes	Number	30/13
16	Reductions in energy grid investments	€	20/17.5
23	Value of total new investments triggered by the project	€	40/32
24	Percentage reduction in simple payback times (SPP)	No. of years	20 %
25	Increase in annual return on investment (ROI)	%	10 %
26	Number of new jobs created	No. of jobs	900

Table A3.2 Comments and remarks to the Sustainable Investment related KPIs.

KPI no.	Remarks
4	The number of new PEB enabling prototypes represent direct added values and outcomes from the project and will create business opportunities after implementation and beyond the project. Prototypes relevant for the public sector will contribute to more efficient working methodologies, public innovation, etc., and contribute to value creation.
16	More efficient and extensive utilisation of locally produced renewable energy and flexibility through the +CityxChange Local Energy Market (LEM) will reduce the tension and contribute to reducing grid bottleneck issues. It will contribute to reducing needs for upgrading the electricity distribution grid, and reduce the grid maintenance costs. The impact will mainly be observed in a longer term based on operation of the PEBs and local markets. Numbers on this KPI will not be available until the end of the +CityxChange project. Reduced grid investments will, however, make up an important part of the total value creation.
23	The project has observed substantial investments triggered, in terms of scaling, replication, spinoffs, and complementary investments. These also contribute to the total value creation within the project, for the businesses themselves, and not the least for the LHC Trondheim and TK.

[63] https://mert.cityxchange.eu/
[64] https://cityxchange.eu/knowledge-base/monitoring-and-evaluation-dashboard/

24, 25	These are the main, and most important KPIs for the LHC Trondheim cases; as *the* concrete indicators and "proof" of value creation with concrete revenue/savings numbers per stakeholder and energy asset (PV, battery storage, heat pump, local flexibility markets, etc.). There is little/no experience on savings and revenues from single assets such as PV working together in smart energy neighbourhoods (PEBs). LHC Trondheim needs some experience and results before measurable impacts can be concluded from these KPIs. The prevailing report will present impacts for indicators based on calculations and a set of qualified assumptions.
26	The numbers are calculated based on a methodology provided by R2M Solutions, and will also contribute to the total value creation for the project, and beyond.

Main Financial KPIs applied to assess the investments:

- **ROI (Return On Investments)** = (Current value of investment - Cost of investment)/Cost of investment.

"Current Value of Investment" includes incomes (returns) obtained from the energy production of the investment. ROI is measured as a percentage and is comparable with returns from other investments. When an investment's ROI is net positive, the investment is convenient and profitable.

- **PBP (Payback Period) or SPP (Simple Payback times)** is the number of years needed to recover the initial investment. It measures the timing of investment to achieve the breakeven point[65].

Together with the ROI it's the first indicator that calls the attention of the investor because it calculates how long the investment takes to get paid back.

[65] A company's breakeven point is the point at which its sales exactly cover its expenses. Fixed Costs ÷ (Price - Variable Costs) = Breakeven Point in Units.

Annex 4 - Questionnaire to analyse business models and their improvements in the PEB

1	Time & date
2	Name of compiler
3	Role
4	Company
5	Company mission
6	Value proposition
7	Customers
	Please add details about your Value Proposition.
8	Referring to the core business of your organisation, please describe the "Product/Service Offering" of your business model. Try to answer the question "what do my customers/users get from my organisation?"
9	Please describe the Distribution Channel used by your business. Try to answer the question: "How do we deliver our product/service?"
10	Please indicate the "Key Resources" required for your existing business. Try to answer the question: "What do we need to create and deliver our product/service"?
	Please add details about your key resources.
11	Please indicate the "Key Activities" required by your business. Try to answer the question: "What do we need to do for our business to work"?
	Please add details about your key activities.
12	Which are the "Business Partners" required in your business activities? Try to answer the question: "Who do we need to work with for our business to function"? Note: do not consider employees and clients here.
	Please add details about your business partners.
13	What is the "Cost Structure" of your business?
	Please add details about your cost structure.
14	Please indicate the "Revenues Structure" of your business. Try to answer the question: "Where does the money we make come from"?
	Please add details about your revenue structure.
15	Which are the "Main Risks" for your business? Try to answer the question: "What could most likely make my business activity fail?"
	Please add details about your main risks.
16	Which is the role of your organisation in the implementation/an or operation of a PEB.
17	Please describe the Value Proposition in your PEB business model. Try to answer the questions: "Which value do you provide to the PEB? What problem do you help to solve within a PEB?"
18	Please indicate the customer segment of your intended PEB business.
	Please add details about your customer segment for PEB business.
19	What is the "Product/Service Offering" in your PEB business model? Try to answer the question "what do our customers/users get from us in a PEB?"

20	Which are the "Key Resources" required for your business within a PEB? Try to answer the question: "What do we need to create and deliver our product/service in the PEB scenario"?
	Please add details about your key resources for PEB business.
21	In relation to the "Key Resources" needed for doing business in a PEB (ref. to previous question): How is your organisation planning to fund them?
	Please add details about intended financial sources for PEB business.
22	Please indicate the "Key Activities" required for your PEB business. Try to answer the question: "What do we need to do for our business to work in a PEB environment"?
	Please describe briefly the "Key activities" selected.
23	In relation to the business of your organisation in a PEB, what is the expected "Cost Structure" of your business.
	Please describe briefly the "Cost Structure" selected above.
24	Please indicate the expected "Revenues Structure" of your PEB business. Try to answer the question: "Where does the money we make in a PEB come from"?
	Please describe briefly the "Revenue Structure" selected above.
25	Please indicate the "Main Barriers" you foresee for your PEB business.
	Please describe briefly the "Main Barriers" selected above and how you plan to overcome them.
26	Please indicate the "Main Risks" foreseen for your PEB business. Try to answer the question: "What could most likely make my PEB business activity fail?"
	Please describe briefly the "Main Risks" selected above and how you plan to mitigate them.
27	Please add here any additional consideration, comment and/or feedback .

Annex – T5.11 Business Modelling Interview Guide

+CityxChange | Work Package 5, Task 5.11

November 2020

Table of Contents

Executive Summary

Positive City ExChange project aims to to develop and deploy Positive Energy Blocks and Districts and scale these out as part of the Clean Energy Transition.
The model proposed in +CxC is based on the journey from PEBs to PEDs to Positive Energy Cities, and it is supported by a distributed and modular energy system architecture that goes beyond nZEB. The concept includes new energy market design coupled to consumer-driven innovation, developed in close working cooperation with national regulators, DSOs/CSOs, property developers, and local energy communities. Flexibility will be put at the core of the distributed energy system by creating new micro-grid operation, prosumer-driven Community System Operators, and new markets for peak shaving/RES trading to reduce grid investment needs and curtailment.

Such an ambitious project requires the design, implementation and testing of innovative and disrupting business models and concepts, alongside with sustainable investment models capable of raising the necessary resources for financing the energy transition towards a sustainable energy model.

Business and investment modelling must happen cooperatively, engaging with and actively involving local and global stakeholders, in order to increase chances of success. This approach is also expected to mitigate risks and enhance acceptance of the proposed solutions.

No-profit organisations are included in the process and play a critical role for the success of the energy transition initiatives: municipalities for example have the duty of leading the process and engaging with the public in order to foster acceptance and involvement. Their own business models are included in this monitoring, analysis and improvement exercise.

We start the process with the monitoring of existing business models of the involved stakeholders, in order to analyse them and then improve and optimise such models taking into account frame condition changes introduced by +CxC, including the regulatory changes and dispensations.
Officinae Verdi, Trondheim Kommune and NTNU have prepared a questionnaire for monitoring business models.

This document has been prepared as a guide for the business modelling questionnaire, providing stakeholders with:

- an overview of +CxC project, of Trondheim related WP5, and Investment related Task T5.11.
- definition of the two phases of PEB implementation and PEB operation, including infrastructures, services, activities and involved actors;
- the description of an "ideal business model" for the PEB;
- example of individual business models elements that stakeholders are requested to provide in relation to their own companies or entities.

This document should be used as a reference and example while filling the Business Models monitoring questionnaire.

1 Presentation +CityXChange

Trondheim, Limerick, Alba Iulia, Pisek, Sestao, Smolyan and Voru and their industry and research partners are joining forces to co-create the future we want to live in. As aspiring

Lighthouse and Follower Cities, respectively, they have detailed out their ambitions into the +CityxChange proposal, which describes a structured approach on how to develop and deploy Positive Energy Blocks and Districts and scale these out as part of the Clean Energy Transition.

The approach combines: Prototyping the Future through Integrated Planning and Design; Enabling the Future through Creation of a Common Energy Market; and Accelerating the Future through CommunityxChange with all stakeholders of the city.

New forms of integrated spatial, social, political, economic, regulatory, legal, and technological innovations will deliver citizen observatories, innovation playgrounds, regulatory sandboxes, and Bold City Visions to engage civil society, local authorities, industry, and RTO[66]s to scale up from PEBs to PEBs to Positive Energy Cities, supported by a distributed and modular energy system architecture that goes beyond nZEB[67].

On top of this, the consortium will create a new energy market design coupled to consumer-driven innovation, developed in close working cooperation with national regulators, DSOs/CSOs, property developers, and local energy communities. Flexibility will be put at the core of the distributed energy system by creating new micro-grid operation, prosumer-driven Community System Operators, and new markets for peak shaving/RES trading to reduce grid investment needs and curtailment.
Their aim is to realise Europe-wide deployment of Positive Energy Districts by 2050 and prepare the way for fully Positive Energy Cities.

2 Presentation WP5 & T5.11

T5.11 Sustainable Investments, overview

T5.11 "Sustainable Investments" for Trondheim aims at developing new business models and concepts in order to enable, and boost, the implementation and operation of Positive Energy Blocks in Trondheim.

The task activities are defined by the DoA concern:
- Business models innovation;
- Energy Performance Contracts development and implementation;
- Financing Risk Sharing Model development for PEB investments;
- Development of a tool for investments assessment in PEBs/PEDs.

