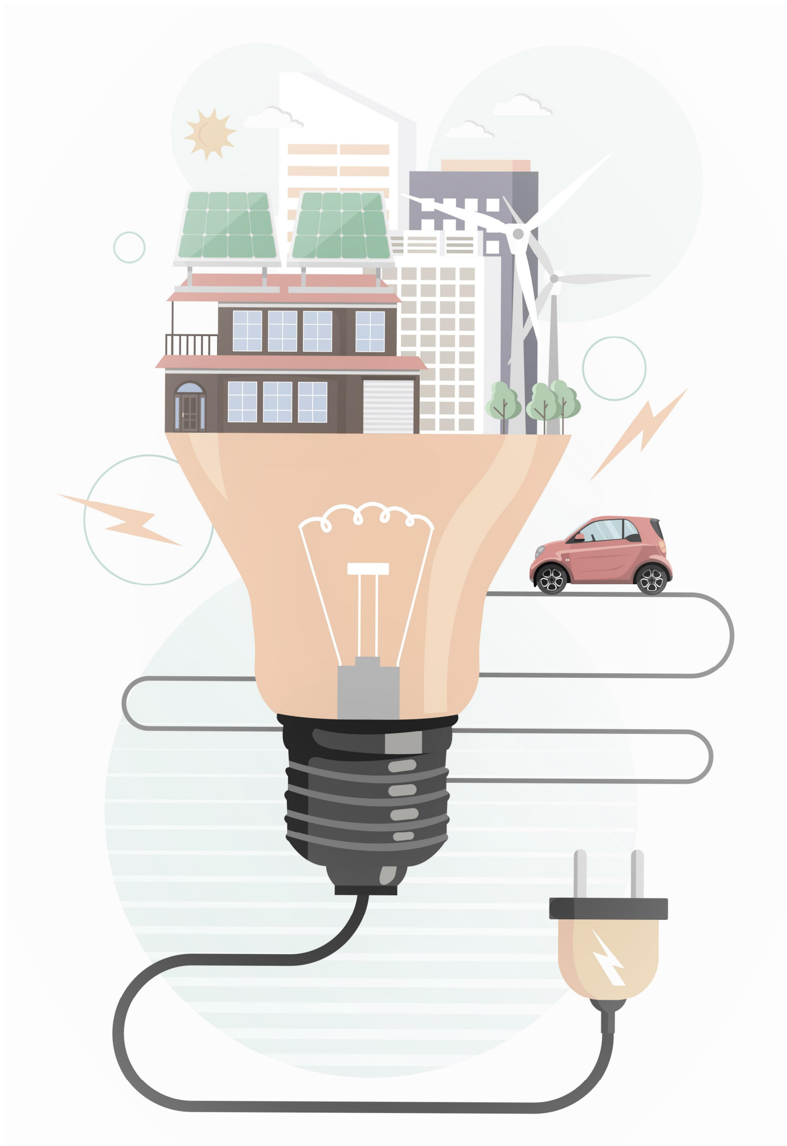
European Commission

ASSET STUDY on
Best Existing Positive Energy Blocks



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About the ASSET project

The ASSET Project (Advanced System Studies for Energy Transition) aims at providing studies in support to EU policy making, research and innovation in the field of energy. Studies are in general focussed on the large-scale integration of renewable energy sources in the EU electricity system and consider, in particular, aspects related to consumer choices, demand-response, energy efficiency, smart meters and grids, storage, RES technologies, etc. Furthermore, connections between the electricity grid and other networks (gas, heating and cooling) as well as synergies between these networks are assessed.

The ASSET studies not only summarize the state-of-the-art in these domains, but also comprise detailed qualitative and quantitative analyses on the basis of recognized techniques in view of offering insights from a technology, policy (regulation, market design) and business point of view.

Disclaimer

The study is carried out for the European Commission and expresses the opinion of the organisation having undertaken them. To this end, it does not reflect the views of the European Commission, TSOs, project promoters and other stakeholders involved. The European Commission does not guarantee the accuracy of the information given in the study, nor does it accept responsibility for any use made thereof.

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Executive summary

Under Horizon 2020, European Innovation Partnership on Smart Cities and Communities (EIP-SCC) defines a Positive Energy Block (PEB) as a group of at least three connected neighbouring buildings producing on a yearly basis more energy than what they consume. The goal of the study is to select and analyse five existing best cases of Positive Energy Blocks in the world which stand out in terms of maturity, innovation and performance, and analyse them in order to identify success factors and barriers on technical, regulatory, financial and social levels regarding the development of PEBs.

The first part of the study provided an inventory of existing sustainable Energy Blocks based on extensive desktop research of initiatives within and out of the European Union. In a second part, the sustainable Energy Blocks are evaluated based on Key Performance Indicators calculated with publicly available information. In a third part, the evaluation enabled to select five best cases that are further studied: Wildpoldsried, a village in the south of Germany; Samsø, an island in Denmark; Hikari, a group of three buildings in Lyon, France; Fort d'Issy, an eco-district with a geothermal network; and Trent Basin, an eco-district in the United Kingdom with advanced energy management system. The third part of the study consists of more in-depth analysis of the cases, with interviews in order to gather anecdotical examples of success factors and barriers. Finally, based on the success factors and barriers identified, recommendations to future Positive Energy Blocks are drawn. These are detailed below from different perspectives.

From a technical perspective, the analysis has underlined that the three functions (production, efficiency, flexibility) required to develop a PEB have been emphasized in different manners by each of the five projects, depending on the resources available. Different types of sites have indeed different specificities, and the technical solution chosen is not especially replicable in another environment. It was concluded that in an urban environment where space is limited, the flexibility function is key to achieve a positive energy balance because it enables to consume and sell energy at optimal times. A first recommendation for future PEB would be to not undermine the importance of the flexibility function and include different solutions to involve users in this flexibility management. Another technical recommendation that can be highlighted is to explore technical synergies between the electricity and thermal vector. It can indeed enable cheaper storage solutions, as well as an additional way of using surplus of electricity. Finally, different user types in a same block is interesting to optimize investment size of assets and hence investments costs.

From a regulatory perspective, a supportive regulatory framework is a critical success factor for a PEB. In that regard, supportive regulation that offers feed-in tariffs for selling electricity back to the grid is a condition to make the current business models of PEB financially viable. Nevertheless, these feed-in-tariffs are not applicable everywhere and are being phased-out in some countries. Therefore, the question on how to make the surplus of energy valuable arises. The solution of selling the surplus electricity on flexibility markets has been raised. PEBs taking a balancing role however implies a higher level of technical expertise. Another solution would consist of increasing the amount of self-consumed energy. However, the analysis has shown that there was, at the time of implementation of the case studies, little ways to ensure that local renewable production of the PEB can be consumed physically (except for individual assets, or through full islanding). Energy sharing is less attractive in the design of current PEBs. Therefore, a recommendation for future PEB consists of designing their project in a context of clarified national regulation for collective self-consumption of electricity. In addition, due to the intermittency of local renewable energy sources, self-consumption would also imply more advanced smart meters with remote access to electric devices, which are not yet mature in the market of all countries. To conclude on the regulatory perspective, more generally, legal aspects

were often considered as barriers in the good development of the project, and a recommendation for a future PEB would be to partner with a law firm and include the legal aspects from the beginning of the project.

From a financial perspective, the analysis has underlined that all the PEBs have required grants or exceptional conditions in order to develop innovative solutions. We highlight a few areas where innovation is welcome for further integration of PEB in the energy system:

- Innovation in flexibility products: there is opportunity for surplus of electricity from DER to be traded on flexibility markets. Further innovation to be able to trade electricity from DER in local flexibility markets would be necessary to further integrate PEBs in the energy system.
- Innovation to involve end-users in increased demand response: ensure consumers will not face significant technical barriers for the optimization of their day-to-day energy use
- Innovation that enable self-consumption in a PEB such as peer-to-peer trading or advanced smart metering
- Innovation in solutions to leverage synergies between the flows of different fluids

In addition, real estate constraints for new building blocks must be considered when investing in innovative energy solutions. Depending on the attractivity of the site, there is indeed a trade-off between energy investments (e.g. energy efficiency investments) and offering an attractive price of the real estate.

Finally, stakeholder management is an important dimension across the development and the operations of all the projects. In PEBs where there were already inhabitants, a meaningful consultative process was implemented where the plans were adjusted to meet the concerns of the local population. In addition, in some cases, collective ownership has built support for renewable energy. Finally, the involvement of public authorities, as well as distribution system operator, energy companies and local communities is a key success factor for the development of a PEB.

Table of Contents

List of Abbreviations and Acronyms

BMS	Building Management System
EB	Energy Block
BMS	Building Management System
DER	Distributed Energy Resources
BRP	Balance Responsible Party
EMS	Energy Management System
FiT	Feed-in-Tariffs
HEMS	Home Energy management System
KPI	Key Performance Indicator
LCA	Life Cycle Assessment
LCOE	Levelized Cost of Electricity
MS	Member States
PEB	Positive Energy Block
PED	Positive Energy District

Introduction

During recent years the electricity supply chain (electricity production, consumption, distribution, storage, and load management) has changed. Adoption of solar PV and other distributed energy resources (DER) are becoming widespread and more affordable. Local on-site energy production gives the opportunity to manage surplus energy and exploiting possible local flexibility sources (e.g. storage, load shifting, and others). These local energy system features have contributed to the rise of positive energy buildings which form a cluster labelled as the Positive Energy Block (PEB).

Under Horizon 2020, European Innovation Partnership on Smart Cities and Communities (EIP-SCC) defines a Positive Energy Block (PEB) as a group of at least three connected neighbouring buildings producing on a yearly basis more energy than what they use. Nonetheless, the definition of PEB concept boundary is still under discussion. The SET plan action is working on a new framework definition of Positive Energy Districts or Neighbourhoods as "energy-efficient and energy-flexible urban areas which produce net zero greenhouse gas emissions and actively manage an annual local or regional surplus production of renewable energy. They require integration of different systems and infrastructures and interaction between buildings, the users and the regional energy, mobility and ICT systems, while optimising the liveability of the urban environment in line with social, economic and environmental sustainability.[1]"

The goal of the study is to select and analyse five existing best cases of Positive Energy Blocks in the world which stand out in terms of maturity, innovation and performance, and analyse them in order to identify success factors and barriers on technical, regulatory, financial and social levels regarding the development of PEBs. It will highlight success factors as well as how challenges were mastered and which, possibly unforeseen, problems hindered the development most. This will enable to give recommendations and technical, regulatory, financial and social requirements for next generation of positive energy blocks projects

The methodology of this study is structured into four different tasks, as illustrated by the following figure:

Figure 1: Proposed methodology for the Positive Energy Blocks study

Task 1's objective is to give an overview of existing sustainable Energy Blocks by conducting an extensive desktop research of initiatives within and out of the European Union. Data collection will consist of gathering initiatives of sustainable Energy Blocks (EB) via existing internal and external databases and literature.

In Task 2, the identified sustainable EBs of Task 1 will be evaluated by introducing certain Key Performance Indicators (KPI) of different domains (technical, financial, environmental, regulatory, …). This will result in five best cases of PEBs. These five best cases will be analysed extensively through interviews in Task 3 from a technical, regulatory, financial and stakeholder management perspectives.

Finally, in Task 4, recommendations for future PEBs in Europe will be given. The study will outline success factors and open challenges based on the lessons learned of the five best cases. The study will also make a judgement as to whether the applied solutions are easily transferable to other urban environments.

[1] Urban Europe, Framework Definition for Positive Energy Districts and Neighbourhoods, Final Draft, August 2019

Task 1: Inventory of existing sustainable energy blocks

The objective of this task is to give an overview of existing sustainable Energy Blocks by conducting an extensive desktop research of initiatives within and out of the European Union

Definition of Positive Energy Block

Under Horizon 2020, European Innovation Partnership on Smart Cities and Communities (EIP-SCC) defines a Positive Energy Block (PEB) is a group of at least three connected neighbouring buildings producing on a yearly basis more primary energy than what they use.

The Strategic Energy Technology (SET) Plan adds defining aspects, or "building blocks" of Positive Energy Districts (PED)[2]:

§ "A PED is based on a high level of energy efficiency, in order to keep annual local energy consumption lower than the amount of locally produced renewable energy.

§ A PED is embedded in an urban and regional energy system, preferably driven by renewable energy, in order to provide optimized security and flexibility of supply.

§ A PED enables the use of renewable energy by offering optimized flexibility and in managing consumption and storage capacities on demand. Active management will allow for balancing and optimization, peak shaving, load shifting, demand response and reduced curtailment of RES, and district-level self-consumption of electricity and thermal energy

§ A PED couples-built environment, sustainable production and consumption, and mobility to reduce energy use and greenhouse gas emissions and to create added value and incentives for the consumer.

§ A PED makes optimal use of elements such as advanced materials, local RES and other low carbon energy sources (e.g. waste heat from industry and service sector, such as data centres), local storage, smart energy grids, demand-response, cutting edge energy management (electricity, heating and cooling), user interaction/involvement and ICT.

§ A PED should offer affordable living for the inhabitants."

According to those definitions, a set of criteria to select cases of potential Positive Energy Blocks was developed. In this task, it will not be assessed whether Energy Blocks have a positive Energy Balance, but criteria requested to obtain such balance will be examined. The criteria that are used to select existing initiatives of sustainable EBs are listed below:

1. Number of connected buildings: the block consists of group of at least three connected neighbouring buildings (new, retrofitted or a combination of both)
2. The initiative's aim to produce on a yearly basis more primary energy than it uses (i.e. positive energy balance) implies at least the following criteria:
    - Presence of low carbon (RES, CHP, etc.) energy production

[2] SET PLAN, Europe to become a global role model ion integrated, innovative solutions for the planning, deployment and replication of Positive Energy Districts, SET-Plan Action ,n°3.2 Implementation Plan, June 2018. Accessed on "https://setis.ec.europa.eu/system/files/setplan_smartcities_implementationplan.pdf

  - Presence of local storage options
  - Presence of ICT technologies such as smart energy grids and demand response for blocks to actively manage their energy consumption and the energy flow between them and the wider energy system.
  - Presence of energy efficiency measures
3. Mixed-used: these buildings must serve different purposes (housing, offices, commercial spaces...) to take advantage of complementary energy consumption curves and optimize local renewable energy production, consumption and storage.
4. Length of operation: the PEB has been minimum one year in operation. This last criterion is included to ensure that historic operational data will be available for further analysis in Task 2.