Highlights:
- *Main task milestone delivery is a report on a set of working business models and concepts for green/renewable investments in Trondheim.*
- *The report will include a description of measures and actions that enable and boost innovative sustainable investments.*
- *The report will disclose and describe working methodology in a replicable, adaptive way for the follower cities and others.*

[66] Research and Technology Organizations
[67] Near Zero Energy Buildings

- *The report will include a financing risk sharing model (FRSM) for the equipment needed to obtain the PEB. The FRSM will be developed during the project period involving all task 5.11 partners.*
- *D5.16 is the deliverable from task 5.11: +Trondheim sustainable investment and business concepts and models (Report - Public)*
- *Planned deadline: 31. October 2021 (M36 of the project).*

T5.11 will implement measures and actions developed in T2.7, to enable and boost innovative sustainable public and private investments for citizens, building owners, and other stakeholders in the Trondheim DPs.

Sub Task	Resp.	Contr.
Monitoring, analysis and review of existing BMs for T5.3, T5.5-5.10	OV	POW; TE, ABV, 4C, SV, TK, NHP
Tool development for analyses and decision support for sustainable investments	TK	OV, NHP
Improvement and adaptation of investment schemes	NHP	OV, TK
Forecasting Pricing models	NTNU	
EPC contracts development	NHP, TK	OV
EPC implementation	TK	OV
Financing/Risk sharing model development	OV	All

Sustainability of business and investments in PEBs is going to be assessed, measured and optimised with the final objective of attracting investors and thus accelerate the energy transition in Trondheim and beyond.

Business Model innovation requires the “monitoring, analysis and improvement” of existing business models for the stakeholders involved in +CxC project in Trondheim: this is the subject of the interview guide and the related questionnaires.

3 Information about Trondheim

Trondheim is situated in the middle of Norway, in Trøndelag county. It is 528 km2 and has approximately 205 000 inhabitants. In addition there is a student population adding another 40 000 people. Trondheim, Norway's 3rd largest city, is probably the oldest city in Norway.
Since 1910, with the foundation of NTH, Norwegian Technological College, Trondheim has been the centre of research and technological development in Norway. It is an international city that has fostered a culture for innovation and exploration, tightly woven into the city’s population, resulting in a knowledge sector that works hand-in-hand with the municipality. The education level in the population is the highest in Norway, and the city aims to co-shape the city and surrounding region as a living, breathing, and engaging test-arena.

In the following of this section, the three demonstration areas (DAs) in Trondheim are described, alongside with the intended innovation to be deployed therein, according to the DoA of +CxC project. Such innovation projects are the ones we have to develop innovative business models for.

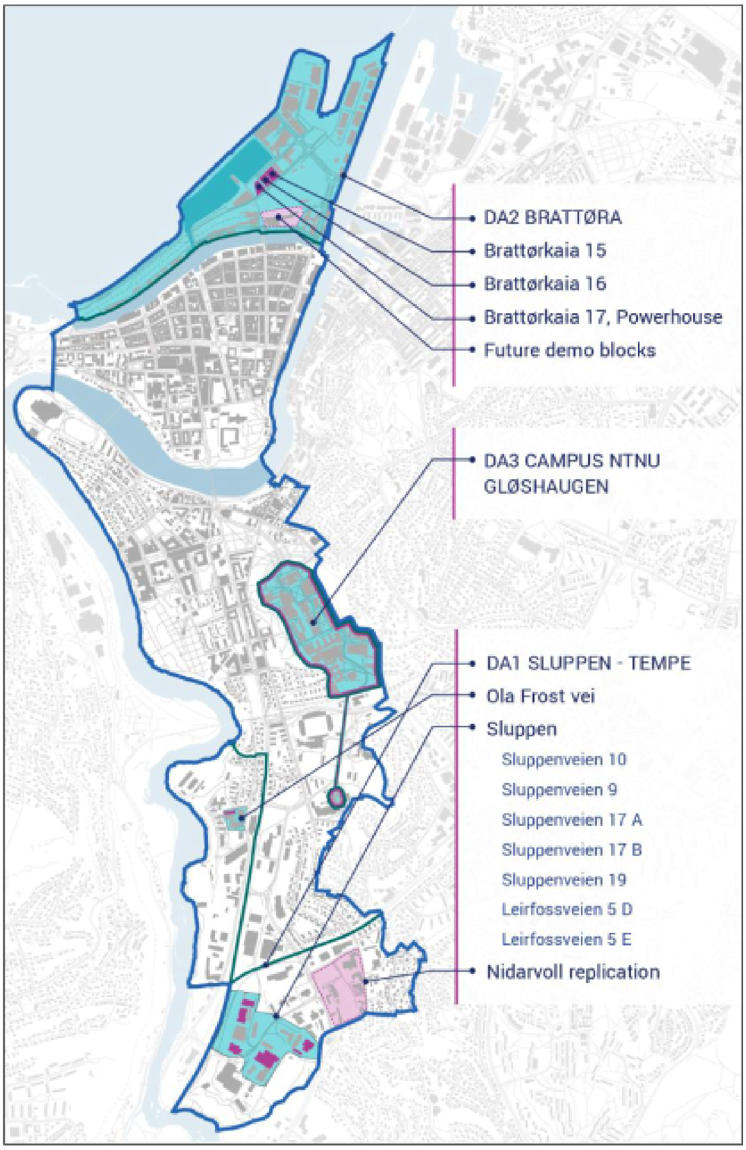


Figure 1. Map of Trondheim demonstration district (DD)

The figure below shows the three selected Demonstration Areas (DAs) as follows:

- DA1: Sluppen-Tempe
- DA2: Brattøra
- DA3: Campus Gløshaugen

DA1 (Sluppen-Tempe) is a mixed used district with 6 buildings comprising one residential buildings (54 apartments), and 5 corporate buildings ranging from old storage and warehouses, industry buildings, a data centre, new/newer office buildings; one office building completed 2019 and one of two anchor buildings at Sluppen will achieve BREEAM Excellent.
Sluppen-Tempe is one of Trondheim's major development areas with massive focus from an urban development point of view with Sluppen 2030 as a sustainable urban

development (corporate, public buildings and dwellings) and a targeted Zero Emission Area. By 2020 TK will build a large new school and a large health and welfare centre at Sluppen (replication case); together with a large number of new dwellings. As such, Sluppen-Tempe will also be an important, early phase upscaling and replication area within the DD.
Sluppen-Tempe is the most complex of the DAs to become a DPEB in Trondheim, with the largest energy gap to fill. The DA is complex as there is a mix of both thermal and electricity measures. There are also many stakeholders, which will need to be engaged across this DA. To create the DPEB, PV will be installed on the roofs of the buildings, and next generation heat pumps will be installed in Sluppenveien no.17A and no.10, respectively, as described in the BEST tables in Technical Annex 4-5. Waste heat from a data centre in the block (no.17A) and a refrigeration store (no.10). Both of these will be connected with the Community Grid to enable this waste heat to be used in each building, but also offered to the other buildings in the block, or redistributed via the larger district heating network (physically or virtually). The nearby apartments will be included in the Community Grid, where this waste heat can also be supplied (physically/virtually). The potential of Computational EL Heating (COELH) in a Community Grid will be demonstrated at Leirfossveien no. 5D (FAKTRY). Finally, Sluppen will host one out of two initial eMaaS hubs also demonstrating V2B/V2G, close to public transport hub Sluppen. Due to the complexity of the case, Sluppen-Tempe will be realised as a DPED after DPEB Brattøra.

DA2 (Brattøra) is a workplace area including the city's harbour, hotels, museums, convention centre and sports facilities/swimming pools. The DA includes 3 buildings, Brattørkaia 17A is the office building Powerhouse (the anchor for the block), Brattørkaia 16 is the Business College of Trondheim BI, and Brattørkaia 15 are the BK15 offices. The BK-offices are owned by the same private real-estate company as Powerhouse and BI, and all three buildings are already connected via a common management/energy management system. Powerhouse is the world's northernmost energy positive building according to the Powerhouse definition, BI is BREEAM Excellent, and BK15 is both classified BREEAM Very Good and BREEAM In-Use Excellent.
Unlike Sluppen-Tempe, which includes both electrical and thermal loads, Brattøra will be a DPEB almost solely based on electricity. To become a DPEB, installing PV at Powerhouse and the BI is important, however the real innovation is a water heat exchange system, which extracts water from the local fjord. As part of the scaling-up of the DA, the DA also includes an E-Bus (pantograph charger - 300kW, linked to the Powerhouse building, Shore-to-Ship facilities (2x1.4 MW and 1x650 kW), and hydrogen/electric ferries. The area will undergo massive densification in the years to come through planned apartment buildings and the Trondheim Station Centre (decided replication case in +CxC), which combines public transport depots, offices and dwellings (of which TK is a co-developer).
Powerhouse will also host the second eMaaS hub in +CityxChange - where Sluppen hosts the first. These eMaaS Hubs will connect the two ends of the Knowledge Axis, with Campus-Gløshaugen in between.
While DA2 will also focus on electricity, thermal energy (high- and low-temp) will be integral and crucial for the scaling-up of the DA into a PED.
The final DA, DA3 (Campus Gløshaugen), will not become a DPEB during the time frame of the project but is an important DA for replication and scaling-up of the solutions in both Trondheim and Limerick and also in future EU cities. DA3 Campus Gløshaugen encompasses 7 buildings varying from old educational buildings to new office buildings and the proposed Valgrinda ZEB Flexible Lab, due by 2020. Gløshaugen is its own concession

4 Ideal Business Model for PEBs

Definitions

Business Model: the representation of a business activity, through the description of some key elements, such as the value proposition, the product or service offering, the business partners, the required infrastructures (and/or business tools), costs and revenues structures and so on. It describes how value is created, distributed and harvested. Depending on the complexity of the business being represented, business models can be "pipe models" (linear) or "platform models" (networks).

Investment Model: the representation of financial flows in a specific project investment. It includes the description of involved actors, roles and responsibilities, contractual agreements and so on.

Business Case: Is the numerical simulation of a business activity; including costs and benefits analysis, financial costs, calculation of economic and financial indicators.