Data collection

The data collection consists of gathering initiatives via existing internal and external databases and literature. The different databases leveraged to collect initiatives are the following:

§ A Navigant, Smart City Tracker Q18, Global Smart City Project by World Region, Market Segment, Technology and Application, 2018

§ Covenant of Mayors Plans and Actions, Support, Library, Case study projects. Accessed on: https://www.eumayors.eu/support/library.html

§ C40 Cities. Accessed on: https://www.c40.org/cities

§ Finland case on Positive Energy Blocks, European Innovation Partnership on Smart Cities and Communities

§ Joint Research Centre, European Commission, Joint Smart Grid Projects List, Smart Electricity Systems and Interoperability

§ Tractebel-Ecofys-EASME, Smart Grid Lighthouse study, 2017

§ European Commission, "Analyzing the potential for wide scale roll out of integrated Smart Cities and Communities solutions", European Union, June 2016. Accessed on: https://ec.europa.eu/energy/sites/ener/files/documents/d2_final_report_v3.0_no_annex_iv.pdf

§ ZEN, Proposal to include the following Zero Emission Neighborhood report: ZEN Report No. 11 THE ZEN DEFINITION – A GUIDELINE FOR THE ZEN PILOT AREAS. Version 1.0 by SINTEF and NTNU, 2018. Accessed on: https://fmezen.no/wp-content/uploads/2019/03/ZEN-Report-no-11_The-ZEN-definition_A-guideline-for-the-ZEN-pilot-areas.pdf

§ JPI Urban Platform, Booklet of Positive Energy Districts in Europe, April 2019. Accessed on: https://jpi-urbaneurope.eu/app/uploads/2019/04/Booklet-of-PEDs_JPI-UE_v6_NO-ADD.pdf

The data collection aims at identifying, for each initiative found in the databases, the number of connected buildings involved, their (mixed) use, the presence of low carbon energy production, local storage options and ICT technologies, and the length of operation.

Identification of existing sustainable Energy Blocks

Collected data are analysed in order to assess whether the initiatives are relevant regarding the defining criteria of PEBs. An initiative is considered as a sustainable Energy Blocks (EB) and gathered in the inventory if it meets all the criteria listed in 0 Definition of Positive Energy Block.

As a result, a representative inventory of sustainable EBs worldwide is built in line with the criteria defined above. The inventory does not have the ambition to be exhaustive, but to be sufficiently accurate to ensure it provides a good overview of the state of PEB developments and it includes most innovative PEB worldwide.

In total, about 600 initiatives found in the different databases were screened. 18 initiatives met all the criteria required to be listed as a sustainable EB. Many initiatives were not selected for the following reasons: the actual operation of the project has not started yet; the initiative only implies one or two buildings; absence of storage options; or no building efficiency measures. The 18 initiatives can be found in 0 Appendix 1: Inventory of existing sustainable EBs worldwide. Task 2 consists of a more in-depth analysis to determine to which extent those sustainable EBs consist of actual Positive Energy Blocks.
Around 70 of the 600 initiatives consisted of initiatives outside the European Union. However, most of them were not selected because they were not clearly in operation and often consisted of policy initiatives. In addition to those, there were many cases of single sustainable buildings in North America, China, the Middle East or Australia. Nevertheless, some of the single buildings initiatives are hosted, as it is a more realistic reflection of mixed-uses in urban areas. For instance, the Shanghai Tower in China, in operation since 2014, hosts offices, shops, restaurants, sport centres, subway station entrance, hotels. The tower encompasses a total of 43 different sustainable technologies, including renewable energy sources, extensive landscaping to help cool the building, and a unique shape which helps improve the building’s wind resistance.

Task 2: Performance Evaluation of energy blocks

Key Performance Indicators

The objective of this task consists of defining Key Performance Indicators (KPIs) to evaluate the performance of the different sustainable EBs identified in Task 1. The KPIs are measurable values that aim to demonstrate how each identified sustainable EB performs, across three proposed dimensions: technical, financial and environmental. A fourth dimension describing the policy and regulatory context in which the Energy Block is embedded will be considered in Task 3 for the initiatives selected as best cases of PEBs.

The choice of Key Performance Indicators has been done through consultation of other initiatives and already existing internal indicator sets. Different frameworks for KPIs have been analysed and compared and from there, the indicators the most relevant to Positive Energy Blocks were selected. The main aim of this indicator list is to allow for comparability between projects. The following sources have been used:

- EU Smart Cities Information system, monitoring KPI Guide D23.1, 2018 (https://smartcities-infosystem.eu/sites/www.smartcities-infosystem.eu/files/document/scis-monitoring_kpi_guide-november_2018.pdf)
- IRIS (Integrated and Replicable Solutions for Co-creation in Sustainable Cities), Report on the list of selected KPIs for each Transition Track, 2018 (https://irissmartcities.eu/sites/default/files/documents/d1.1_report_on_the_list_of_selected_kpis_for_each_transition_track.pdf)
- Polly, B., Kutscher, C., Macumber, D., Schott, M., Pless, S., Livingood, B., & Van Geet, O. (2016). From zero energy buildings to zero energy districts. Proceedings of the 2016 American Council for an Energy Efficient Economy Summer Study on Energy Efficiency in Buildings, Pacific Grove, CA, USA, 21-26.
- Tractebel internal database

In addition, different weights are assigned to each KPIs, in order to give more importance to KPIs which are key defining elements of the definition of Positive Energy Blocks (weight of 100%), by contrast with KPIs which are necessary to achieve good scores for the former KPIs (weight of 50%) and more subsidiary KPIs (weight of 25%).

For many of the indicators, two energy vectors were considered in the evaluation, to the extent of available information: electric and thermal. Some sustainable EB consider indeed both energy vectors. In that case, the KPI is an average of the indicators of both electrical and thermal vectors. In addition, to account for the comprehensive approach of the sustainable EB considering both vectors, an additional KPI is included, that assesses the number of vectors considered.

In the following section, the KPIs that will be researched for the different sustainable energy blocks listed in Task 1 are defined, from a technical, financial and environmental perspective.

Technical key performance indicators

KPIs from a technical perspective measure the effectiveness of a given solution with respect to the operating parameters and technical constraints acting on electricity and thermal grids of the energy block and active or passive users, on block-level.

Error! Reference source not found. below provides KPIs for the technical dimension of PEB, and the related scoring. Among these KPIs, energy autonomy is the core element of PEBs and is therefore assigned the weight of 100%. Other KPIs such as energy consumption of building, energy efficiency, smart storage capacity, or existence of load control are KPIs that supports the energy autonomy objective and are therefore assigned a weight of 50%. Mobility measures consist of a KPI that is more subsidiary compared to the core definition of PEB and is therefore assigned a weight of 25%. Finally, a KPI regarding the energy vectors considered in the approach of each initiative was added. This KPI is crucial as well as it shows whether the initiative is complete in terms of energy carriers and is therefore assigned a weight of 100%.

KPI	Definition	Unit	Vector	Scoring	Weights
Energy consumption of buildings (kWh/m2/y)	Energy consumption is based on the monitored data. This typically includes building energy use for heating, cooling, ventilation, domestic hot water, de-/humidification, and lighting and may include plug loads. The energy performance of a building is expressed by a numeric indicator of primary energy use in kWh/m2/y for the purpose of both energy performance certification and compliance with minimum energy performance requirements.	kWh/m²/y	Separately for thermal and electricity if possible	0: Primary consumption>170 kWh/m2/y 1: 85<Primary Consumption<170 kWh/m2/y 2: 45<Primary Consumption<85 kWh/m2/y 3: 0<Primary Consumption<45 kWh/m2/y [3]	50%
Maximize building efficiency[4]	Different dimensions of building efficiency are considered in this qualitative KPI: - Thermal aspects and equipment (thermal capacity, insulation, passive heating, cooling elements, thermal bridges, heat pumps, etc.) - Architecture: design, positioning and orientation of the building. e.g. maximize natural daylighting, passive solar design - Natural and mechanical ventilation which may include airtightness - Optimize electric equipment e.g. build-in lighting installation	Yes/No	Separately for thermal and electricity if possible	0: none of the efficiency measures 1: implemented one of the efficiency measures 2: implemented two of the efficiency measures 3.implemented three or more of the efficiency measures	50%

[3] Based Energy Performance Certificate of Wallonia, Belgium: https://energie.wallonie.be/servlet/Repository/energie4-decembre-2017.pdf?IDR=40371. Score 3 corresponds to level A+; score 2 corresponds to level A, score 1 corresponds to level B and score 0 corresponds to levels C to G.

[4] Based upon efficiency measures developed in Polly, B., Kutscher, C., Macumber, D., Schott, M., Pless, S., Livingood, B., & Van Geet, O. (2016). From zero energy buildings to zero energy districts. Proceedings of the 2016 American Council for an Energy Efficient Economy Summer Study on Energy Efficiency in Buildings, Pacific Grove, CA, USA, 21-26.

KPI	Definition	Unit	Vector	Scoring	Weights
Energy autonomy[5]	Energy autonomy is described as the balance between energy production and energy consumption of electricity, heat and cold.	%	Separately for thermal and electricity if possible	0: <80% 1: 80-99% 2: >100% 3: hourly positive	100%
Smart storage capacity[6]	The smart storage capacity includes all the energy storage technologies integrated in the city smart grid containing electricity, heating and mobility.	Yes/No	Separately for thermal and electricity if possible	0: no storage 1: yes, but elsewhere (to avoid curtailment or maximize local production) 2. thermal or electric storage 3. thermal and electric storage	50%
Maximize Load Control[7]	Establish controls for building or energy system to accommodate the variable renewable energy supplies and support the district's interaction with the electric grid. We define Building Management system (BMS) is a computer-based control system installed in building that controls and monitors the building's mechanical and electrical equipment such as ventilation, lighting, power systems, and fire and security systems. BMS is primarily about real-time control, it is the steering control for the operating system. An energy management system (EMS) is a system of computer aided tools used by operators of electric utility grids to monitor, control and optimize the generation and/or transmission system. EMS is primarily a reporting and decision support tool.[8]	%	Electric	0: no ICT 1: EMS: monitoring/visualization without automated control (micro-level) 2: BMS: real-time steering control for the operating system (macro-level) 3: EMS and BMS	50%

[5] Based upon EU Smart Cities Information system, monitoring KPI Guide D23.1, 2018 (https://smartcities-infosystem.eu/sites/www.smartcities-infosystem.eu/files/document/scis-monitoring_kpi_guide-november_2018.pdf)
[6] Based upon IRIS (Integrated and Replicable Solutions for Co-creation in Sustainable Cities), Report on the list of selected KPIs for each Transition Track, 2018 (https://irissmartcities.eu/sites/default/files/documents/d1.1_report_on_the_list_of_selected_kpis_for_each_transition_track.pdf)
[7] Polly, B., Kutscher, C., Macumber, D., Schott, M., Pless, S., Livingood, B., & Van Geet, O. (2016). From zero energy buildings to zero energy districts. Proceedings of the 2016 American Council for an Energy Efficient Economy Summer Study on Energy Efficiency in Buildings, Pacific Grove, CA, USA, 21-26.
[8] Based upon EMS and BMS definition in https://www.qagraphics.com/understanding-the-difference-between-ems-and-bms/

KPI	Definition	Unit	Vector	Scoring	Weights
Energy vectors considered in energy block	Electricity and heating/cooling	Yes/No	-	0: none 1: electricity or heating/cooling 2: not applicable 3: electricity and heating/cooling	100%
Mobility (included in the optimization of Energy System)	Different types of mobility measures: - Cleaner fuelled vehicles for mobility with installation of public e-charging stations - Development of high capacity public transport system (e. subway system, computer rails system,) - Development of carpooling/car sharing locations - Modal split measures	Yes/No	-	0: no mobility measure 1: one mobility measure implemented 2: two mobility measures implemented 3: three of more mobility measures implemented	25%

Financial key performance indicators

The financial performance evaluation considers the business efficiency and value proposition of the initiative from the market stakeholders' perspective. KPIs such as access to financial support, from the standpoint of the developer but also the end-user during the operation, aims to account for the business efficiency of the initiative and may contribute to offer affordable living for the inhabitants. Nevertheless, giving a score on the financial mechanisms to support the developer's during the construction are ambiguous as favourable mechanisms prevent the replicability of the project on the one hand, but supported its business models on the other hand. Therefore, this KPI was given a weight of 0 and will be further analysed in Task 3. Financial mechanisms to support end user remain subsidiary in defining best cases of PEB and are therefore assigned the weight of 25%. Another KPI concerns the energy community status of a block, which is important considering the connected aspect of PEB and is therefore assigned a weight of 50%. Error! Reference source not found. below provides KPIs for the financial dimension and the related scoring.

KPI	Definition	Unit	Vector	Scoring	Weights
Energy community	A legal entity that: - is based on voluntary and open participation and is effectively controlled by members or shareholders that are natural persons, local authorities, including municipalities, or small enterprises; - has for its primary purpose to provide environmental, economic or social community benefits to its members or shareholders or to the local areas where it operates rather than to generate financial profits; and - may engage in generation, including from renewable sources, distribution, supply, consumption, aggregation, energy storage, energy efficiency services or charging services for electric vehicles or	Yes/No	All (confounded)	0: none of the three defining elements 1. One of the defining elements 2. Two of the defining elements 3. Three of the defining elements	50%

KPI	Definition	Unit	Vector	Scoring	Weights
	provide other energy services to its members or shareholders;[9]				
Access to financial support mechanisms from a developer point of view during the construction	Examples of financial support mechanisms from a developer point of view during the construction: - tax incentives - grants - tradable green certificates - subsidies	Yes/No	All (confounded)	0: no support mechanisms 1: one support mechanism 2: two support mechanisms 3. at least three support mechanisms	0%[10]
Access to financial support mechanisms for the end-user during operation of the project[11]	One dimension of value creation by the smart city project is the extent to which the project generated cost savings for end-users. Examples of access to financial supports mechanisms for the end-user during the operation of the project: - a reduction in energy use thanks to flexibility -feed-in tariffs -tax incentives -group purchase	Yes/No	All (confounded)	0: no support mechanisms 1: one support mechanism 2: two support mechanisms 3. at least three support mechanisms	25%

Table 1: Financial KPIs

Environmental key performance indicators

KPIs from the environmental perspective are important for understanding and evaluating the environmental impact of energy consumption and production, storage, smart grid distribution. Local renewable share in energy production is a core defining aspect of PEB and has therefore a weight of 100%. Reduction in annual final energy consumption is a consequence of energy efficiency and ICT measures and is assigned a weight of 50%. Finally, carbon dioxide emissions witness the sustainability of the EB. Nevertheless, given the great variety of scopes that are used in the calculation of the different EB (energy dimension only or wider, different LCA scopes, etc.), this KPIs were assigned a weight of 25% in order to not prevent a KPI that is not calculated with much transparency from weighting too much in the evaluation. Table *2* below provides the environmental KPIs and the related scoring.

[9] 14/06/2019 – Directive (EU) 2019/944, Electricity Directive, Article 2(11) – 'Citizen Energy Community

[10] While there is fewer replicability of a project if the project is financially support by various schemes, however some of the financing schemes are essential for their success. Scoring this aspect is therefore ambiguous and hence it has been given a weight of 0%. Support scheme mechanisms will be further looked at in Task 3.

[11] Based upon IRIS (Integrated and Replicable Solutions for Co-creation in Sustainable Cities), Report on the list of selected KPIs for each Transition Track, 2018 (https://irissmartcities.eu/sites/default/files/documents/d1.1_report_on_the_list_of_selected_kpis_for_each_transition_track.pdf)

KPI	Definition	Unit	Vector	Scoring	Weights
Reduction in annual final energy consumption (Y/N)	This indicator will assess the final energy consumption of the project taking into account all forms of energy (e.g. electricity, gas, heat/cold, fuels) and for all functions (transport, buildings, ICT, industry, etc.). The final energy consumption is the energy actually consumed by the end-user. The annual final energy consumption is to be compared to the situation before energy efficiency measures and ICT.	%	Separately for thermal and electricity if possible	0: no reduction 1:0-20% 2:20-40% 3:40%-100%	50%
Local renewable share in electricity, heating, cooling production (%)[12]	Share of locally produced energy from RES in total energy production	%	Separately for thermal and electricity if possible	3:75% and more 2:50-75% 1:25-50% 0%: 0-25%	100%
Carbon dioxide emissions (kg eq. CO2/m2/year)	The emitted mass of CO2 is calculated from the delivered and exported energy for each energy carrier	tonne/year/m2	Separately for thermal and electricity if possible	0. above 300,28 kgCO2/m2/year 1. 12,74<kgCO2/m2/year <300,28 2.12,74<kgCO2/m2/year) <0 3: Net zero carbon[13]	25%

Table 2: Environmental KPIs

Evaluation and selection of the different sustainable EBs

The KPIs are calculated, to the extent of information available, for each sustainable EB, and a scoring system is defined with scores from 0 to 3 to allow comparison between projects (0 if the objective is not at all covered to 3 if the objective is achieved). This scoring of the different KPIs enables the selection of the best cases of PEBs, i.e. the identified sustainable EBs which correspond the most to the definition of PEBs, with high maturity levels from a technical, financial and environmental perspective.

[12] Based upon EU Smart Cities Information system, monitoring KPI Guide D23.1, 2018 (https://smartcities-infosystem.eu/sites/www.smartcities-infosystem.eu/files/document/scis-monitoring_kpi_guide-november_2018.pdf

[13] Based on Energy Consumption KPI's scoring converted in CO2: Energy consumption criteria converted into CO2 (https://www.rensmart.com/Calculators/KWH-to-CO2)

The evaluation of each sustainable EBs can be found in 0 Appendix 2: Performance of sustainable EBs initiatives listed in Task 1. No score is given to a KPI that is unknown.

Name	City	Country	Energy autonomy (%)	Energy vectors (Y/N)	Local RES share in production (%)	Score	Ranking
Plus Energy Village	Wildpoldsried	Germany	2	3	3	1,9	1
HIKARI	Lyon	France	1	3	2	1,7	2
Isle of Eigg	Isle of Eigg	UK (Scotland)	2	3	2	1,7	3
Feldheim	Feldheim	Germany	2	3	3	1,7	4
SMILE islands, Samsø	Samsø	Denmark	1	3	3	1,6	5
Savona Campus Living Lab	Genova	Italy	0	3	1	1,6	6
Fort d'Issy	Issy-les-Moulineaux	France	0	1	2	1,6	7
Project SCENe - Trent Basin	Nottingham	UK	0	3	0	1,5	8
Isle of Muck	Isle of Muck	UK (Scotland)	2	3	-	1,4	9
Smart Grid Hyllie	Malmo	Sweden	-	3	-	1,3	10
Campus Evenstad	Evenstad	Norway	0	3	2	1,3	11
mySMARTlife	Old Town Bay, Helsinki	Finland	-	3	-	1,1	12
Nice Grid	Nice, industrial zone of Carros	France	-	3		1	13
READY Site Växjö	Växjö	Sweden	0	3	2	0,9	14
Ashton Hayes Smart Village	Ashton Hayes, Cheshire	England	0	1	0	0,9	15
Smart Grid Gotland	Gotland Island	Sweden	-	1	-	0,7	16
Smart Energy Aland	Aland Island	Finland	1	3		0,7	17
Fujisawa SST	Fujisawa	Japan	-	1	1	0,5	18

Table 4Appendix 2: Performance of sustainable EBs initiatives listed in Task 1summarizes the final performance score of each sustainable EBs and the most important KPIs' scores. It should be noted that the KPIs "Energy autonomy" and "Local renewable share" are scored differently: while the former takes the perspective of comparing production with consumption, the latter takes the perspective of energy production solely and its composition in terms of renewable generation.

The initiatives selected for deeper analysis are Wildpoldsried - a energy village in Germany with a very positive electricity balance, Samsø – an island in Denmark with high level of autonomy, Hikari – in iconic block of 3 buildings with really advanced energy efficiency measures, Fort d'Issy - an eco-district with an independent geo-thermal heat network and Trend Basin, an eco-district with collaborative self-consumption. These five case studied will be analysed in Task 3.

The initiatives not selected are listed below, with the main reason for their lower scoring:

- Feldheim, Germany: although the village of Feldheim was assigned a top score, the initiative was not considered in the five best cases given the very low density and rural aspect of the village that are not relevant with replicability in urban neighbourhood.
- Isle of Eigg, UK: Although the isle of Muck was assigned a top score, the initiative was not considered in the five best cases given disconnected aspect of this island (i.e. micro-grid) that prevents it from exporting potential energy surplus
- Savona Campus Living Lab, Italy:Savona Campus Living Lab's overall performance was quite high but showed low level of autonomy in the electric vector and small share of renewable local production.
- Isle of Muck, UK: The isle of Muck showed high performance regarding storage, load control and Energy community but its poorer performance in energy efficiency measures and renewables production lowered its evaluation.
- Smart Grid Hyllie, Sweden: Smart Grid Hyllie witnessed low performance in energy autonomy, storage and load control, which mostly explains its lower score.
- Campus Evenstad, Norway: Campus Evenstad in Norway has a low performance in terms of energy autonomy.
- My Smartlife project, Old Town Bay, Helsinky, Finland: The Smartlife project showed little information regarding main KPI such as energy autonomy and RES share, and ends up therefore with a low performance
- READY Site, Växjö, Sweden: the site of Växjö has a low performance in terms of autonomy. In addition, it does not have smart storage capacity nor ICT to maximize load control.
- Nice Grid, France: the industrial zone of Carros, France served as a demonstration to be autonomous in real-time. The demonstration managed to work as a micro-grid with no outside connection for eight hours, but autonomy on a yearly or monthly basis was not indicated. In addition, there is no information available on the share of RES in the local production.
- Ashton Hayes Smart Village, England: despite a lot of public information and the consideration of the electricity and thermal vectors, the evaluation of the performance of the village of Ashton Hayes was quite poor, mainly due to low performance in most of the KPIs
- Smart Grid Gotland, Sweden: the island of Gotland in Sweden, despite good performance in storage and load control, performs poorly due to little autonomy and the sole consideration of the electric vector.

- Smart Energy Aland, Finland: the island of Aland is Finland performs poorly due to lack of information and low performance in energy autonomy.
- Fujisawa SST, Japan: the Fujisawa city in Japan performs poorly mainly due to lack of information.

Task 3: Analysis and interviews of best positive energy blocks

The analysis of the five selected cases aimed at highlighting best practices and lessons learned regarding the implementation of PEBs. This will be examined from four perspectives: technical, regulatory, financial and stakeholders' management.
To analyse the cases, in addition to written reports, interviews were conducted for each of the five cases with people involved in the development as well as operation of the project. One interview was conducted for each of the case. A similar set of questions was used for each of the interviews, nonetheless slightly adapted to fit each of the cases. This questionnaire can be found in Appendix 3.

Introduction

Plus Energy Village in Wildpoldsried, Germany

Wildpoldsried is a small village in southern Bavaria, Germany with 2,600 inhabitants. In the 1990s, the town decided to embrace renewables by adopting the Innovative Leadership Plan, WIR-2020. Today, it produces from renewable energy several times more than the energy that is consumes and it has become a testing ground for future smart grid technologies.

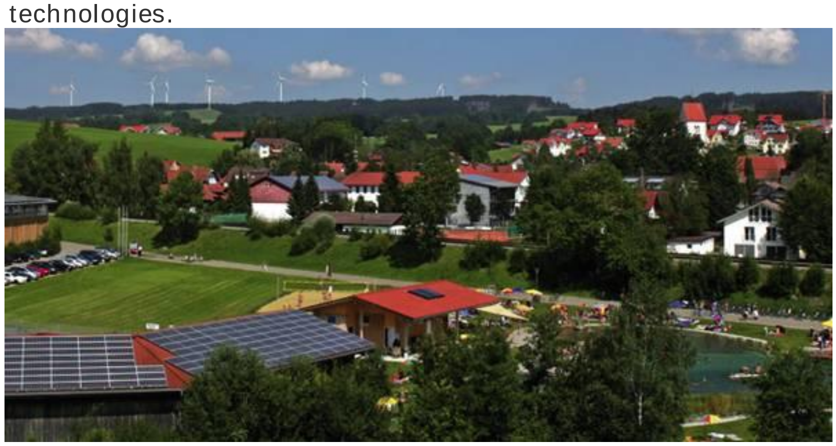

Figure 2: Wildpoldsried village in Germany[14]

Name of the initiative	Location	Project starting date	Type of territory	Number of buildings concerned	Type of building	RES
Plus Energy Village	Wildpoldsried, Germany	1999	Semi-urban	1,200 households	Residential, School, Leisure	PV, Wind, Hydro, Biomass

Table 3: Key facts on Wildpoldsried

[14] Image taken from: https://www.rechargenews.com/technology/840725/how-a-german-dairy-town-is-milking-renewable-energy

Hikari in Lyon, France

The Hikari project ("Light" in Japanese) consists of a positive-energy mixed-use sustainable block, in the new district of Lyon Confluence. The project is carried out by Bouygues Immobilier and corporation Toshiba technologies. It has become the symbol of Lyon Smart Community, a model smart grid initiated in 2011 by Greater Lyon and NEDO, the Japanese government agency which supports innovation in renewable energies and environmental and industrial technologies. The Hikari block is composed of three buildings with mixed uses such as offices, shops and dwellings. The block has been operational since 2015.

Figure 3: Hikari buildings in Lyon[15]

Name of the initiative	Location	Project starting date	Type of territory	Number of buildings concerned	Type of building	RES
Hikari	Lyon, France	September 2015	Urban	3 (12,500 m2)	Offices, shops, residential	PV, geothermal, rapeseed oil

Table 4: Key facts on Hikari

Samsø island in Denmark

The island Samsø in Denmark is located on the east coast of the Danish mainland. It presents typical characteristics of Danish municipalities regarding energy supply, but also specifics related to being an exemplary renewable energy island. Their main objective related to energy is to transfer energy from the electricity sector to the heat and transport sectors by means of conversion and storage devices.

[15] Image taken from: https://www.bouygues-immobilier-corporate.com/en/press-release/greater-lyon-inaugurates-hikari-first-positive-energy-mixed-use-development-france

Figure 4: Samsø Island[16]

Name of the initiative	Location	Project starting date	Type of territory	Number of buildings concerned	Type of building	RES
Samsø island and SMILE	Samsø, Denmark	1997	Semi-urban	<3 (3,724 inhabitants)	Residential, school, farms	PV, Wind, geothermal, biomass

Table 5: Key facts on Samsø

Fort d'Issy in France

Fort d'Issy is an eco-neighbourhood with1,620 housing units (60,000 m²) marketed by Bouygues Immobilier in Issy-les-Moulineaux, near Paris. It also hosts 2,300 m² of retail, 5,241 m² of school and a swimming pool of 2,000 m². The bioclimatic design of the buildings, the heating and hot water produced by geothermal energy and the home automation-controlled energy consumption all ensure a high level of energy efficiency for the programme.

Figure 5: Fort d'Issy17

[16] Image taken from: http://projects.mcrit.com/esponfutures/index.php/principal/31-Samsø-island-completely-powered-by-renewable-energy

[17] Image taken from: https://resilienceidf.wordpress.com/fort-dissy/

Name of the initiative	Location	Project starting date	Type of territory	Number of buildings concerned	Type of building	RES
Fort d'Issy	Issy Les Moulineaux, France	2013	Urban	1,620 homes	Housing, retail, school, swimming pool	Geothermal

Table 6: Key facts on Fort d'Issy

Trent Basin in Nottingham, UK

The Waterside along the River Trent is part of a major regeneration project in Nottingham known as Project SCENe (Sustainable Community Energy Networks). The project SCENe (Sustainable Community Energy Networks) aims to accelerate the adoption of Community Energy Systems which suggests a different way of generating and supplying locally generated heat and electricity to homes and commercial buildings. The University of Nottingham is working with Blueprint, specialists in the development of sustainable homes and workspace, on the design and delivery of a sustainable housing in the area. The project involves 41 homes in its first phase. The eco-district of Trent Basin has been operational since 2017.