Business Plan: Is the planning of a business operation looked at from several perspectives. It includes a business model, market studies, a competitive scenario analysis, risk management, business cases and sensitivity analysis as a minimum.

The Ideal Model

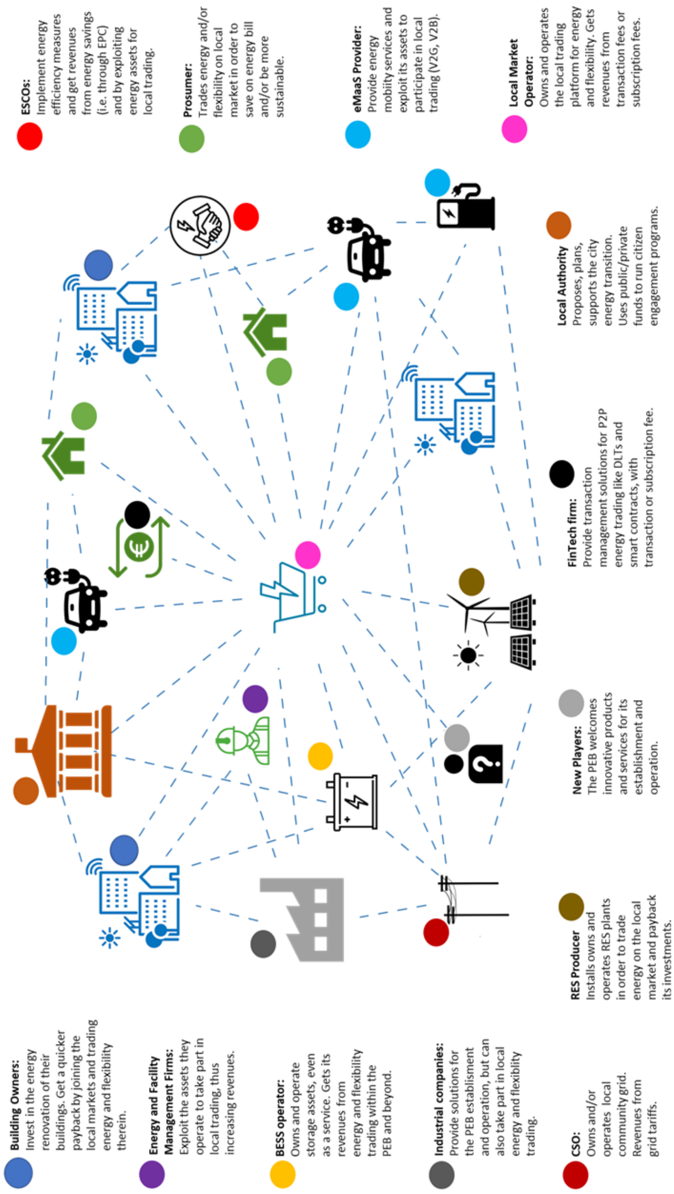
The ideal business model describes the activities, the players, the roles and the business mechanisms that are required for the creation and the operation of Positive Energy Blocks and Districts, in order to attract investments and minimise related risks.

Its objective is to present stakeholders with examples of how business and investments might happen, ideally, in a PEB, referring to an "ideal scenario" and originating from the work done in T2.7 and reported in D2.4.

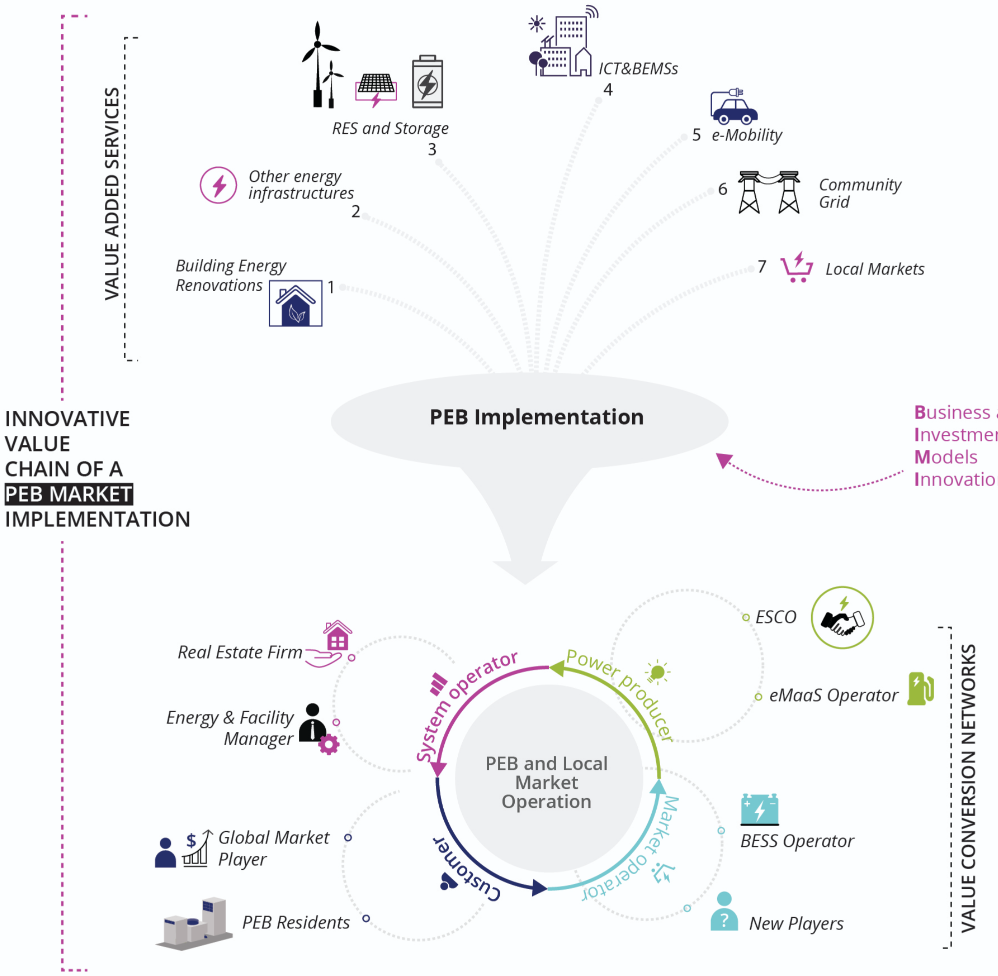
It is intended as a starting point, as we can move from this model for the adjustment and design of innovative and disruptive models for business and investments in +CxC Trondheim PEBs. Those will be "real world" models designed for and by Trondheim stakeholders and therefore directly applicable to the city projects and investments.

The following diagram represents graphically the several players involved in the PEB ideal business model; for each of them a brief description of their ideal business is reported.

It is worth noting how not only "profit" organizations take part in the establishment and operation of a PEB, but also "not-for-profit" entities, such as municipalities, research institutions and citizen associations play a decisive role in the process.
Such no-profit organizations have their own business model, whose returns are not in the form of financial revenues (or at least not only) but encompass social and environmental benefits; they are usually funded by public money for the sake of pursuing the public good.



If we imagine the PEB as a "business platform" we can see how many different actors and stakeholders can "connect" to that platform and do their own business.
Business can be done for the implementation phase of the PEB, like the energy refurbishment of a building by an ESCO or a construction company.
Business can be done within the operation phase of the PEB, like the P2P energy sale from a prosumer to their neighbours.
The figure below, taken from D2.4, shows the two phases of "implementation" and "operation" of a Positive Energy Block, and includes examples of infrastructures (i.e Renewable Energy Plants), services (i.e. e-Mobility), activities (i.e buildings energy renovation), players (i.e. ESCOs).



Potential roles and players in a PEB have been identified in T2.7; they are reported in the table below extracted from D2.4.

Potential Players taking on the 4 roles in the Local Market			
Customer	Producer	System Operator	Market Operator
Consumer/Prosumer	Consumer	DSO	Energy Cooperative
DSO	Energy Cooperative	CSO	Dedicated company
Energy Supplier	Real Estate firm	Dedicated company	New Player
BRP	New player	Energy cooperative	
Aggregator	e-MaaS provider		
EMaaS provider	BESS company		
BESS company	Aggregator		
Prosumer	Prosumer		

Source D2.4 - Table 4.2: Local Energy Market Players and Roles.

For the different players listed in table 4.2, we carried out an "ecosystem level analysis", describing roles, objectives and business strategies. Just a few examples are reported in the following table, the complete analysis is available in D2.4 (https://docs.google.com/document/d/1JsdIDBCzQ1090G5wIzgK5l8tEgJf4ImbMg2JSkmVtEY/edit)

Player	Role in classic energy market	Role(s) in Local Energy Market	Objectives	Business Strategy in LEM
Consumer	Customer - Purchase energy from a power supplier through distribution (transmission) network. Pays a tariff to the supplier that includes energy, DUoS and taxes.	Customer - Can purchase locally generated energy by accessing the LEM. Has always the right to choose a supplier in the global market.	Lower energy bill. Be sustainable and resilient, by increasing self-consumption and being part of a local, independent energy community.	Access the LEM in order to source locally produced energy. In order to still retain its commercial relation with global market supplier the LEM trade has to happen through smart contracts through DLS.
Prosumer	Customer, Power Producer - Same as consumer for the purchase side. Self consumes its own generated energy and either stores or sells any surplus back to the grid, via dedicated scheme/contract (PPA, FIT, etc.).	Customer, Producer - Same as consumer for the purchase side. Surplus generation can be sold to the local market for higher rewards compared to the global market.	Lower energy bill. Be sustainable and resilient, by increasing self-consumption and being part of a local, independent energy community.	Purchase energy in the LEM when cheaper than from the supplier. Sell surplus production to the local market when more convenient than selling to the global market. If prosumer with storage, can use storage to provide flexi services to the local (global) market (through aggregation, even implicit).
Energy Cooperative	Consumer - several examples of cooperatives that managed to strike convenient deals with suppliers.	Consumer, Producer, System Operator, Market Operator.	Lower energy bills of members, improve PEB sustainability and optimise LEM operation.	Exploit strengthened negotiation and financial power in order to increase revenues for members by accessing and optimizing LEM operations. Utilise LEM in order to put in place plants and energy sharing schemes for members.