Figure 6: The Trent Basin project in Nottingham [18]

Name of the initiative	Location	Project starting date	Type of territory	Number of buildings concerned	Type of building	RES
Project SCENe - Trent Basin	Nottingham, UK	2017	Urban	41	Residential, leisure	PV

Table 7: Key facts on Trent Basin

[18] Image taken from: https://www.projectscene.uk/trentbasin/

From a technical perspective

This section outlines three main technical functions required to tend towards climate neutrality and energy surplus:

§ energy production function

§ energy efficiency function

§ energy flexibility function

Regarding the energy production function, the Positive Energy Block (PEB) should rely on renewable energy only. Secondly, a PEB is based on a high level of energy efficiency, in order to keep annual local energy consumption lower than the amount of locally produced renewable energy. Finally, the flexibility function ensures that the consumers act in a way which is optimally beneficial for the energy system.[19]. To achieve this flexibility function, we distinguish flexibility at macro-level, implying real-time steering control of the operating system, and flexibility at a micro-level, which implies initiatives and technologies that encourage the consumers to optimize their energy use at the building level. The five selected cases of sustainable energy blocks will be successively described in order to assess the extent of their energy surplus, and the balance chosen between those three functions. Electricity and thermal energy carriers will both be considered.

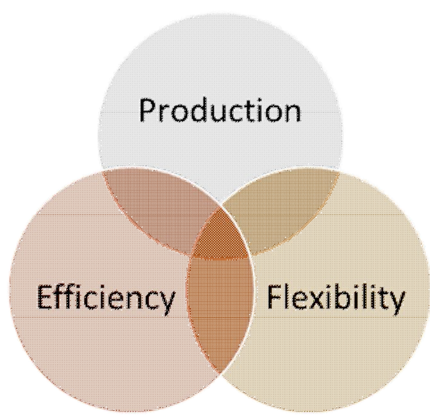

Figure 7: Technical functions of Positive Energy Blocks

[19] SET PLAN, Europe to become a global role model ion integrated, innovative solutions for the planning, deployment and replication of Positive Energy Districts, SET-Plan Action, n°3.2 Implementation Plan, June 2018. Accessed on https://setis.ec.europa.eu/system/files/setplan_smartcities_implementationplan.pdf

Wildpoldsried

Production function

Regarding the electricity vector, the village invested in 8,350 kWp of solar panels, 11 wind turbines of a total capacity over 18 MW, three hydro power plants, and biogas cogeneration units [20]. These local renewables facilities produced in 2018 612% more electricity than the village consumes[21]. A dedicated website provides detailed insights on this balance: the generation is updated every five seconds and set into relation with the estimated demand. In 2018, 46,546 MWh of electricity was regeneratively generated in the municipality, more than seven times the local consumption (6,131 MWh)[22]. However, most of the surplus is injected on the electricity grid and sold: only electricity from solar panels is "directly" self-consumed, often combined with a Sonnen battery.

Regarding the thermal vector, the village has five biogas plants, and a biomass district heating network. The biomass used for the district heating network is sourced from waste wood from local forests[23]. The majority of heat is produced by the biogas plants and the biomass. A smaller part of heat is produced via heat pumps, directly installed in and or close to buildings. These local renewables assets produce 55 and 60 percent of its heat demand. The remaining heat demand is covered by oil (the village does not have a connection to the gas grid). Today, 55 to 60% of heat demand is satisfied by local renewable production. The existing heat network of the village will be extended in the future. The target is to connect older as well as industrial buildings to supply them with renewable heat. In new built areas, with higher energy efficiency and lower heat demand, a connection to the heat network is less beneficial. Such buildings will be equipped with heat pumps instead.[24]
Overall, few issues were reported with regard to the different energy carriers and technologies. The only reported technical issues were two windmills that had to be de-commissioned due to continuous issues with faulty technology. The two windmills were then replaced with technology from another supplier.

[20] Fondation Tuck, Community Power : why, how and wat for?, June 2019. Accessed on 10 November 2019: http://www.fondation-tuck.fr/upload/docs/application/pdf/2019-08/2019.07.30_community_energy_case_studies_dv.pdf
[21] Energiewiende Team, "A small town in Germany becomes a testing ground for a smart grid", Energie transition, 13 November 2014. Accessed on 1st of November on: https://energytransition.org/2014/11/wildpoldsried-testing-ground-for-smart-grid/
[22] Fondation Tuck, *loc. cit.*
[23] Energiewiende Team, *loc. cit.*
[24] Interview

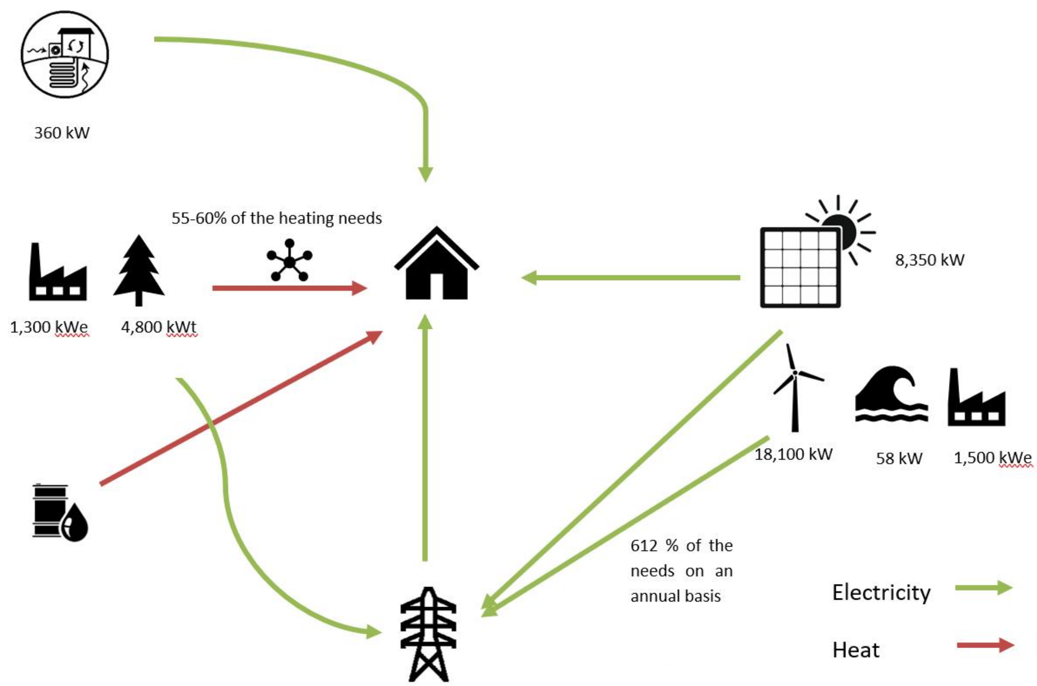

Figure 8: Energy production and consumption mapping of Wildpoldsried

Energy efficiency measures

The village of Wildpoldsried has implemented a series of energy efficiency measures. The installation of more efficient streetlighting in 2014 led to electricity savings of about 75 % related to streetlighting only. In addition, the village offers thermographic measurements for up to 40 residential or small offices buildings per year with a view to identify potential insulation measures[25]. Also, “energy consultation hours” are offered, during which the citizens are informed about energy related topics.[26]

Flexibility

As the excess of renewable electricity production started to threaten the grid stability in 2010, the distribution system operator Allgäu Überlandwerk GmbH (AÜW) selected Wildpoldsried as the site for a smart grid experiment. Meanwhile, Siemens was looking for a grid operator to test its new smart grid technologies. Siemens and AÜW cooperated and launched a $6 million project called IRENE (Integration of Regenerative Energy and Electric Mobility). The first step in IRENE was to install 200 measuring devices at renewable energy systems throughout the town. The devices measure different electrical variables such as current, voltage, and frequency, to determine which asset is feeding energy into the grid, who is consuming energy from the grid, and to find any problems affecting the network’s stability. Once any problems are identified, a variable transformer offsets voltage fluctuation. [27] In addition, the

[25] Wildpoldsried official website: https://www.wildpoldsried.de/index.shtml?thermo
[26] *Idem*
[27] Interview

town has integrated 138 kWh of battery storage into the system, which receives and discharges electricity to help stabilize the grid.

	Electricity	Thermal
Capacity of RES	Hydro: 58 kW Wind: 18,100 kW PV: 8,350 kW Biogas: 1,500 kWe	Solid biomass: 4,800 kWt Biogas: 1,300 kWt Geothermal: 360 kW
RES yearly production	37,546 MWh/year	Unknown
Yearly consumption	6,131 MWh/year	Unknown
% of needs covered on a yearly basis	612%[28]	55-60%[29]
Self-consumption	For the individual PV	Yes
Storage	Battery storage: 138 kWh	None
Energy efficiency (kWh/m²/y)	Unknown	Unknown

Table 8: Summary of technical figures for Wildpoldsried[30]

Hikari

Production and storage assets

The objective of the Hikari project was that the production of renewable electricity and thermal energy covers all, or more than, the buildings energy consumption, calculated in terms of primary energy. To do so, solar panels have been integrated into the roof (168 kW) and in front of the dwelling (21kW). In addition, a cogeneration plant based on vegetable oil providing electricity and heat has been installed.

However, in the first two years of operation, there have been issues with the cogeneration plant, which produced at only a third of its optimized capacity. During this period, Hikari imported electricity from the distribution network to meet its electricity demand. Today, the cogeneration plant issues have been resolved to achieve the positive level of electricity energy, but the consumption and production monitoring campaign is no longer in operation and therefore no number can confirm it.

Regarding the thermal vector, there is a distribution infrastructure of heating and cooling common to the three buildings[31]. Heat demand was meant to be fully satisfied by the cogeneration plant, with a large back-up gas boiler that could be activated only during peak periods. In the first two years however, to compensate for the malfunctions of the cogeneration plant that was operational at 30% of its capacity (300 MWh), gas boilers produced a volume of 700 MWh, i.e. 60% of the heat demand.

Cooling demand is satisfied thanks to an absorption machine that produces chilled water, from the heat of cogeneration and from geothermal energy. Geothermal energy draws freshness from the waters of the Saône and contributes to the cooling storage and pooling of the energy produced to cover the needs of the various buildings. A low temperature heat storage system that exploits the Phase Change Material ability to absorb and release a large amount of thermal energy during its phase transition is used for improving the performance of the absorption chiller. It covers 100% of the cooling needs of offices and shops (homes do not have a cooling demand)[32].

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28 Own calculation based on yearly production and consumption

29 Interview

30 Based on number of 2018. Accessed on: https://www.wildpoldsried.de/se_data/_filebank/alte_pdfbank/res.pdf

31 While the surface exhibits three separate buildings, the buildings are actually on the same foundation block, therefore, it cannot be compared to a district thermal network.

32 Interview

As a direct consequence of the experience with the cogeneration plant, the urban planner of Lyon Confluence expressed its wish to stop asking the developers to manage their need for heat in a decentralized system, such as cogeneration units, and put in place a district heat network in the public domain. The district heating is connected to a wood-gas fired cogeneration plant. Therefore, all the buildings built in Lyon Confluence after Hikari were offered a renewable energy network solution so that they do not have to install complex systems such as cogeneration units fed by rapeseed oil.

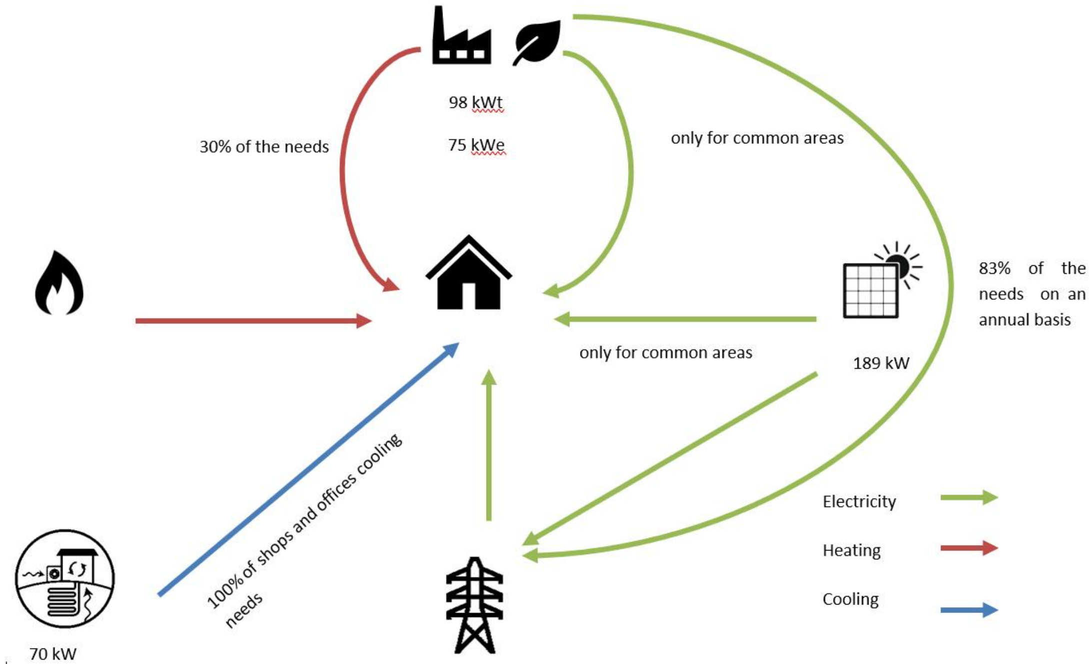

Figure 9: Energy production and consumption mapping of Hikari

Energy efficiency measures

The energy and environmental performances of Hikari come from a bioclimatic architecture design and a systematic search for very low energy consumption. The buildings of HIKARI have been given the label of BEPOS Effinergie.[33] In light of thermal aspects, buildings are equipped with regulating heating and air conditioning and smart opening and closing of windows. Strategic orientation has also been chosen to minimize energy consumption. The three buildings all use mechanical air extract systems .In addition, one of the three buildings has a specific design to increase natural ventilation during the night. This is enabled by fresh air inlets located on the corners of the buildings, as well as two chimneys in the middle of the floor to generate airflow to extract the heated air[34]. Hikari buildings are also equipped with LED lighting and motion sensors and controls for electric appliances. Overall, in terms of energy

[33] For more information on the BEPOS Effinergie 2017, please refer to https://www.effinergie.org/web/les-labels-effinergie/le-label-bepos-bepos-effinergie-2017

[34] NEXT-Buildings, D. 5.1. Report on the P Plot overall construction process, ENER/FP7/284533/NEXT-BUILDINGS, September 2015.

efficiency, the Hikari project was a real success and the requirements made in the context of this project are now replicated to many other project.[35]

Flexibility

Storage battery with a capacity of 100 kWh had been deployed on the site, for demonstration purposes. This battery storage system could be used to respond to power outages or consumption peaks. The operation was however terminated rather quickly, as batteries have a fairly low efficiency (to release 100 kWh, it is necessary to store 120 kWh, due to the roundtrip efficiency of a battery) that had degraded the level of performance of the building.

The consumption and energy production of the three buildings is shared through an energy communication network. The energy and assembly management is controlled and managed by a BEMS (Building Energy Management System), which collects and disseminates energy data.

In addition, all production and consumption of the block are also monitored, and dwellings have been equipped with home automation (HEMS) allowing the visualization of consumptions and the control of electrical appliances. This HEMS system for residents includes functions such as condition checking, remote control, automatic control and schedule. There is no return on experience on the use of these flexibility installations.

Finally, the buildings of Hikari are mixed-used buildings. Therefore, it gives the possibility to pool the energy consumptions between offices occupied during the day, and homes occupied during evenings and weekend. As a result, the system could be undersized.

[35] Interview

Indicators	Electricity	Thermal
Capacity of RES	PV roof: 168 kW PV façade: 21 kWp Cogeneration system: 75 kWe	Cogeneration system: 98 kWt Absorption chiller: 70 kW
RES yearly production	343 MWh	317 MWh
Yearly final consumption	410 MWh[36]	Unknown
% of needs covered on an annual basis	83%[37]	Approx. 30%[38]
Self-consumption	For common areas of the building	Yes
Storage	Battery storage: 100 kWh => no longer in use	Heat storage: 65 m³ if water Cold storage: 20 m³ of phase change material
Energy efficiency (kWh/m²/y)	Unknown	Housing: 30.9 kWh/m2/y heat and 21.8 kWh/m2/y direct hot water Office: 30.9 kWh/m2/year

Table 9: Summary of technical figures for Hikari[39]

Samsø

Production and storage assets

Regarding electricity production, Samsø has 10 wind turbines onshore (10 x 1 MW) and 11 wind turbines offshore (11 x 2.3 MW). On a yearly average, the. The surplus flows to the mainland, but it helps to compensate for the fossil fuel consumed on the island.[40]An electric cable is connected to the mainland and electricity is sent in both directions depending on the weather: if there is no wind electricity is imported to the island and if there is wind, the island exports electricity to the mainland.

There is also local solar PV, which accounts for about 1% of electricity production. Overall, considering on-shore and off-shore wind turbines in the balance, Samsø island has achieved to become 100% self-sufficient with local renewable energy sources.

There is a battery system that has been installed in Ballen Marina. The battery arrived in December 2018 and was supplied by the project partner Lithium Balance. Its objective is to ensure stable power supply based in sustainable energy. The battery has a capacity of 240 kWh, the inverter 50 kW. [41]

As for heating, the island counts four straw-fired (biomass) district heating systems (Nordby Maarup District Heating Plant, Ballen-Brundby District Heating Plant, Onsbjerg District heating Plant). Some people's houses are not connected to any of the four district heating networks, because the distance is too long and investing in a connection between these houses and the networks would be very expensive due to losses on the network to transport on higher distance. Therefore, some houses and

[36] 1315 MWh primary energy divided by a factor or 3.2

[37] Own calculation

[38] Interview

[39] Based on results of monitoring year 2 (August 2016 – July 2017). NEXT-Buildings, D. 6.4, Report on energy results in all buildings and plant P Plot, ENER/FP7/284533/NEXT-BUILDINGS, September 2017.

[40] SMILE, Deliverable D3.1. Specifications and Data Report for the Samsø Demonstrator, 2017. Available on : http://www.h2020smile.eu/wp-content/uploads/2018/06/Deliverable-D3.1.pdf

[41] Trine Larsen, Ballen Marina tests intelligent power grid, Sustainable energy in Marinas, March 2019. Accessed on 20th of October: https://www.h2020smile.eu/wp-content/uploads/2019/05/Larsen2019.pdf

public buildings have invested in individual renewable energy heating systems (heat pumps, wood stoves and solar hot water collectors).

In addition, to cover heating energy demands, excess electric power from the local solar panels and wind turbines feeds heat pumps whose heat can be used or stored in the district heating system storage facilities. In this way, some of the energy covered from the straw-fired power plants can be replaced by power generated by RES and the biomass can be used for other purposes in the future for instance making biogas for the ferry to the island[42]. The district heating plans using biomass account for 69% of the energy needs and solar heating shares accounts for 2%[43]. The rest of the heating demand is supplied by individual heat pumps or wood stoves.

Overall, Samsø Island has achieved to become more than 100% self-sufficient on a yearly basis, and 96% on an instantaneous basis, with local renewable energy sources for electricity, and above 70 % self-sufficient with renewable energy sources for heat[44].

Samsø strategy was primarily to use well-tested technology to avoid technical issues. Nevertheless, one of the offshore wind turbines broke and fell in the sea. A taller wind turbine was built instead, with the goal to produce more to compensate for the losses. The owners had to make a permit application to the authorities due to height constraints. In addition, the wind turbines are getting old (15 years) and there is uncertainty about their lifetime and about the maintenance costs to repair them at that point of their lifetime.

The return on experience has shown that today's challenge is not to be energy positive, but it consists of getting rid of all fossil fuels by 2030. While having a renewable energy source covering 100% of the energy needs is a condition for getting rid of fossil fuels, having a positive energy balance is not necessary. A previous project that ended in 2017 on the island aimed at a positive energy balance. As of today, Samsø new goal consists of having a zero-carbon island. An element where a positive balance of electricity could nevertheless be interesting is to use the extra electricity for heating and electric cars.

"Our new goal is to get rid of the fossil fuels. It does not matter anymore whether you produce more electricity than we need."
Samsø interview

Energy efficiency

Aside the heat pumps providing a good efficiency[45], no efficiency measures were taken for the buildings of the island. The island of Samsø aims at maximizing production but not to save energy.

[42] SMILE, Deliverable D3.1. Specifications and Data Report for the Samsø Demonstrator, 2017. Available on : http://www.h2020smile.eu/wp-content/uploads/2018/06/Deliverable-D3.1.pdf

[43] https://www.mdpi.com/1996-1073/12/18/3484/htm

[44] Interview

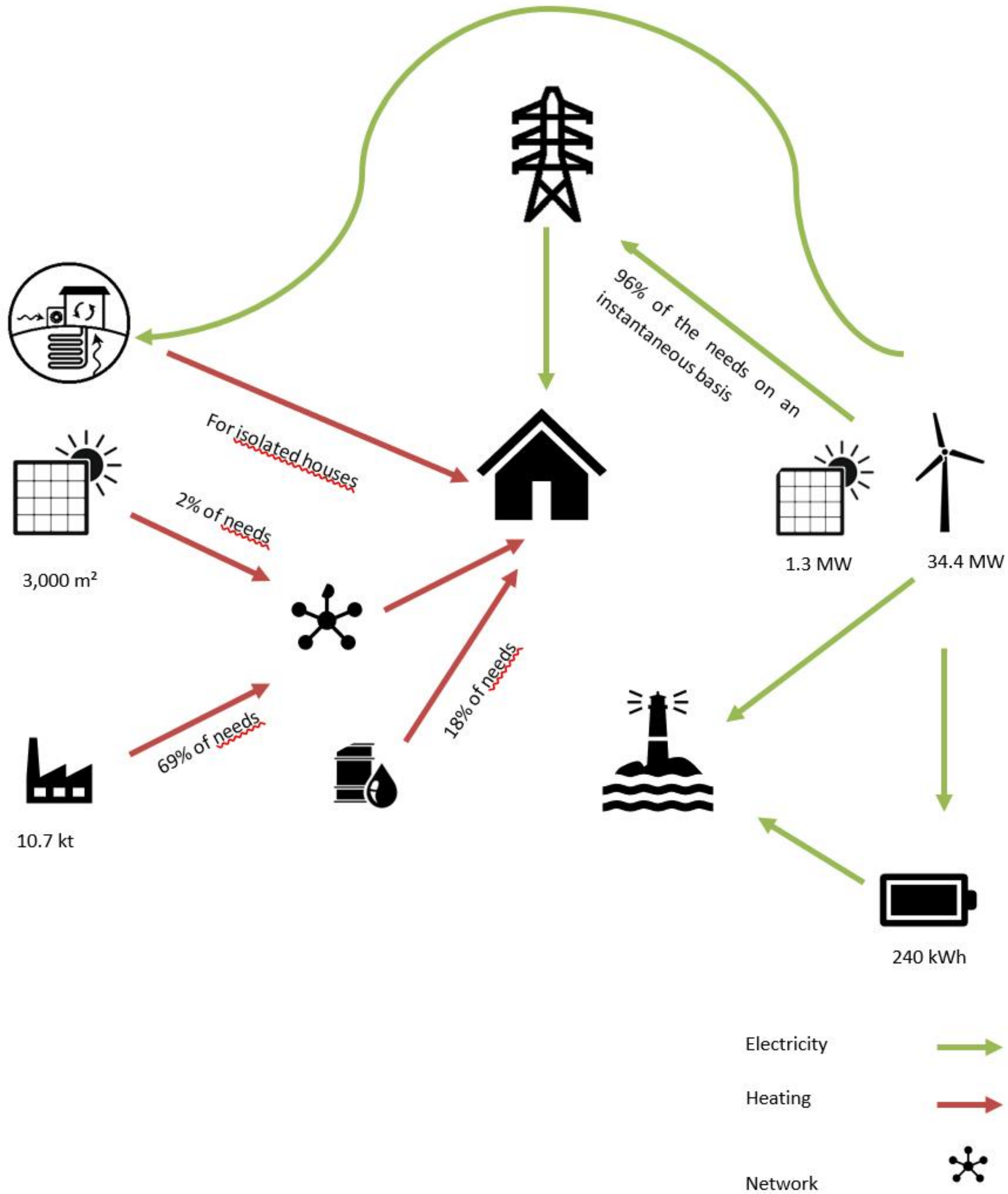

Figure 10: Energy production and consumption mapping of Samsø island

Energy efficiency

Aside the heat pumps providing a good efficiency[46], no efficiency measures were taken for the buildings of the island. The island of Samsø aims at maximizing production but not to save energy.

Flexibility

The Ballan marina smart grid pilot aims to monitor load on the grid, which in turn enables the harbour to manage current distribution. This is done by turning on and off for instance the sauna, the sanitary pump, the circulating pump in the service building etc.

Indicators	Electricity	Thermal
Capacity of RES	Wind: 34.4 MW Individual PV: 1.3 MW	Biomass plant: > 10.7 kt Solar thermal: app. 3,000 m² (Individual heat pumps)
RES yearly production	Wind: 108.4 GWh/year PV: 3.14 GWh/year	Solar thermal: 1.36 GWh
Biomass input	-	52.1 GWh
Yearly consumption	25.5 GWh	46.3 GWh 71% needs covered from RES production
% of needs covered on an annual basis	437%[47]	
% of needs covered on an instantaneous basis	96% of the needs[48]	
Self-consumption	No except individual PV	Yes
Storage (kWh)	Battery storage in Ballen marina pilot: 240 kWh	No
Energy efficiency (kWh/m²/y)	Unknown	Unknown

Table 10: Summary of technical figures for Samsø[49]

Fort d'Issy

Production and storage assets

The electric vector will not be considered when examining the eco-district of Fort d'Issy. The electric vector is limited to a few solar panels of the roof of one school of the eco-district which self-consumes its production. At the development stage of the project, prioritization choices were oriented towards the geothermal system, water management and roofing of green terrace, at the expense of electricity production or flexibility. Today, it is still not in the scope of the eco-district to increase the electricity autonomy.

Regarding the thermal vector, Fort d'Issy is equipped with a geothermal network starting at 700 meters under the land. The water is captured there at 28 degrees, and an exchanger allows to reinject the water into a second storage at 15 degrees. The network connects with the buildings, each equipped with a water heat pump. This system ensures the production of heating and domestic hot water. As a result, the production of heat in renewable energy accounts for 78%: all heating supply is provided by the geothermal system, but the electric water heat pumps are fed by electricity from the grid which is not 100% renewable.

[47] Own calculation based on yearly production and consumption

[48] Own calculation based on production, consumption and export of electricity

[49] SMILE, D. 8.1. Reference energy simulation models for the three pilot islands, European Commission, January 2018. Accessed on: https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5b82ea2ac&appId=PPGMS

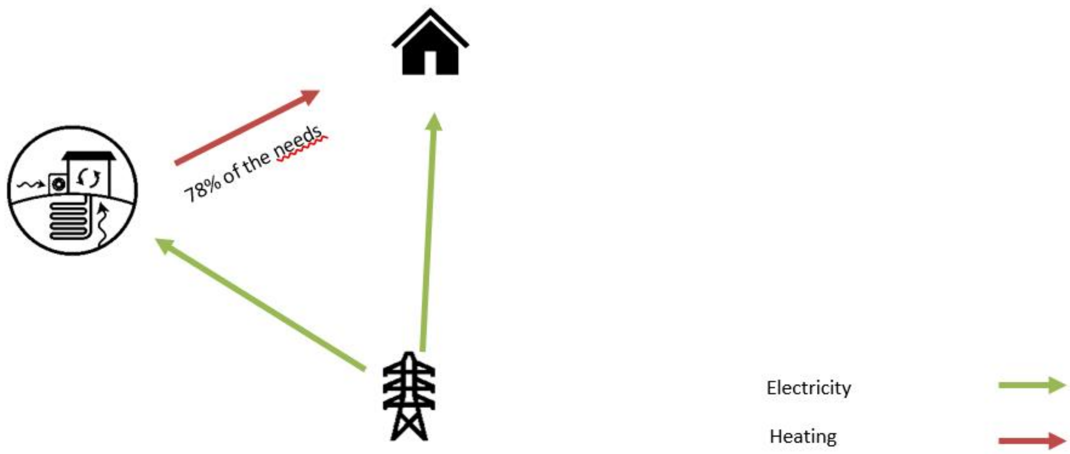

Figure 11: Energy production and consumption mapping of Fort d'Issy

Energy efficiency measures

The construction of the buildings of Fort d'Issy comprised optimization of the orientation of the buildings to maximize the contribution of the sun, as well as protection for the users from being too exposed to the sun. In addition, an insulation system from the outside has been implemented. At the time of delivery in 2013, the eco-district was labelled BBC-Effinergie, therefore several years ahead on the RT 2012 regulation[50].