Source D2.4 - Table 4.3: Ecosystem Level Analysis for PEB establishment and LEM implementation and operation.

Moving forward with the analysis, business modes have been drafted, in a high level "ideal" modeling exercise. Examples of the results are reported in the following table, the complete analysis is in D2.4.

Player	Value Proposition	Product Offering	Infrastructure	Revenue Model	Relationship type
Consumer	- Reduced energy bill - Reduced energy consumption - Reduced environmental footprint - Status/Image	Locally generated renewable energy	Smart Meter.	Energy cost reduction.	- Ongoing close relationship; - Settlement; - P2P contracts.

Prosumer	- Reduced energy bill - Reduced energy consumption - Reduced environmental footprint - Status/Image	- consumption optimisation - peak reduction - increased self-consumption /local energy consumption	Smart meter, EMS (Energy Management Systems), RES generation, storage.	- Sale of prosumer flexibility, energy to actors within and outside the PEB. - Increased ROI for the customer - Sale of added value services.	- Ongoing close relationship; - Settlement; - P2P contracts.
BESS Provider	- Improve local energy generation and consumption through storage and flexibility services.	- Battery storage systems and services (including battery as a service).	- BESS - RES - Smart Metering	- Products and services trade; - service fee for battery capacity access.	- B2C/B2B smart contracts; - B2B/B2C bilateral contracts - system and service provision.
Facility Manager / FM company	- Reduce energy costs; - Improve efficiency and sustainability.	- Energy and flexibility products.	- Smart energy assets; - Energy Management Systems; - Smart metering.	- Smart energy assets; - Energy Management Systems; - Smart metering.	B2B Smart contracts

Source D2.4 - Table 4.4: Business Model Level Analysis results

5 Identification of Barriers

It is important to identify the barriers expected in the deployment of the intended business models for the PEB, in order to discuss and find ways for overcoming them and so ensuring higher probability of success.

At this aim, we can refer to the PESTEL framework, which provides an approach based on "environmental" factors that can affect the business or, in a wider sense, activities in the establishment and operation of positive energy blocks and districts.

Each one of the macro-factors identified can generate one or more barriers to the successfulness of businesses in +CxC scenario.

Here the macro environmental factors are listed, together with examples of potential barriers.

- Political factors concern the intervention of governments in the economy and therefore how such impact affects business. Political barriers can relate to trade tariffs, law regulating labour relations, environmental policy and limitations, tax regulation and so on.
- Economic factors include all macro-economic aspects such as growth, monetary policy (inflation, interest rates, etc.). They can introduce barriers for example in capital-intensive activities that can suffer from increase in interest rates.
- Social factors related to population, demography, cultural and educational aspects. Their effect in terms of barriers can relate to the cost of labour which increases in well educated and "conscious" workforces, while can decrease in high unemployment situations.
- Technological factors are related to product innovation, level of automation, etc. They can determine entry barriers for businesses which do not achieve a minimum productivity level or that cannot keep the pace with digitization of processes.

- Environmental factors concern aspects related to ecosystems, climate and climate changes. Environmental factors can pose barriers to businesses whose products do not comply with consumers' attitude toward a sustainable economy, or to activities that are threatened by climate change (i.e agriculture or tourism). Environmental barriers are also related to fragile or protected ecosystems where specific activities, which represent a threat to their existence, will not be allowed.
- Legal and Regulatory factors include all laws regulating businesses such as environmental, health and safety, competition and so on. They introduce barriers in terms of compliance costs. For example Health & Safety costs could be higher for businesses operating in dangerous environments.
  Regulation is also a barrier when some business activities get restricted by for example competition law (like a DSO which cannot own energy storage assets by national regulation as it happens in several EU MSs).

6 Risk assessment

No activity is immune to risks, and some risks have the ability to be more detrimental than others. Therefore it is paramount to identify risks when developing a business model in order to put in place measures to avoid or mitigate them.

Risk in business is, by definition, the likelihood and the severity of financial losses that can occur as a consequence of not-foreseeable and/or not preventable events.

Risks are somehow related to barriers and the same PESTEL framework can be utilised for risk identification; here are some examples.

- Political: government stability can represent a risk for a business which is dependent on specific policies enforced, for example electric cars are dependent on emission reduction policies.
- Economic: recession is an economic risk, relatively higher to companies producing non-essential goods. In general economic risks are related to the negative effects, on an investments, generated from macro-economic factors, including but not limited to interest rates, governmental policies and financial regulations, tax policies.
- Social: an ageing population can be a social risk as the "buying" habits would change accordingly or cause a lack of workforces in a specific area.
- Technological: risks may arise from disruptive technologies, for example high efficient batteries or a "super-fast" charging solution for electric cars represent a risk for traditional petrol and diesel car manufacturers and distributors. It can also be seen as a loss of opportunity, when not adapting to new, disruptive technology.
- Environmental: a catastrophic event such as a hurricane or heavy flooding is a risk for some productions and activities in vulnerable areas.
- Legal and Regulatory: a change in import/export tariffs is a risk for any businesses trading overseas.

It is worth noting how all the examples provided so far are "negative" risks, although also "positive" risks can be identified. A change in regulation for example can be a positive risk: the ban on petrol and diesel cars some countries are planning to introduce is a positive risk for the entire EVs field.

7 Conclusions and Remarks

Business Models innovation for Positive Energy Blocks and Districts should come from a collaborative effort from all involved actors and stakeholders.
This document is intended as a support in terms of "food for thoughts" for the business models monitoring questionnaire that you are requested to fill in.

This is a starting point for the business models analysis and improvement, which are the next steps in this process and which will take into account all the condition frame changes, including the regulatory framework and the dispensations secured within the project.

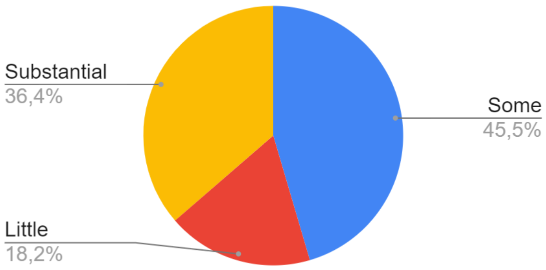
The questionnaire will be followed up with one-to-one meetings and discussions between OV and partner organisations involved in the deployment of the innovations in Trondheim.

Please feel free to contact OV for any support or clarification you may have about this document and/or the associated questionnaire.

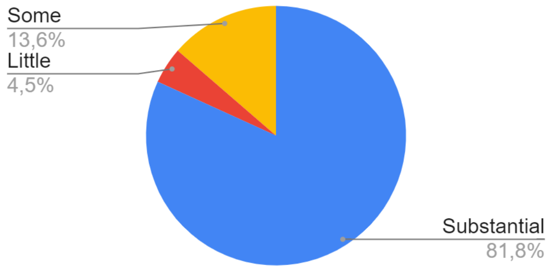
You can drop us an email (v.cimini@ovaerdi.com) and if needed we can also plan bespoke quick calls to go through your questions and doubts.

Annex 6 - Survey on sustainability vs value creation

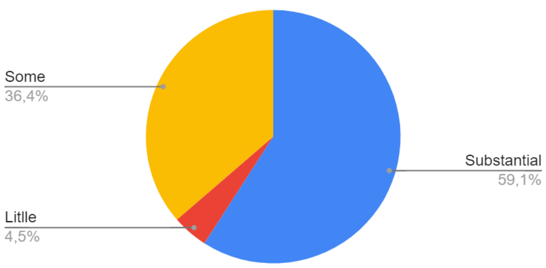
1. How important is it that a new property is certified, e.g. BREEAM



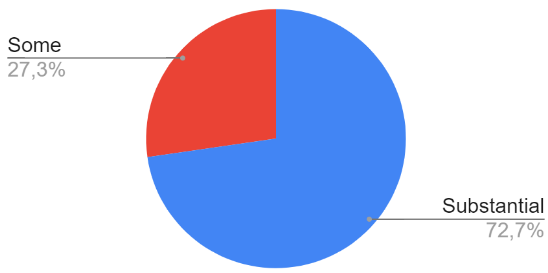
2. How important is it to certify a property you have developed yourself?



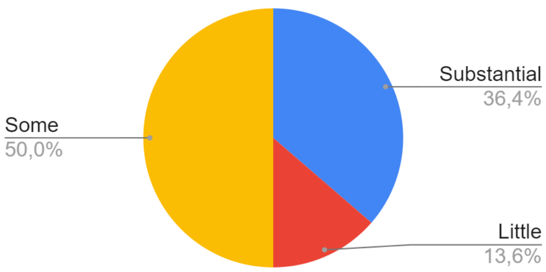
3. To what extent do you consider certification is important for the property value?



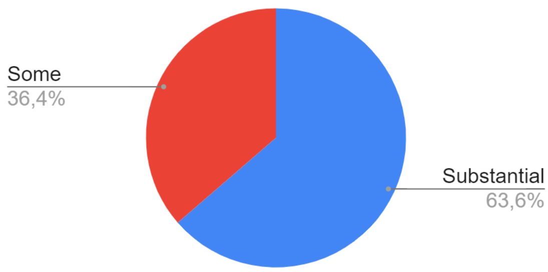
4. How large is the focus on sustainability when developing own properties?



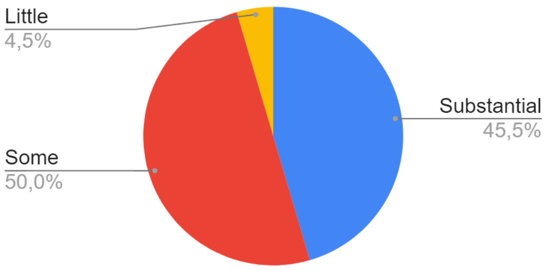
5. How important is innovation in setting the values of developed or aquired properties?