Flexibility

All the homes in Fort d'Issy are equipped with a home automation system that allows to follow and control several elements of the home (blinds, heaters). Each housing has a touch screen with a light management system, shutter, heating, possibility of programming scenarios (e.g. closes everyday shutters at 20h). Since the beginning, the eco-district benefitted from optical fibre, enabling remote control, which was something very innovative in 2013.

In addition, Issy Grid is a smart grid that has been put in place by the city Issy-les-Moulineaux., initially on a district called Val de Seine. Afterwards, the idea of spreading the project to other districts, including Fort d'Issy, merged. It consisted of installing Linky meters for each home. This installation of meters however did not result in any significant changes in the behaviour of the inhabitants. Indeed, the inhabitants already had a sensitivity and control of their own consumption.[51]

[50] Interview

[51] *Idem*

Indicators	Thermal
Capacity of RES	n.a.
RES yearly production	Unknown
Yearly consumption	Unknown
% of needs covered (on an instantaneous basis)	78%
Self-consumption	Yes
Storage (kWh)	Unknown
Energy efficiency (kWh/m²/y)	65 kWh/m2/an

Table 11: Summary of technical figures for Fort d'Issy

Trent Basin

Production and storage assets

With respect to the electric vector, the eco-district of Trent Basin is equipped with solar panels on its homes' roofs and a solar panels farm installed on the empty land of old warehouses. The inhabitants are connected to the grid and have choice of energy providers. In addition, through a community energy service company managing the assets, the inhabitants get about 25% of the energy they consume from the local production, and the rest of it either is injected in the grid or goes into the community battery. The battery will either export electricity to the grid or import from the grid-when it is cheaper at night. Through this process, green energy is imported, because in the UK there is more green energy available at night. The community battery is a large battery of 2.1 MWh, from Tesla, that has been installed in the context of the project. Its integration in the system at the early stage of development represents a significant step forward in the use of renewable energy in housing projects across the UK.

> *"Depending on the price of electricity, the energy mix and the regulation, 25% of autonomy now may not be the optimal share tomorrow."*
> Interview Trent Basin

The particularity of Trent Basin's electricity system compared to the previous cases is that the production of electricity is physically collectively self-consumed: 25% of the directly produced renewable energy comes to their homes or through the community battery to their homes. This self-consumption percentage (25 %) is currently the business optimal solution. The percentage of needs covered by the local solar panels on a yearly basis is nevertheless positive. The annual production from solar panel accounts for 416 MWh per year and the annual consumption amounts to 158 MWh per year [52], leading to local production accounting for 333% of consumption on a yearly basis.

Regarding the thermal vector, currently in 2019 the local renewable thermal generation has not been implemented yet. Gas condensing boilers constitute the thermal assets in every home. The ambition to have thermal generation depends on the outcome of several applications for grant funding for an experimental heating system. In the future, a school of 250 children will be built, and will host the heating energy centre: a ground-source heat pump would feed a thermal storage, which would feed the school and the adjacent homes via a low temperature heat network. In the later phase of the project, thermal demand is planned to be fully covered by this system.

[52] Fondation Tuck, Community Power : why, how and wat for?, June 2019. Accessed on 10 November 2019: http://www.fondation-tuck.fr/upload/docs/application/pdf/2019-08/2019.07.30_community_energy_case_studies_dv.pdf

In addition, there is ambition to link thermal storage and electrical storage to optimize the system and balance out the needs with the local grid: if there is an excess of electricity, it will be used to charge the thermal storage linked to the heat pump system so that when the homeowners come back in the evening, they will be able this stored heat. This integration between thermal and electricity would enable to resolve the issue of capacity on the local grid by having thermal and battery energy storage on site.

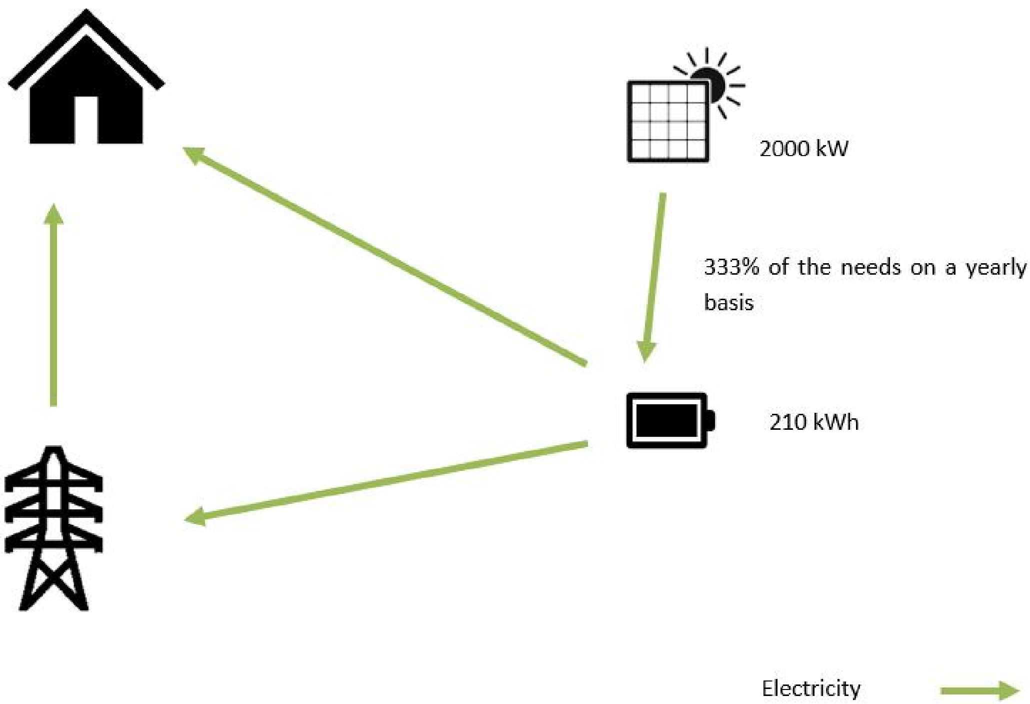

Figure 12: Energy production and consumption mapping of Trent Basin

Energy efficiency measures

Each home is designed to meet the 2016 Fabric Energy Efficiency Standard (FEES) for space heating of 39 kWh/m2/y for apartments and mid terraces and 46 kWh/m2/y for end terraces. To do so, each building is equipped with a mix of double and triple glazed windows combined with high levels of insulation. Efforts were also made regarding mechanical ventilation systems. Regarding electrical aspects, low energy lighting is employed for each building and all electric appliances should be classified with an energy efficiency of class A.

There is overall an intention to make Trent Basin energy positive. However, to achieve this goal, it is considered that there is no need to have further generation on-site because the production is enough thanks to the storage possibility. The priority would be to invest more in buildings' efficiency[53]. In the first phases of the project, there was a limitation in how much the developer would invest in the buildings' fabrics, because it is not the direct beneficiary from energy savings. In the next phase, the project is looking for funding to look at prototypes where the homes are at the highest possible targets. The developers agree to take energy efficiency measures a step further,

[53] Interview

examining first two prototypes, and committing to replicate that right solution to the rest of the site.

Flexibility

In addition to the traditional in-house energy meters, the eco-district is equipped with the Trent Basin-Community Information Model (TB-CIM), which is an interactive online platform that displays historical and real-time energy data. The main goal of this visualization tool is to engage the community residents and inform them of the block's energy generation, consumption and storage. Furthermore, this is complemented by a voice activating service (Alexa by Amazon). The presence of ICT technologies at Trend Basin focuses here rather on the micro-level, collecting and analysing data that can useful for the residents.

Indicators	Electricity
Capacity of RES	2 MW
RES yearly production	416 MWh
Yearly consumption	125 MWh
% of needs covered on a yearly basis	333%[54]
Self-consumption	Yes. 25%
Storage	2.1 MWh
Energy efficiency	39 kWh/m2/y

Table 12: Summary of technical figures for Trent Basin[55]

Conclusion

The table below summarizes the yearly energy (electricity and heat) balance for each case as well as the main barriers for not achieving higher level of autonomy/positivity. Three main reasons appeared as reasons for not achieving higher level of autonomy:

§ The maximum capacity production has been reached;

§ The business model does not incentivize for physically consuming more energy

§ Despite high level achieved of autonomy, the goal of the project does not consist of primarily being energy positive.

The cases selected presented thus very different levels of energy balance. The figure below shows that Wildpoldsried, Samsø and Trent Basin have the highest balance of electricity on a yearly basis. Regarding the thermal vector, Fort d'Issy and Samsø have shown the highest levels of autonomy. While the case of Hikari most probably has attained a higher energy balance regarding heat, the current absence of measuring system does not allow to properly quantify it. Hence the balance indicated here is based on the year 2016 where the cogeneration plant was not properly functioning. While the degree of positive energy was calculated in a similar manner for all the projects, the projects had different definitions of being energy positive. Some project emphasized the export aspect, other highlighted the percentage of self-consumption while others focussed on indicators on a yearly basis.

Finally, the willingness to integrate both vectors, being electricity and heating, is also underlined in the table. Samsø and Trent Basin show the ambition of an integrated energy system using solar or wind energy with thermal geothermal energy generation.

[54] Own calculation: yearly production/yearly consumption

[55] Fondation Tuck, Community Power : why, how and wat for?, June 2019. Accessed on 10 November 2019: http://www.fondation-tuck.fr/upload/docs/application/pdf/2019-08/2019.07.30_community_energy_case_studies_dv.pdf

	% electricity needs on a yearly basis	% electricity needs on an instantaneous basis	% thermal needs (instantaneous)	Interpretation of PEB	Main barrier towards higher balance	Integrated multi-fluid approach
Wildpoldsried	612%	-	55-60%	Balance of yearly production and yearly consumption	Max. capacity achieved	No
Hikari	83%	-	At least 30%	The yearly primary energy consumption must be smaller than the yearly primary energy produced on-site	Max. capacity achieved	No
Samsø	437%	96%	71%	Energy exported	Not the primary objective	Yes
Fort d'Issy	n.a.	n.a.	78%	Share of heating needs covered by renewable thermal and electricity energy	Not in the scope	No
Trent Basin	333%	25% self-consumption	n.a.	Self-consumption	Business model	In the future

Table 13: Summary of energy balance of the five selected cases

In conclusion, this section has shown that the production, efficiency and flexibility functions did not have the same importance in the different projects. The PEB should indeed be able to optimize the different function to find a balance between the three, according to their resources available. The figure below shows different optimization for each case. None of the projects have focused strongly on the all three functions, but usually chosen on or two. The eco-district of Fort d'Issy shows an equilibrium between the three functions, while the island of Samsø and Wildpoldsried (on the same green triangle) focuses primarily on the production function, at the expense of the efficiency and flexibility functions. While undermining the efficiency function does not seem to be an obstacle for Samsø and Wildpoldsried high energy balance, this function is nevertheless underlined in the interview of Trent Basin as a major enabler to reach higher level of positivity in real-time. The only case that showed collective self-consumption in real-time of electricity has put the strongest focus on flexibility, using a large battery system.

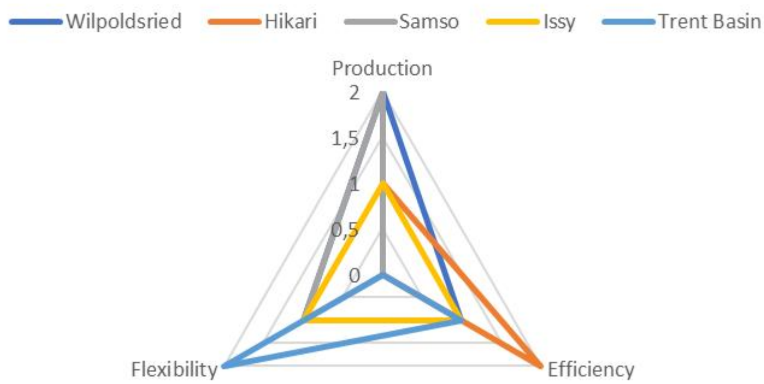

Figure 13 : The difference in focus of production, efficiency and flexibility functions for the different sites

From a regulatory perspective

Local energy community

Positive Energy Blocks cannot be considered without the concept of self-consumption, at individual and community level. This section aims to exemplify the different business models of energy communities that can exist within the current regularity frameworks. While individual self-consumption is possible in most Member States (MS), collective self-consumption is an emerging concept. Some European member states have already put forward legal frameworks for collective self-consumption or are in the process of developing new ones.

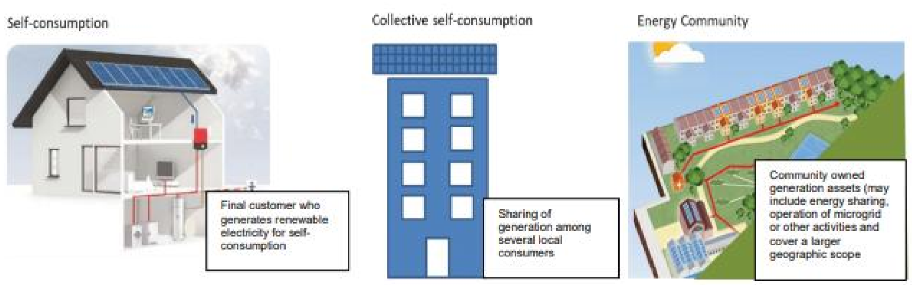

Figure 14: Diagram showing self-consumption, collective self-consumption and energy community[56]

[56] CEER, Regulatory Aspects of Self-Consumption and Energy Communities, 25 June 20019. Available on : https://www.ceer.eu/documents/104400/-/-/8ee38e61-a802-bd6f-db27-4fb61aa6eb6a

On the EU level, the energy community concept is defined in the Renewable Energy Directive (REDII)[57] and the Internal Electricity Market Directive (IEMD)[58]. Renewable energy communities are entitled to:

§ produce, consume, store and sell renewable energy, including through renewables power purchase agreements

§ share, within the renewable energy community, renewable energy that is produced in own units

§ access all suitable energy markets directly or through aggregation.