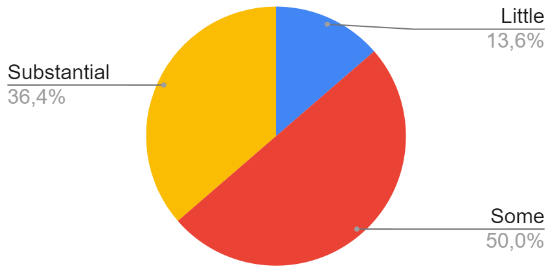
6. To what degree is there a connection between innovation and sustainability?



7. To what degree is sustainability important for the daily operation in your company?



8. To what degree influences sustainability the decisions taken by employees in the company?



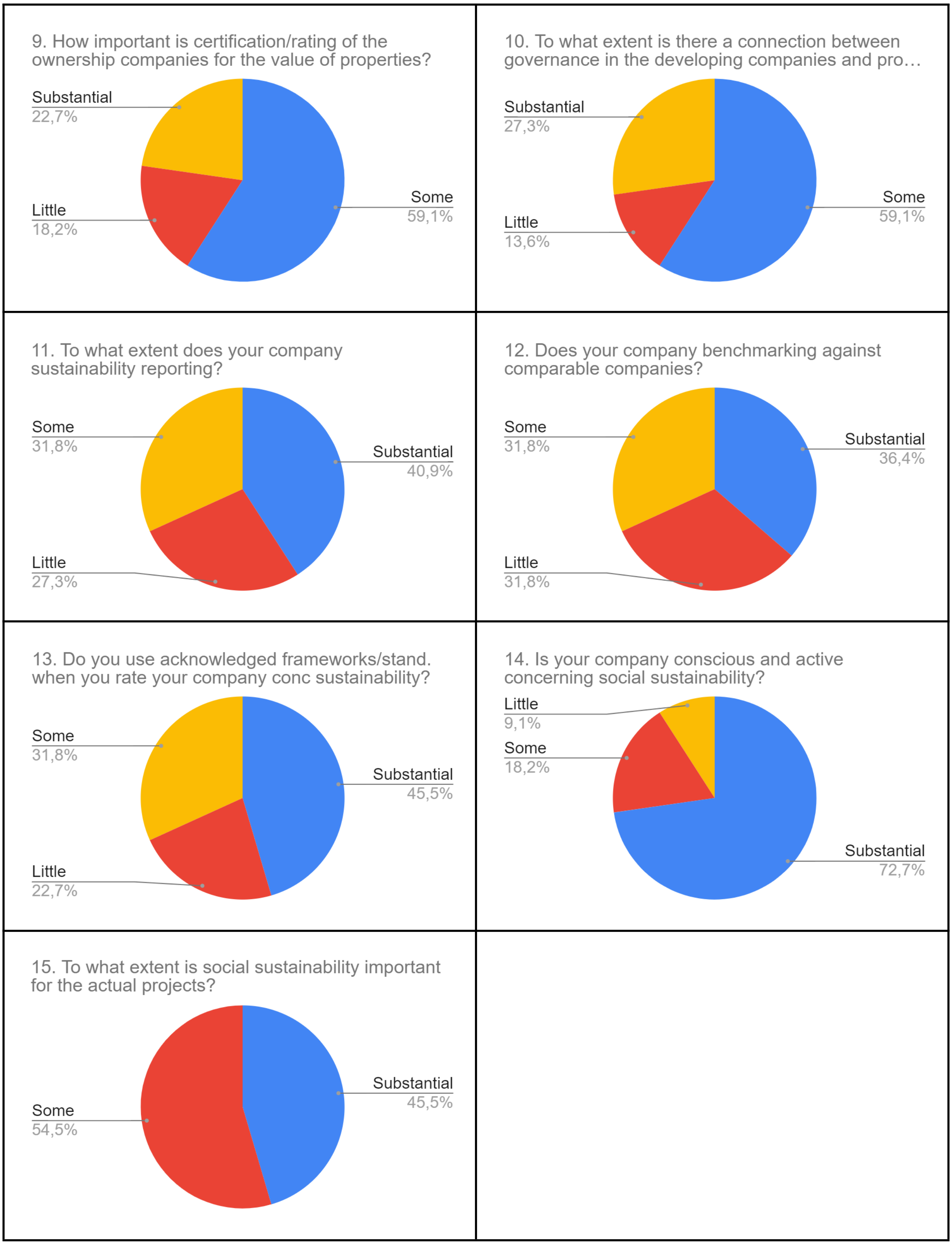


Figure A3.1 Answers to survey on the connections between sustainability and value creation related to property value. Actors asked: Bank and finance institutions and real-estate companies. N = 22.

Table A3.1 Detailed answers to survey on the connections between sustainability and value creation related to property value.

1. How important is it that a new property is certified, e.g. BREEAM?	Banks and finance institutions	Large real-estate company	Small real-estate company
Little		20,00%	28,57%
Some	60,00%	50,00%	28,57%
Substantial	40,00%	30,00%	42,86%

2. How important is it to certify a property you have developed yourself?	Banks and finance institutions	Large real-estate company	Small real-estate company
Little			14,29%
Some		10,00%	28,57%
Substantial	100,00%	90,00%	57,14%

3. To what extent do you consider certification is important for the property value?	Banks and finance institutions	Large real-estate company	Small real-estate company
Little			14,29%
Some	40,00%	30,00%	42,86%
Substantial	60,00%	70,00%	42,86%

4. How large is the focus on sustainability when developing own properties?	Banks and finance institutions	Large real-estate company	Small real-estate company
Some	60,00%		42,86%
Substantial	40,00%	100,00%	57,14%

5. How important is innovation in setting the values of developed or aquired properties?	Banks and finance institutions	Large real-estate company	Small real-estate company
Little		10,00%	28,57%
Some	40,00%	50,00%	57,14%
Substantial	60,00%	40,00%	14,29%

6. To what degree is there a connection between innovation and sustainability?	Banks and finance institutions	Large real-estate company	Small real-estate company
Some	40,00%	20,00%	57,14%
Substantial	60,00%	80,00%	42,86%

7. To what degree is sustainability important for the daily operation in your company?	Banks and finance institutions	Large real-estate company	Small real-estate company
Little			14,29%
Some	60,00%	30,00%	71,43%
Substantial	40,00%	70,00%	14,29%

8. To what degree influences sustainability the decisions taken by employees in the company?	Banks and finance institutions	Large real-estate	Small real-estate

		company	company
Little		10,00%	28,57%
Some	60,00%	40,00%	57,14%
Substantial	40,00%	50,00%	14,29%

9. How important is certification/rating of the ownership companies for the value of properties?	Banks and finance institutions	Large real-estate company	Small real-estate company
Little	20,00%	20,00%	14,29%
Some	60,00%	50,00%	71,43%
Substantial	20,00%	30,00%	14,29%

10. To what extent is there a connection between governance in the developing companies and property values?	Banks and finance institutions	Large real-estate company	Small real-estate company
Little	20,00%	20,00%	
Some	20,00%	50,00%	100,00%
Substantial	60,00%	30,00%	

11. To what extent does your company sustainability reporting?	Banks and finance institutions	Large real-estate company	Small real-estate company
Little			85,71%
Some	80,00%	20,00%	14,29%
Substantial	20,00%	80,00%	

12. Does your company benchmarking against comparable companies?	Banks and finance institutions	Large real-estate company	Small real-estate company
Little	20,00%		85,71%
Some		60,00%	14,29%
Substantial	80,00%	40,00%	

Annex 7 - Detailed PEB and mobility CAPEX and OPEX

Table A4.1 PEB Sluppen detailed CAPEX and OPEX.

ID	Intervention	Owner/ Leader	Implemented by	Total costs	EU Contribution	In kind Contribution	3rd Party contribution	Annual OPEX
SLP-01	Energy Renovation Sluppen	**RK**	**KEF**	**€ 68.422**	€ 60.000	€ 8.422	€ 0	
SLP-02	PV Sluppenvegen 11	RK	TE	€ 201.104	€ 0	€ 201.104	€ 0	
SLP-03	PV Sluppenvegen 17B	RK	TE	€ 95.027	€ 0	€ 95.027	€ 0	
SLP-04	PV import from remote site	TE	TE	€ 130.000	€ 0	€ 130.000	€ 0	€ 0
SLP-05	Thermal energy import from seawater HP Brattøra	SV	SV	€ 571.500	€ 50.000	€ 521.500	€ 0	€ 15.000
SLP-06	Exchange HP with DH	SV	SV	€ 42.900	€ 30.000	€ 12.900	€ 0	
SLP-07	BESS	TE	TE	€ 430.000	€ 0	€ 430.000	€ 0	€ 3.000
SLP-08	PV Sluppenvegen 19	RK	RK	€ 230.000	€ 0	€ 230.000	€ 0	
SLP-09	HP Sluppenvn 19	RK	RK	€ 80.000	€ 0	€ 80.000	€ 0	
SLP-10	Computer waste heat for hot water production	4C	4C	€ 128.500	€ 90.000	€ 38.500	€ 0	
SLP-11	ABB Optimax integration	ABB	ABB	€ 314.250	€ 219.975	€ 94.275	€ 0	€ 5.000
SLP-12	Energy Trading Platform	Volue	Volue	€ 270.000	€ 143.500	€ 126.500	€ 0	€ 10.000
SLP-13	Local Flexibility Market	TE	TE	€ 648.500	€ 453.970	€ 194.530	€ 0	€ 15.000
SLP-14	Energy and Building Management Integration	RK	KEF	€ 314.300	€ 220.000	€ 94.300	€ 0	
SLP-15	Necessary investment in Management	RK	KEF	€ 114.300	€ 80.000	€ 34.300		
SLP-16	EV chargers (1xV2G, 4x1-way smart chargers)	ABG	Trh Parking	€ 27.400		€ 19.900	€ 7.500	
SLP-17	PV Tempe Health Care Centre	TK	TK	€ 150.000		€ 150.000		
SLP-18	Energy Renovation Tempe HCC	TK	TK	€ 200.000		€ 200.000		
SLP-19	ABB Optimax integration Tempe HCC	TK	ABB	€ 45.000		€ 45.000		
SLP-20	BESS Tempe HCC	TK	-	€ 63.500		€ 63.500		
				€ 4.124.703	**€ 1.347.445**	**€ 2.769.758**	**€ 7.500**	**€ 48.000**
				PEB cost:	**€ 4.124.703**			

Table A4.2 PEB Brattøra detailed CAPEX and OPEX.