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. But there are also energy communities providing more complex solutions to its members, such as self-consumption combined with storage, p2p-trade, balancing, where management of the distributed energy resources and in some cases even of the distribution grid and trading, becomes increasingly important. In a study for the European Commission in the Asset framework[59] on local energy communities, four archetypes of European energy communities were developed, with different business models: cooperative investment, energy platform, aggregator and micro-grid. Even if energy communities may pursue non-profit goals, they still need to achieve a successful business models for their shareholders

	Cooperative investment	Energy sharing	Aggregator	Microgrid
RES producer	X			
Retailer		X		
Balancing Service Provider			X	
Distribution System Operator				X

Table 14: Required market roles for each identified energy community archetype[59]

[57] Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (Text with EEA relevance.) 767 final/2, https://ec.europa.eu/energy/sites/ener/files/documents/1_en_act_part1_v7_1.pdf

58 Proposal for a Directive of the European Parliament and of the Council on common rules for the internal market in electricity (recast) - Analysis of the, COM(2016) 864 final compromise text with a view to agreement, 2016/0380(COD), Council of the European Union, 11.01.2019/2, https://eur-lex.europa.eu/resource.html?uri=cellar:c7e47f46-faa4-11e6-8a35-01aa75ed71a1.0014.02/DOC_1&format=PDF

[59] Energy Communities in the European Union, Frédéric Tounquet, 2019. Can be accessed on: https://asset-ec.eu/wp-content/uploads/2019/07/ASSET-Energy-Comminities-Revised-final-report.pdf

Cooperative investment

In a cooperative investment, community members fulfil the role of renewable energy investors. By paying a fixed membership fee or a variable stake, consumers become effective members of a community that act as an energy producer. We will consider in this report the model of cooperative investment in its stricter sense of "community owned generation assets". This is currently the most common type of energy community. The members of such communities usually do not self-consume the energy produced but sell it to a supplier. The income is typically shared with members and/or reinvested in energy projects[60].

Wildpoldsried

In Germany, there is a widespread public support for community ownership of renewable energy generation, approximately half of the RE capacity is installed under some form of community ownership.

The case of Wildpoldsried illustrates a well-established case of community owned generation assets. Overall, 50 million euros were invested in generation assets, and approximately 48 million euros were financed by the citizens of Wildpoldsried (via individual equity and debt), while the remaining two million euros were financed by the public authority. 900 out of 2567 inhabitants are investors in at least one renewable energy asset. While electricity produced from individual solar panels (about 250 households are equipped with renewable electricity assets, often combined with a battery storage from Sonnen) is mostly self-consumed with only a small proportion fed to the grid, electricity produced by community wind turbines is fully fed to the grid and remunerated via feed-in tariffs[61]. In this business model, there is no collective self-consumption from community owned generation assets[62].

The interview on the case Wildpoldsried has indeed underlined existing regulatory barriers with sharing of produced electricity. In reaction to this, the project titled "Pebbles" targeting "Peer to Peer Energy Trading based on Blockchain Infrastructure" has started in March 2018. The project aims to "design and develop an integrative platform-based model for cooperation between technology providers, platform providers, platform users and distribution system operators." As a result, a community that can trade electricity corresponding to the individual needs of all participants shall be created.

Samsø

The case of the Samsø island also illustrates the cooperative investment business model. In Denmark, public participation is central to the wind power development scheme as local citizens have the option of purchasing wind power shares.[63] Consequently, community energy generation in Denmark now occurs predominantly in

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[60] CEER, Regulatory Aspects of Self-Consumption and Energy Communities, 25 June 20019. Available on : https://www.ceer.eu/documents/104400/-/-/8ee38e61-a802-bd6f-db27-4fb61aa6eb6a

[61] Fondation Tuck, Community Power : why, how and wat for?, June 2019. Accessed on 10 November 2019: http://www.fondation-tuck.fr/upload/docs/application/pdf/2019-08/2019.07.30_community_energy_case_studies_dv.pdf

[62] Interview

[63] According to the 2009 Promotion of Renewable Energy Sources Act 'any person who erects one or more wind turbines of at least 25m in height onshore, or offshore wind turbines established without a tendering procedure [...], shall, prior to commencement of erection, offer for sale at least 20 per cent of the ownership shares to the persons [...]' living within a 4.5 km radius of the turbine

partnership with energy utilities (co-owned community energy projects) rather than in fully private owned projects. This legislation has allowed communities to collectively invest in wind energy since the 1970s.[64] As a result, in Samsø, 9 of the 11 onshore wind turbines were bought by farmers, and the remaining two bought by more than 500 people who live on the island or have summer homes there. Each 1 megawatt wind turbine powers approximately 630 homes.[65]

In Samsø, the electricity produced via community-owned wind turbine is sold immediately to the grid, with no self-consumption. Regarding the heating network of the island, one district plant is also owned by consumers. Conversely to electricity, the heat is sold to the same consumers[66]. Currently, 300 consumers are part of this cooperative[67].

Fort d'Issy and Hikari

In some cases, it is not possible to have community owned generation assets. For instance, in the case of Fort d'Issy, the heating system and domestic hot water was carried upstream of the realization of the district. No inhabitants were present at the time when the technical choices of the geothermal system were made and implemented. It was physically not possible. Similarly, in the case of Hikari, the generations assets were already installed during the construction of the block, and users bought the homes/offices with those already installed generation assets. These systems are therefore owned by their operator.

Trent Basin

Regarding Trent Basin, one of the biggest issues in the project was the legal framework required to install solar panels on roofs which were common to the building and not individually owned by the owner of each apartment. In the apartments built in the first of the project, there was a connection ready for solar panels on the common roof, but the inhabitants had to form a community to rent the roof and install solar panels. In the second phase of the project, the solar panels were considered as a standard and installed beforehand. Today, the solar panel assets are leased to the owners of the house.

> *"The inhabitants [of the apartments of Trent Basin] had to form a community to rent the common roof and install PV panels."* Trent Basin interview

Energy sharing

Some energy communities do not only own and operate generation assets, but also share the energy produced among their members. This type of sharing can be

[64] Fondation Tuck, Community Power : why, how and wat for?, June 2019. Accessed on 10 November 2019: http://www.fondation-tuck.fr/upload/docs/application/pdf/2019-08/2019.07.30_community_energy_case_studies_dv.pdf

[65]EcoWatch, Samsø: World's first 100% Renewable Energy-Powered Island in a Beacon for Sustainable Communities. Accessed on: https://www.ecowatch.com/Samsø-worlds-first-100-renewable-energy-powered-island-is-a-beacon-for-1881905310.html

[66] If a consumer wishes to withdraw from the Ballen-Brundby district heating contract, the consumer must pay a significant exit fee.

[67] Interview

organised through a common supplier, who takes care of the matching between production and consumption and supplies additional energy if needed.

Trent Basin

The Trent Basin cases illustrates well the business model of energy sharing. In the UK, a household cannot sell its produced electricity to a neighbour and is obliged to serve the grid. To enable collective self-consumption, the Trent Basin project set an energy service company (ESCO) that offers energy-related services to end users[68]. Through this ESCO, the homes of Trent Basin consume physically 25% of the energy produced by the local renewable assets, and the rest of it goes into the community battery. Because the energy mix, and hence the price of electricity at different times, is changing all the time in the UK, the optimal solution might change in the future. There might be in the future less advantage to import energy and more value to consume it on-site. This operation requires officially a licenced supplier, which is very expensive. Trent Basin applied for an exemption. On the thermal side, supplying heat does not require any licensed supplier, and energy sharing is therefore easier to implement.

> *"On the thermal side, no regulatory issues. It is very straightforward because at the moment supplying heat to the buildings is unregulated. We can do that as an ESCO . We are able to supply heat to the buildings we are serving. You do not need a supply license to supply heat whereas you do with electricity. It is a lot simpler."* Trent Basin interview

Samsø

In Samsø island, all the produced electricity is sold immediately to the grid, with hence no energy sharing. The case is however interesting for the energy sharing business model if we examined the demonstration in Ballen marina. The objective there consists of storing locally produced electricity in a battery to be able to sell it, at optimal times, to boats. The current regulatory framework is however not appropriate, because it is very new to link the battery to the public grid, and the network company's cooperation is quite restricted. There is also some doubt on whether electricity can be sold to the boat owners freely or whether there would be taxes.[69]

> "The current regulatory framework is however not appropriate, because it is very new to link the battery to the public grid. The network company is not happy but they know they have to solve it for the future." Samsø interview

More generally, Samsø is investigating energy sharing in the future by having have a local electricity company, a sort of trader to which wind turbines can sell their electricity, and citizens can buy from this company. A type of aggregator, as long as the citizens have the possibility to choose to buy from another company.

Fort d'Issy and Hikari

France has developed a framework for collective self-consumption, where energy can be shared within a group of customers, without requiring the direct involvement of a

[68] The services on an ESCO generally include insight services, energy optimisation services, and services such as the remote maintenance of energy assets. For instance, if the supplier or DSO is applying implicit demand response through time-of-use tariffs, the ESCO can provide energy optimisation services based on these tariffs. Unlike an aggregator, the ESCO is not active on wholesale or balancing markets.

[69] Interview

supplier[70]. A community can therefore also be a vehicle to organise collective self-consumption.[71] However, none of the French cases analysed in this report have applied collective self-consumption of electricity.

It must be noted that the implementation of the two projects dates prior the regulation on collective self-consumption. In Hikari, the local production of electricity is self-consumed only by the common areas of the buildings, while individual areas' electricity needs are fed by the grid.

One resident who bought an apartment was disappointed by the fact that he could not self-consume the building's electricity production. Even though the Hikari building is at almost his full capacity in terms of solar panel installation, the resident applied to the co-property and then the network operator to install solar panels and self-consume it. At the time of the construction of the building, there was indeed no regulatory framework for collective self-consumption. Today, while collective self-consumption has been transposed to the national French legislation, the complexity of the building's operations is such that there is not willingness to make changes in the buildings energy system to allow collective self-consumption.

Aggregator

The aggregator archetype consists of providing flexibility from decentralised energy resources to various possible "requestors" in the power system. An aggregator is a new type of energy service provider which can increase or moderate the electricity consumption of a group of consumers according to total electricity demand on the grid. An aggregator can also operate on behalf of a group of consumers producing their own electricity by selling the excess electricity they produce[72]. The existence of a contract requirement with the supplier and the aggregator is a critical aspect, as well as the obligation for the aggregator to appoint the related Balance Responsible Provider (BRP). In this business model, the market role fulfilled by the community is the role of the BRP, which is responsible for the imbalances in the grid caused by his customers, maintaining a partial balance between production and consumption in real time. The BRP will settle imbalances with the connecting TSO. This results in a financial safety for recovering the costs of balancing in the system. In that spirit, the village of Wildpoldsried has integrated 138 kWh of battery storage into the system, which receives and discharges electricity to help stabilize the grid.

[70] See Article 16, paragraph 2a (e) of the Directive (EU) 2019/944 on common rules for the internal market in electricity (recast).

[71]CEER, Regulatory Aspects of Self-Consumption and Energy Communities, 25 June 20019. Available on : https://www.ceer.eu/documents/104400/-/-/8ee38e61-a802-bd6f-db27-4fb61aa6eb6a

[72]The European Consumer Organisation, Electricity aggregators: starting off the right foot with consumers, 2018. Accessed on: https://www.beuc.eu/publications/beuc-x-2018-010_electricity_aggregators_starting_off_on_the_right_foot_with_consumers.pdf

Micro-grid [73]

The thermal system of some of the cases can be considered as a micro-grid business model. For instance, Samsø exhibits a few independent district heating networks. The geothermal system at Fort d'Issy is closed and independent from any other source of heat. Similarly, the heating and cooling system of Hikari is independent from other networks, with a gas boiler back-up system in case of peaks.

Conclusion

The business model of cooperative investment, and more particularly community owned generation assets, is well established (e.g. Samsø for electricity and thermal, Wildpoldsried for electricity) but depends on whether the assets are assets typically required to be installed before the arrival of any users (e.g. Hikari, Issy for thermal and electricity) or can be installed beforehand.
The energy sharing business model is less established in the sustainable energy blocks analysed, especially regarding electricity. The interviewees have underlined that the energy sharing archetype is highly sensitive to national regulation (e.g. taxes, license requirements, etc.) as the value creation dynamics will be deeply affected by the ability of the members to sell their electricity to other community. The table below indeed summarizes that out of the five cases, only the case of Trent Basin developed an energy sharing business model, in terms of electricity.

Electricity	Cooperative investment	Energy sharing	Aggregator	Microgrid
Wildpoldsried	Yes	No	No	No
Hikari	Not community owned	No (for common spaces only)	No	No
Samsø	Yes (9 out of 11 wind turbines)	No	No	No
Issy	N.a.	N.a.	N.a.	N.a.
Trent Basin	Leasing	Yes	No	No

Table 15: Summary of energy community business models for electricity

The interviews have revealed fewer regulatory issues to share energy on the thermal side. In many of the cases there is currently physical collective self-consumption of heat or cold production. Table 14 indeed summarizes that all the cases (except Trent Basin whose thermal system is not yet installed, but nevertheless will be designed to enable collective self-consumption) functions with an energy sharing business model for the thermal vector.
Finally, none of the cases function as micro-grid in terms of electricity, as their business model mainly consists of selling the locally produced electricity to the grid. On the other hand, none of the cases export heat nor cold, due to the costs of

[73] Regarding electricity, a micro-grid, which is a small network of electricity users with a local source of supply that is usually attached to a centralized national grid but is able to function independently. In this business model, the market role fulfilled by the community is the role of the distribution system operator. The distribution grid operator manages one or multiple distribution grids and ensures its capacity meets the reasonable needs of its users. Since the concept of PEB consists of exporting surplus of energy on the grid, this last business model is less relevant in this study. In the case studies, all the electricity systems are always connected to the grid.

extending the network, and hence the micro-grid business model is well established with respect to the thermal vector.

Thermal	Cooperative investment	Energy sharing	Aggregator	Microgrid
Wildpoldsried	No (municipality)	Yes	Not relevant	Yes for district heating networks
Hikari	No	Yes	Not relevant	Yes, not connected to district network of Lyon Confluence
Samsø	Yes for 1 district plant	Yes	Not relevant	Yes
Issy	No	Yes	Not relevant	Yes
Trent Basin	N.a.	N.a.	N.a.	N.a.