ID	Intervention	Owner/ Leader	Implemented by	Total cost	EU Contribution	In kind Contribution	3rd Party contribution	Annual OPEX
BRT-01	PV BK16	Entra	Entra	€ 319.200	€ 0	€ 319.200	€ 0	€ 2.000
BRT-02	PV BK17A	Entra	Entra	€ 1.245.000	€ 0	€ 1.245.000	€ 0	€ 2.000
BRT-03	HP BK 16	Entra	Entra	€ 75.000	€ 0	€ 75.000	€ 0	€ 3.000
BRT-04	HP BK17A	Entra	Entra	€ 650.000	€ 0	€ 650.000	€ 0	€ 3.000
BRT-05	Sea water pump + belonging systems [1)]	Entra	Entra					
BRT-06	BESS	TE	TE	€ 430.000	€ 0	€ 430.000	€ 0	€ 3.000
BRT-07	ABB Optimax integration	ABB	ABB	€ 300.000	€ 210.000	€ 90.000	€ 0	€ 5.000
BRT-08	Energy Trading Platform	Volue	Volue	€ 177.500	€ 60.000	€ 117.500	€ 0	€ 10.000
BRT-09	Local Flexibility Market	TE	TE	€ 245.700	€ 217.000	€ 28.700	€ 0	€ 15.000
BRT-10	Energy and Building Management Integration	Entra	Entra	€ 241.400	€ 0	€ 145.000	€ 96.400	€ 10.000
				€ 3.683.800	**€ 487.000**	**€ 3.100.400**	**€ 96.400**	**€ 51.000**
				PEB cost:	**€ 3.683.800**			

[1)] Data not available. Investment cost is, however, substantial

Table A4.3 Costs for the eMaaS case. Numbers are based on totally 20 shared EVs (only 5 EV chargers are installed so far at Sluppen), and numbers represent both eMaaS hubs - Brattøra and Sluppen.

ID	Intervention	Owner/ Leader	Implemented by	Total cost	EU Contribution	In kind Contribution	3rd Party contribution	Annual OPEX
MOB-01	Shared EVs	ABG	ABG/MoveAbout	€ 384.000	€ 0	€ 384.000	€ 0	€ 17.900
MOB-02	2 pcs. 2-way EV chargers, 1 at Brt 1 at Slp	TK	TK	€ 15.000	€ 0	€ 15.000	€ 0	€ 0
MOB-03	4 pcs Zaptech 1-way EV chargers Sluppen	Trh Parking	Trh Parking	€ 23.676	0	€ 23.676	€ 0	€ 0
MOB-04	X pcs Schneider 1-way EV chargers Brattøra	Entra	Entra	€ 20.000	0	€ 20.000	€ 0	€ 0
MOB-05	Mobility platform + app	4C	4C	€ 180.000	€ 126.000	€ 54.000	€ 0	€ 0
MOB-06	Parking spaces Brattøra	Entra		€ 27.000	€ 0	€ 27.000	€ 0	€ 27.000
MOB-07	Parking spaces Sluppen	RK	ABG	€ 27.000	€ 0	€ 27.000	€ 0	€ 27.000
MOB-08	Kitting of shared EVs	ABG	MoveAbout	€ 12.500	€ 7.600	€ 4.900	€ 0	€ 0
MOB-09	Ground work EV chargers Sluppen	RK		€ 8.750	€ 0	€ 8.750	€ 0	€ 0
MOB-10	Electrical entrepreneur work building-EV charger	Trh Parking		€ 7.500	€ 0	€ 7.500	€ 0	€ 0
MOB-11	El to EV, Sluppen	RK	ABG	€ 3.600	€ 0	€ 3.600	€ 0	€ 3.600
MOB-12	El to EV, Brattøra	Entra	ABG	€ 3.000	€ 0	€ 3.000	€ 0	€ 3.000
				€ 651.426	**€ 133.600**	**€ 517.826**	€ 0	**€ 78.500**
				Mobility cost:	**€ 651.426**			

Annual costs for P spaces and electricity for charging shared EVs	€ 60.600

Annex 8 - Rooftop PV detailed calculations

Ref section 6.3.

	January	February	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Sum
Total energy consumption (kWh)	35092	31831	30901	17218	19876	12594	11153	18034	25841	32425	38222	35421	308608
Energy production PV (kWh)	261	1282	5320	18 479	21088	22060	23149	16925	8992	4282	762	63	122663
Net energy consumption (kWh)	34831	30549	25581	−1 261	−1212	−9466	−11996	1109	16849	28143	37460	35358	185945
Net PV production PV in % of total consumption	0,74%	4,03%	17,2%	107,32%	106,10%	175,16%	207,56%	93,85%	34,80%	13,21%	1,99%	0,18%	39,75%
Energy cost for energy bought from grid (€/kWh)	**0,1750**	**0,1566**	**0,2062**	**0,2040**	**0,1886**	**0,1850**	**0,2086**	**0,3439**	**0,3537**	**0,1415**	**0,1571**	**0,2186**	
Energy price for energy sold to local market (€/kWh)	0,1700	0,1516	0,2012	0,1990	0,1836	0,1800	0,2036	0,3389	0,3487	0,1365	0,1521	0,2136	
% PV production sold to the local market	0%	0%	0%	20%	20%	50%	60%	0%	0%	0%	0%	0%	
Energy production PV (kWh)	261	1282	5320	18 479	21088	22060	23149	16925	8992	4282	762	63	122663
Monthly share of total annual PV production (%)	0,21%	1,05%	4,34%	15,06%	17,19%	17,98%	18,87%	13,80%	7,33%	3,49%	0,62%	0,05%	100,00%

Finance costs (€)						**Year 1**							
Depreciation	45	222	923	3 206	3 658	3 827	4 016	2 936	1 560	743	132	11	21 280

Interest cost after tax (22%)	1 037	1 037	1 037	1 034	1 023	1 011	999	986	976	971	969	968	
Sum	**1 083**	**1 260**	**1 959**	**4 239**	**4 682**	**4 838**	**5 015**	**3 922**	**2 536**	**1 714**	**1 101**	**979**	**33 328**
Registered value/remaining debt	319 155	318 932	318 009	314 804	311 145	307 318	303 302	300 366	298 806	298 063	297 931	297 920	
Income/saving	46	201	1 097	3 751	3 956	4 026	4 759	5 821	3 180	606	120	14	27 575
Net result	**−1 037**	**−1 059**	**−863**	**−489**	**−726**	**−813**	**−256**	**1 899**	**644**	**−1 108**	**−981**	**−965**	**−5 753**
Finance costs (€)	**Year 2**												
Depreciation	45	222	923	3 206	3 658	3 827	4 016	2 936	1 560	743	132	11	
Interest cost after tax (22%)	968	968	967	964	954	942	930	917	907	902	900	899	
Sum	**1 014**	**1 190**	**1 890**	**4 170**	**4 612**	**4 769**	**4 946**	**3 853**	**2 467**	**1 645**	**1 032**	**910**	32 498
Registered value/remaining debt	297 875	297 652	296 729	293 524	289 865	286 038	282 022	279 086	277 526	276 783	276 651	276 640	
Income/saving	46	201	1 097	3 751	3 956	4 026	4 759	5 821	3 180	606	120	14	27 575
Net result	**−968**	**−990**	**−793**	**−420**	**−657**	**−744**	**−187**	**1 968**	**713**	**−1 039**	**−912**	**−896**	**−4 923**
Finance costs (€)	**Year 3**												
Depreciation	45	222	923	3 206	3 658	3 827	4 016	2 936	1 560	743	132	11	
Interest cost after tax (22%)	899	899	898	895	885	873	860	847	838	833	830	830	
Sum	**944**	**1 121**	**1 821**	**4 101**	**4 543**	**4 700**	**4 876**	**3 784**	**2 398**	**1 576**	**963**	**841**	31 668
Registered value/remaining debt	276 595	276 372	275 449	272 244	268 585	264 758	260 742	257 806	256 246	255 503	255 371	255 360	
Income/saving	46	201	1 097	3 751	3 956	4 026	4 759	5 821	3 180	606	120	14	27 575
Net result	**−899**	**−921**	**−724**	**−350**	**−587**	**−674**	**−118**	**2 038**	**783**	**−970**	**−843**	**−827**	**−4 093**
Finance costs (€)	**Year 4**												
Depreciation	45	222	923	3 206	3 658	3 827	4 016	2 936	1 560	743	132	11	
Interest cost after tax (22%)	830	830	829	826	816	804	791	778	769	764	761	761	
Sum	**875**	**1 052**	**1 752**	**4 032**	**4 474**	**4 631**	**4 807**	**3 714**	**2 329**	**1 506**	**893**	**772**	30 838

Registered value/remaining debt	255 315	255 092	254 169	250 964	247 305	243 478	239 462	236 526	234 966	234 223	234 091	234 080	
Income/saving	46	201	1 097	3 751	3 956	4 026	4 759	5 821	3 180	606	120	14	27 575
Net result	**−830**	**−851**	**−655**	**−281**	**−518**	**−605**	**−49**	**2 107**	**852**	**−901**	**−774**	**−758**	**−3 263**
Finance costs (€)							**Year 5**						
Depreciation	45	222	923	3 206	3 658	3 827	4 016	2 936	1 560	743	132	11	
Interest cost after tax (22%)	761	761	760	757	746	735	722	709	700	694	692	692	
Sum	**806**	**983**	**1 683**	**3 963**	**4 405**	**4 562**	**4 738**	**3 645**	**2 260**	**1 437**	**824**	**703**	30 008
Registered value/remaining debt	234 035	233 812	232 889	229 684	226 025	222 198	218 182	215 246	213 686	212 943	212 811	212 800	
Income/saving	46	201	1 097	3 751	3 956	4 026	4 759	5 821	3 180	606	120	14	27 575
Net result	**−760**	**−782**	**−586**	**−212**	**−449**	**−536**	**21**	**2 176**	**921**	**−832**	**−705**	**−689**	**−2 433**
Finance costs (€)							**Year 6**						
Depreciation	45	222	923	3 206	3 658	3 827	4 016	2 936	1 560	743	132	11	
Interest cost after tax (22%)	692	691	691	688	677	665	653	640	630	625	623	622	
Sum	**737**	**914**	**1 614**	**3 894**	**4 336**	**4 492**	**4 669**	**3 576**	**2 190**	**1 368**	**755**	**633**	29 178
Registered value/remaining debt	212 755	212 532	211 609	208 404	204 745	200 918	196 902	193 966	192 406	191 663	191 531	191 520	
Income/saving	46	201	1 097	3 751	3 956	4 026	4 759	5 821	3 180	606	120	14	27 575
Net result	**−691**	**−713**	**−517**	**−143**	**−380**	**−467**	**90**	**2 245**	**990**	**−762**	**−635**	**−620**	**−1 603**
Finance costs (€)							**Year 7**						
Depreciation	45	222	923	3 206	3 658	3 827	4 016	2 936	1 560	743	132	11	
Interest cost after tax (22%)	622	622	622	619	608	596	584	571	561	556	554	553	
Sum	**668**	**845**	**1 545**	**3 824**	**4 267**	**4 423**	**4 600**	**3 507**	**2 121**	**1 299**	**686**	**564**	28 348
Registered value/remaining debt	191 475	191 252	190 329	187 124	183 465	179 638	175 622	172 686	171 126	170 383	170 251	170 240	
Income/saving	46	201	1 097	3 751	3 956	4 026	4 759	5 821	3 180	606	120	14	27 575

Net result	**−622**	**−644**	**−448**	**−74**	**−311**	**−398**	**159**	**2 314**	**1 059**	**−693**	**−566**	**−550**	**−773**
Finance costs (€)	**Year 8**												
Depreciation	45	222	923	3 206	3 658	3 827	4 016	2 936	1 560	743	132	11	
Interest cost after tax (22%)	553	553	552	549	539	527	515	502	492	487	485	484	
Sum	**599**	**776**	**1 475**	**3 755**	**4 197**	**4 354**	**4 531**	**3 438**	**2 052**	**1 230**	**617**	**495**	27 518
Registered value/remaining debt	170 195	169 972	169 049	165 844	162 185	158 358	154 342	151 406	149 846	149 103	148 971	148 960	
Income/saving	46	201	1 097	3 751	3 956	4 026	4 759	5 821	3 180	606	120	14	27 575
Net result	**−553**	**−575**	**−378**	**−5**	**−242**	**−329**	**228**	**2 383**	**1 128**	**−624**	**−497**	**−481**	**57**
Finance costs (€)	**Year 9**												
Depreciation	45	222	923	3 206	3 658	3 827	4 016	2 936	1 560	743	132	11	
Interest cost after tax (22%)	484	484	483	480	470	458	446	432	423	418	415	415	
Sum	**529**	**706**	**1 406**	**3 686**	**4 128**	**4 285**	**4 461**	**3 369**	**1 983**	**1 161**	**548**	**426**	26 688
Registered value/remaining debt	148 915	148 692	147 769	144 564	140 905	137 078	133 062	130 126	128 566	127 823	127 691	127 680	
Income/saving	46	201	1 097	3 751	3 956	4 026	4 759	5 821	3 180	606	120	14	27 575
Net result	**−484**	**−506**	**−309**	**65**	**−173**	**−259**	**297**	**2 453**	**1 198**	**−555**	**−428**	**−412**	**886**
Finance costs (€)	**Year 10**												
Depreciation	45	222	923	3 206	3 658	3 827	4 016	2 936	1 560	743	132	11	
Interest cost after tax (22%)	415	415	414	411	401	389	376	363	354	349	346	346	
Sum	**460**	**637**	**1 337**	**3 617**	**4 059**	**4 216**	**4 392**	**3 299**	**1 914**	**1 092**	**478**	**357**	25 859
Registered value/remaining debt	127 635	127 412	126 489	123 284	119 625	115 798	111 782	108 846	107 286	106 543	106 411	106 400	
Income/saving	46	201	1 097	3 751	3 956	4 026	4 759	5 821	3 180	606	120	14	27 575
Net result	**−415**	**−436**	**−240**	**134**	**−103**	**−190**	**366**	**2 522**	**1 267**	**−486**	**−359**	**−343**	**1 716**
Finance costs	**Year 11**												

Depreciation	45	222	923	3 206	3 658	3 827	4 016	2 936	1 560	743	132	11	
Interest cost after tax (22%)	346	346	345	342	332	320	307	294	285	280	277	277	
Sum	**391**	**568**	**1 268**	**3 548**	**3 990**	**4 147**	**4 323**	**3 230**	**1 845**	**1 022**	**409**	**288**	25 029
Registered value/remaining debt	106 355	106 132	105 209	102 004	98 345	94 518	90 502	87 566	86 006	85 263	85 131	85 120	
Income/saving	46	201	1 097	3 751	3 956	4 026	4 759	5 821	3 180	606	120	14	275 750
Net result	**−345**	**−367**	**−171**	**203**	**−34**	**−121**	**436**	**2 591**	**1 336**	**−417**	**−290**	**−274**	**2 546**
Finance costs (€)	**Year 12**												
Depreciation	45	222	923	3 206	3 658	3 827	4 016	2 936	1 560	743	132	11	
Interest cost after tax (22%)	277	276	276	273	262	250	238	225	215	210	208	208	
Sum	**322**	**499**	**1 199**	**3 479**	**3 921**	**4 078**	**4 254**	**3 161**	**1 775**	**953**	**340**	**218**	24 199
Registered value/remaining debt	85 075	84 852	83 929	80 724	77 065	73 238	69 222	66 286	64 726	63 983	63 851	63 840	
Income/saving	46	201	1 097	3 751	3 956	4 026	4 759	5 821	3 180	606	120	14	275 750
Net result	**−276**	**−298**	**−102**	**272**	**35**	**−52**	**505**	**2 660**	**1 405**	**−347**	**−220**	**−205**	**3 376**
Finance costs (€)	**Year 13**												
Depreciation	45	222	923	3 206	3 658	3 827	4 016	2 936	1 560	743	132	11	
Interest cost after tax (22%)	207	207	207	204	193	181	169	156	146	141	139	138	
Sum	**253**	**430**	**1 130**	**3 409**	**3 852**	**4 008**	**4 185**	**3 092**	**1 706**	**884**	**271**	**149**	23 369
Registered value/remaining debt	63 795	63 572	62 649	59 444	55 785	51 958	47 942	45 006	43 446	42 703	42 571	42 560	
Income/saving	46	201	1 097	3 751	3 956	4 026	4 759	5 821	3 180	606	120	14	275 750
Net result	**−207**	**−229**	**−33**	**341**	**104**	**17**	**574**	**2 729**	**1 474**	**−278**	**−151**	**−136**	**4 206**
Finance costs (€)	**Year 14**												
Depreciation	45	222	923	3 206	3 658	3 827	4 016	2 936	1 560	743	132	11	
Interest cost after tax (22%)	138	138	137	134	124	112	100	87	77	72	70	69	
Sum	**184**	**361**	**1 060**	**3 340**	**3 782**	**3 939**	**4 116**	**3 023**	**1 637**	**815**	**202**	**80**	22 539
Registered value/remaining debt	42 515	42 292	41 369	38 164	34 505	30 678	26 662	23 726	22 166	21 423	21 291	21 280	

Income/saving	46	201	1 097	3 751	3 956	4 026	4 759	5 821	3 180	606	120	14	275 750
Net result	**−138**	**−160**	**37**	**410**	**173**	**86**	**643**	**2 798**	**1 543**	**−209**	**−82**	**−66**	**5 036**
Finance costs (€)	**Year 15**												
Depreciation	45	222	923	3 206	3 658	3 827	4 016	2 936	1 560	743	132	11	
Interest cost after tax (22%)	69	69	68	65	55	43	31	17	8	3	0	0	
Sum	**114**	**291**	**991**	**3 271**	**3 713**	**3 870**	**4 047**	**2 954**	**1 568**	**746**	**133**	**11**	21 709
Registered value/remaining debt	21 235	21 012	20 089	16 884	13 225	9 398	5 382	2 446	886	143	11	0	
Income/saving	46	201	1 097	3 751	3 956	4 026	4 759	5 821	3 180	606	120	14	275 750
Net result	**−69**	**−91**	**106**	**480**	**242**	**156**	**712**	**2 867**	**1 612**	**−140**	**−13**	**3**	**5 866**

Annex 9 - Financing Risk Sharing Model - FRSM

FRSM: https://cityxchange.eu/knowledge-base/d5-16-trondheim-sustainable-investment-and-business-concepts-and-models/

The main FRSM comprises the following main modules:

0. Intro & Guidelines
1. Stakeholders & BMs
2. PEBs Inputs & data
3. PEBs Outputs KPIs & Fin. Risk

Annex 10 - Vehicle-to-Grid (V2G) detailed calculations

EV sharing perspective											
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Total
Per 10 EVs											
Cost - parking space rental	−€24 000,00	−€24 000,00	−€24 000,00	−€24 000,00	−€24 000,00	−€24 000,00	−€24 000,00	−€24 000,00	−€24 000,00	−€24 000,00	−€240 000,00
Lending EVs to local building owner	€2 000,00	€2 000,00	€2 000,00	€2 000,00	€2 000,00	€2 000,00	€2 000,00	€2 000,00	€2 000,00	€2 000,00	
Cost	−€22 000,00	−€22 000,00	−€22 000,00	−€22 000,00	−€22 000,00	−€22 000,00	−€22 000,00	−€22 000,00	−€22 000,00	−€22 000,00	−€220 000,00

Cost reduction giving access to the EV battery	**8,33%**

Building owner centric											
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Total
Per 10 EVs											
Revenue V2G	€14 000,00	€14 000,00	€14 000,00	€14 000,00	€14 000,00	€14 000,00	€14 000,00	€14 000,00	€14 000,00	€14 000,00	
Cost, rental of EVs	−€2 000,00	−€2 000,00	−€2 000,00	−€2 000,00	−€2 000,00	−€2 000,00	−€2 000,00	−€2 000,00	−€2 000,00	−€2 000,00	
Gross revenue	€12 000,00	€12 000,00	€12 000,00	€12 000,00	€12 000,00	€12 000,00	€12 000,00	€12 000,00	€12 000,00	€12 000,00	
Sale of electricity to EV sharing company											
Financing V2G chargers, Annuity, 7 yrs, 5% interest rate, 22% tax refund	−€6 865,90	−€6 865,90	−€6 865,90	−€6 865,90	−€6 865,90	−€6 865,90	−€6 865,90	€0,00	€0,00	€0,00	
OPEX EV chargers	−€600,00	−€600,00	−€600,00	−€600,00	−€600,00	−€600,00	−€600,00	−€600,00	−€600,00	−€600,00	
Net revenue V2G	€4 534,10	€4 534,10	€4 534,10	€4 534,10	€4 534,10	€4 534,10	€4 534,10	€11 400,00	€11 400,00	€11 400,00	€65 938,70
Investment 10 V2G chargers	€42 000,00							€42 000,00			
Annual ROI	**10,80%**							**27,14%**			

EV sharing centric											
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**	**Total**
Per 10 EVs											
Cost - parking space rental	−€24 000,00	−€24 000,00	−€24 000,00	−€24 000,00	−€24 000,00	−€24 000,00	−€24 000,00	−€24 000,00	−€24 000,00	−€24 000,00	
Lost revenue, lending of EVs	−€2 000,00	−€2 000,00	−€2 000,00	−€2 000,00	−€2 000,00	−€2 000,00	−€2 000,00	−€2 000,00	−€2 000,00	−€2 000,00	
Revenue V2G	€14 000,00	€14 000,00	€14 000,00	€14 000,00	€14 000,00	€14 000,00	€14 000,00	€14 000,00	€14 000,00	€14 000,00	
Financing V2G chargers, Annuity, 7 yrs, 5% interest rate, 22% tax refund	−€6 865,90	−€6 865,90	−€6 865,90	−€6 865,90	−€6 865,90	−€6 865,90	−€6 865,90	€0,00	€0,00	€0,00	
OPEX EV chargers	−€600,00	−€600,00	−€600,00	−€600,00	−€600,00	−€600,00	−€600,00	−€600,00	−€600,00	−€600,00	
Net cost P space rental incl sales of kWh via V2G	−€19 465,90	−€19 465,90	−€19 465,90	−€19 465,90	−€19 465,90	−€19 465,90	−€19 465,90	−€12 600,00	−€12 600,00	−€12 600,00	
Cost, traditional renting of P spaces	−€24 000,00	−€24 000,00	−€24 000,00	−€24 000,00	−€24 000,00	−€24 000,00	−€24 000,00	−€24 000,00	−€24 000,00	−€24 000,00	
Revenue	**€4 534,10**	**€4 534,10**	**€4 534,10**	**€4 534,10**	**€4 534,10**	**€4 534,10**	**€4 534,10**	**€11 400,00**	**€11 400,00**	**€11 400,00**	€65 938,70
Investment 10 V2G chargers	€42 000,00										
Annual ROI	**10,80%**							27,14%			
Cost reduction	−€4 534,10							−€11 400,00			
Cost reduction (%)	**18,89%**							47,50%			

Annex 11 - LHC Trondheim BEST Tables

BEST Table version: 10/2022 (same version/data used for D5.11 / PEB report

SLUPPEN	built/retrofitted	year of construction / retrofit	use type	floor area [m2]	Net energy need for +Trondheim DPEB SLUPPEN: Space heating, cooling, and air conditioning [kWh/m2/y] [kwh/y]		Hot water [kwh/y]	Hot water [kwh/y]	Lighting [kWh/m2/y] [kwh/y]		Appliances [kWh/m2/y] [kwh/y]		sub-total net energy need [kwh/y]
Sluppenvegen 11/13	built	1976/2020	Culture/Restaurant/Climbing centre	5 789	81,8	473 504	5	71 288	25,7	149 005	41,7	241 600	935 397
Sluppenveien 17B	built	2015	Office building	11 949	43,6	520 608	5	70 992	14,6	174 908	22,0	262 362	1 028 870
Sluppenveien 19	built	2018	Office building	12 815	33,7	432 400	5	65 118	10,6	135 899	17,2	220 491	853 908
Ola Frost vei 1	built	2006	Residential	2 800	56,4	158 008	30	132 836	19,0	53 319	44,3	123 902	468 065
Valøyvegen 12	built	2004/2013& 2019	Health Centre	6 073	69,0	418 751	29,8	191 579	49,6	301 486	25,1	152 243	1 064 059
											Total net energy need [kwh/y]		4 350 299

Local RES (within the boundaries of the project district)	Photovoltaic [kWp] [kwh/y]		V2B/V2G [kwh/y]	Waste heat HP [kwh/y]	Heat pump [kwh/y]	Urban heating [kwh/y]	sub-total net energy need [kwh/y]
Decided RES at Demo Area level	84	84 000	10 000	160 000		320 000	574 000
Sluppenvegen 11/13	207	150 075			50 000	368 943	569 225
Sluppenveien 17B	97.2	75 256			268 480	104 759	448 495
Sluppenveien 19	169	120 950			400 000	95 177	616 127
Ola Frost vei 1	85	57 548		63 000	50 000	190 288	360 921
Valøyvegen 12	142	112 000			100 000	367 500	579 642
				Total net energy production [kwh/y]			3 148 410

Legend: Existing RES | Decided RES | Proposed RES

Storage

	Batteries [kWh]
District level	540,00

% of total net energy need covered by local RES:	72,37%

BRATTØRA	78 686	year of construction/ retrofit	use type	floor area [m2]	*Space heating, cooling, and air conditioning [kWh/m2/y] [kwh/y]*		*Hot water [kwh/y]*	*Hot water [kwh/y]*	*Lighting [kWh/m2/y] [kwh/y]*		*Appliances [kWh/m2/y] [kwh/y]*		*sub-total net energy need [kwh/y]*
Brattørkaia 15	built	2013	Office building	12 869	40	518 674	5	87 962	21	276 019	26	330 617	1 213 272
Brattørkaia 16	built	2018	Office building	8 016	12	95 658	3	16 653	8	61 707	19	148 716	322 734
Brattørkaia 17A	built	2019	Office building	14 291	18	259 523	3	37 233	9	133 090	22	320 784	750 630
										Total net energy need [kwh/y]			2 286 636

Existing RES	Decided RES	Proposed RES

Local RES (within the boundaries of the project district)	Photovoltaic [kWp] [kwh/y]		V2B/V2G [kwh/y]	Waste heat HP [kwh/y]	Heat pump [kwh/y]	urban energy [kwh/y]	*sub-total net energy need [kwh/y]*
Proposed RES at Demo Area level		0	10 000	0	0	0	10 000
Brattørkaia 15	0	0		0	501 641	138 380	640 021
Brattørkaia 16	195	122 662	0	0	279 216	14 127	416 005
Brattørkaia 17A	577	416 753	0	0	554 472	27 423	998 648
				Total net production [kwh/y]			2 064 674

	Batteries [kWh]
District level	540

% of total net energy need covered by local RES: **90,29%**

Annex 12 - Heat pump design and projecting tool

Developed by NTNU and Statkraft Varme (district heating operator).

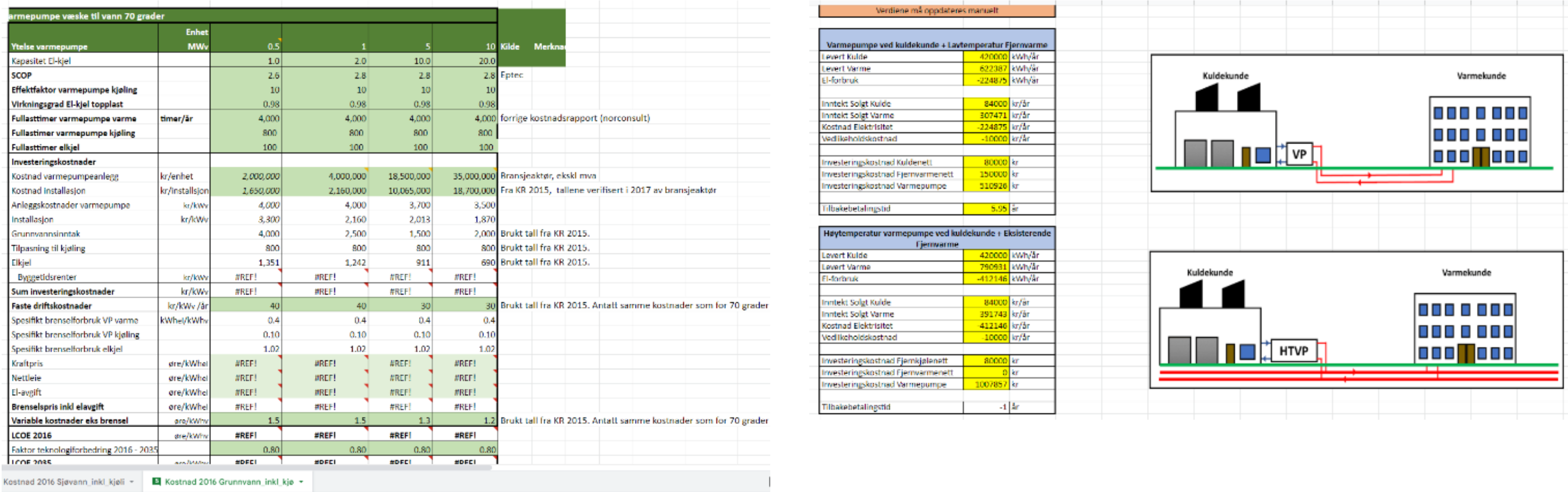


Figure A8.1 Two calculation tools including cooling options and solutions for a variety of heat pump alternatives and temperature lifts, including solutions for different temperature lifts.