Table 16: Summary of energy community business models for thermal

To conclude, exploring the different business models of energy communities has enabled to differentiate yearly energy balance from real-time energy balance, the latter being possible in energy sharing and micro-grid business models. In addition, understanding what market roles energy communities are allowed to fulfil is critical to assess their ability to develop successfully and consistently with the energy system. Such innovation should be properly recognised in the internal electricity market, at both commercial (supplier) and network (DSO) levels. For instance, the marina demonstrator is Samsø is having issues with being recognized properly by the DSO.

Regulatory energy tariffs

This section will focus on feed-in-tariffs that are tariffs obtained when selling energy back to the grid, and tax exemptions linked to consumption or sale of renewable energy.

Wildpoldsried

In Germany, small power plants up to 100 kW are supported by a feed-in tariff, whose amount depend on the year and type of installation[74].The development of community energy projects in Wildpoldsried is the result of the will of the mayor and the inhabitants, but could not have happened without the existence of feed-in tariffs. Between 2000 and 2009, feed-in tariffs were very favourable (over 0,54 EUR/kWh for solar panels) and self-consumption was not developed. Therefore, all citizens were selling 100 % of the electricity produced from their solar panels and were receiving two separate invoices, one for the electricity sold to the grid and one from their conventional supplier for the electricity consumed.

> *"Without the initial feed-in-tariffs, the development of projects would not have been possible."* Wildpoldsried interview

After 2009, individual self-consumption started to be more common. Today, since renewables are subject to market mechanisms such as the tendering process, environmental protection associations and renewable energy professionals fear for the energy transition in Germany. "Renewable energies are at risk of going backwards," said Mr Zengerle, mayor of Wildpoldsried, even if, for his municipality, the system does not change. "The new rules will only be valid for new installations".

[74] Under several conditions described by the EEG 2017: http://www.res-legal.eu/search-by-country/germany/single/s/res-e/t/promotion/aid/feed-in-tariff-eeg-feed-in-tariff/lastp/135/

Hikari

In France, the use of the grid for the transmission of electricity from renewable sources is subject to the general legislation on energy. There are no special provisions for electricity from renewable sources. The generation of electricity from certain renewable energy sources is promoted through a feed-in tariff scheme. Operators of renewable electricity plants are contractually entitled against the suppliers (EDF and private suppliers) to payment for electricity exported to the grid. The distribution grid operator is obliged to enter into agreements on the purchase of electricity at a price fixed by law ("obligation to conclude agreements"). With that mechanisms, the feed-in tariff applied in the case of Hikari amounted to 0.04 EUR/kWh. As far as heating and cooling is concerned, public distribution of heat in France is a competence of the local or regional authorities. The production of heat from renewable energy sources is promoted through several tax incentives. [75]

Samsø

In Denmark, electricity from renewable sources is promoted through a premium tariff and net-metering. Regarding the premium tariff, the operators of renewable energy plants usually receive a variable bonus, which is paid on top of the market price. The sum of the market price and the bonus shall not exceed a statutory maximum per kWh, which depends on the source of energy used and the date of connection of a given plant. Regarding net metering, electricity producers using all or part of the electricity produced for their own needs are totally or partly exempt from paying Public Service Obligation on this electricity.[76] For instance, in the case of Samsø, as wind turbines are out of the inhabitants' parcel, there is no net-metering. Today, despite high support from the Danish government, subsidies for set-up costs and previous feed-in-tariff laws for wind turbines are no longer available for new installation[77]. It would require new wind turbines to sell the produced electricity to the grid.

Trent Basin

In the United Kingdom, renewable energy sources are supported through a feed-in tariff and tax regulation mechanisms. Regarding the feed-in-tariff, eligible renewable energy plants with a capacity of up to 5 MW must generally undergo an accreditation process so that the electricity exported to the grid by the plant is bought by a feed-in tariffs licensee, i.e. an electricity supplier, at rates fixed by the FTO 2012 and corrected yearly by the Gas and Electricity Markets Authority (Ofgem). The case of Trent Basin has shown nevertheless the challenges of buying a licence or functioning without a license. From April 2013, Carbon Price Floor was introduced in Great Britain. The tax applies to fossil fuels used for electricity generation. Renewable electricity is exempt from paying this tax[1].

Summary

The table below summarizes the feed-in tariffs and tax exemptions regarding electricity. All the cases with renewable electricity production benefit from feed-in-tariffs. The latter therefore seem to be a necessary condition to implement a positive energy block, with respect to electricity. With respect to heat, feed-in tariffs are less

[75] http://www.res-legal.eu/search-by-country/france/tools-list/c/france/s/res-hc/t/promotion/sum/132/lpid/131/

[76] The Public Service Obligation is a charge levied to support renewable energy. Electricity tax represents two thirds of the billing cost for a private consumer[76]. According to this rule, it is only interesting for prosumers to self-consume what is produced on their own property, called the cadastral parcel. As soon as the parcel is crossed, taxes are applicable.

[77] https://cor.europa.eu/en/engage/studies/Documents/local-energy-ownership.pdf

acceptable as thermal energy is seldom exported. The support schemes regarding heat are rather focused on loans and taxes.

	Feed-in tariffs (electricity)	Tax exemptions
Wildpoldsried	Wind: 4.66 to 8.38 cEUR/kWh Solar: 8.91 to 12.70 cEUR/kWh Hydro: 3.47 to 12.40 cEUR/kWh	No
Hikari	Solar: 4 cEUR/KWh[78]	Yes[79]
Samsø	Wind: 3 cEUR/kWh[80]	Yes (net-metering)
Issy	-	-
Trent Basin	6,4 c€/kWh[81]	Carbon Price Floor

Table 17: Feed-in tariffs and tax exemption for production and consumption of electricity

Other regulatory enablers or barriers

There are a couple of other regulatory remarks that have been highlighted in the interviews.

Thanks to its early commitment, at a time when the feed-in tariff system was in place, the village of Wildpoldsried has not met any real difficulties. Their main constraint is that since November 17, 2014, a new regulation has been introduced around omni-directional radio range equipment (navigation systems for aviation) which increases the minimum distance of wind turbines to such systems from initially three to now 15 kilometres. Due to the change of that regulation, it will not be possible to install additional wind power in Wildpoldsried (except for those projects that are already in development). In other European countries such regulation is less restrictive, as minimum distances are lower.[82]

The Hikari case has shown also that additional efforts were needed in the context of the existing regulations in terms of energy efficiency. For instance, the regulation in terms of constructive techniques did not allow photovoltaic facade. A rather specific process was implemented consisting of testing in a laboratory the solidity of the technologies for the photovoltaic façade, that would serve as frame of the building. Conclusive tests validated the technical solution, to reassure insurers and bankers.

> *"The legislation has not been blocking but has not been very motivating. The requirements can be improved so that positive energy buildings come into existence while the national legislation does not require it. Today, the regulation is not even at the level of what we did [with Hikari] in 2015."* Interview Hikari

More generally, in order to implement the energy specifications that required building a positive energy building, the urban planners improved the national thermal

[78] Interview. Arrêté tarifaire en vigueur en Septembre 2015

[79] Natural persons may deduce from income tax a certain percentage of investments in renewable energy plants.

[80] SMILE, Deliverable D3.1. Specifications and Data Report for the Samsø Demonstrator, 2017. Available on : http://www.h2020smile.eu/wp-content/uploads/2018/06/Deliverable-D3.1.pdf

[81] Average solar price of the solar kWh sold to the grid. http://www.fondation-tuck.fr/upload/docs/application/pdf/2019-08/2019.07.30_community_energy_case_studies_dv.pdf

[82] Interview

regulation by proposing their own performance criteria, as cities can act when they control the ground[83].

From a financial perspective

Investments

In this section, we examine investments and more particularly how each project was financed (privately, by consumers, publicly). In some cases, the distinction between the building and the energy system is made while it is more difficult to do so in others.

Wildpoldsried

Regarding the energy system of Wildpoldsried, 50 million euros were invested. Approximately 48 million euros were financed by the citizens of Wildpoldsried, via individual equity and debt, while the remaining two million euros were financed by the public authorities.

> *"Too many citizens want(ed) to invest and thus the financial contribution per citizen had to be capped at 5,000 € (the cap has been reduced over time from an initial cap of 100,000 €)."* Interview Wildpoldsried

Hikari

The construction of Hikari was mostly privately financed by private developers. However, the project won a grant of 100,000 euros from the European Commission, which represents about 1.7% of the total investment.
Nonetheless, this grant triggered collaborations with other organisations. For instance, the Japanese research organization NEDO offered to install sensors to monitor energy consumption of the building. In addition, the solar panels installation on the façade, made of high-quality glass, was also provided by NEDO. Similarly, the absorption machine was given in kind. As a result, a number of energy installations were not financed by private developers.

Samsø

With respect to the case of Samsø, the demonstration at the Ballen marina as well as the production assets of overall island must be distinguished. Regarding the wind turbines on the island, the investment was mostly financed by citizens. Regarding the demonstration in the marina, the project received 200,000 euros grant from the European Commission for equipment investment, and the municipality contracted a loan for the same amount.

Fort d'Issy

Regarding the eco-district of Fort d'Issy, the investments are made in the context of a development operation where the public renovation is financed by private promoters. However, the biggest investment in terms of energy was the geothermal system and it was subsidized at 40% by the French Environment and Energy Management Agency (ADEME). The remaining of the geothermal investment is paid by the contracted operators for hot water and heating.

Trent Basin

There is a long history of academic funding regarding the case of Trent Basin. Project

> *"Without the money from R&D, it [the energy aspect of the project] would have never happened. […] The whole idea of the project SCENe is to develop business model that are replicable without the grant."* Interview Trent Basin

[83] Interview

SCENe and ERA are UK research funds that financed the R&D aspect of Trent Basin, by opposition to the operational business. The latter was financed by private developers. The interview highlighted that the goal of such R&D grant is to make similar projects replicable, without research funding.

Summary

In conclusion, a great variety of financing sources was observed. It should be underlined that the majority of project benefitted from public grant, which shows that PEB implementation are to some extent still in the stage of research and development and require support to find the adequate business models or technologies. The table below details the importance of the grant, compared to the total investments needed, regarding the investments costs of the energy system.

Case	Private	Citizens	Public	% Public funding
Wildpoldsried	No	Mostly	Loan (municipality)	2%
Hikari	Mostly	No	Grant (EC)	1.7%
Samsø	No	Wind turbines	Grant (EC for R&D); Loan (municipality)	100% for the marina pilot
Issy	Yes	No	ADEME (geothermal)	40%
Trent Basin	Yes	No	Research funding	100% for R&D part

Table 18: Summary of type of investments

Incomes and distribution

Producing more energy than the energy block consumes may generate revenues. This section examines how the revenues are generated, and how and to who they are distributed. Please refer to Appendix 0 for more details on regulatory feed-in tariffs.

Wildpoldsried

In Wildpoldsried, the value streams largely depend on the technology. The electricity produced by wind and hydro is fully fed to the grid and remunerated via feed-in tariffs. Locally produced solar electricity, often combined with a battery storage (Sonnen), is mostly self-consumed and only a small proportion is fed to the grid. Without the initial feed-in tariffs, the development of projects would not have been possible. Today, due to the gradual reduction of feed-in tariffs for existing installations, other or new revenue streams become increasingly more important. Participation to flexibility markets and or the production of hydrogen are considered as potential tracks to investigate. Both options are currently evaluated from a strategic perspective – taking into account the trends of the energy industry in Germany (nuclear and coal phase out, decarbonization of industry and sector coupling).[84] The profit from the feed-in-tariffs is distributed according to the number of shares a stakeholder has purchased in each of the assets.

Samsø

The same scheme as Wildpoldsried above applies to Samsø. Regarding thermal assets, there is no excess heat or cold sold to the market that generates revenue. In the case of community owned generation assets, in Samsø, one district heating plant is owned by the consumers. The heat is sold to the consumers, it is a not profitable operation as the price of the heat is determined by the cost. If the price is too high one year, it will be lowered the next year to reflect the costs.

[84] interview

Hikari

In Hikari, the excess of electricity locally produced, i.e. that is not used for the common spaces, is sold to the grid. This generates a revenue that is received as an income by the co-ownership of the buildings. This income is then reflected on the expenses that the users of the buildings pay periodically to the co-ownership. The particularity of the case of Hikari is that one building host different types of users (housings, offices and shops). This was a very first experience in the district of Lyon Confluence. While it did not complicate the technical operation of the building, it raised issues regarding the beneficiaries of the incomes. Indeed, offices renters benefitted on the one hand from cheap locally produced electricity during the day for their common spaces, and on the other hand from reduced co-ownership charges. On the other hand, because their common spaces are less occupied during the day, owners of the homes only benefitted from lower co-ownership charges. Therefore, the sharing of the revenue was considered quite unfavourable for homeowners and the division of charges was revised. On another building under construction in Lyon Confluence, with mixed usage as well, the developer plans to install a battery to store a part of the solar electricity production that occurs during the day, to redistribute it to the inhabitants at night when they return home, so that the offices and housing are on an equal footing as regards with self-consumption.

Trent Basin

In Trent Basin, profits are made by the ESCO from selling locally produced electricity to the grid. This profit is firstly used to manage the assets. The remaining profit would be shared by the inhabitants that have signed up in the community via a community fund.

Real estate considerations

Aside the energy system consideration, the real estate context of the PEB must be considered in order to consider the success of the PEB. It was underlined that some of the projects (Trent Basin, Fort d'Issy and Hikari) were developed from scratch by private developers, which aimed to attract private investors and then inhabitants.

> *"If a developer wants to build and sell, it makes a lot less sense to invest a lot on the fabric and generation assets because they do not have the long-term benefits."* Trent Basin interview

Hikari is located in Lyon Confluence, a hyper-central, hyper-accessible area of Lyon which makes it very attractive for investors, consumers and enterprises. This very attractive location makes energy innovation possible because the high prices would not discourage investors. The different offices, shops and homes of Hikari were therefore not sold for social housing but to private investors, in order to amortize the high cost of innovation.

Conversely, in Trent Basin, in the first phase, the developer was more restricted than in Hikari in terms of innovation of energy efficiency of the buildings. The location attractivity of Trent Basin is not as exceptional as the one of Hikari and therefore developers could not afford to make very high investments in energy efficiency. Indeed, the investor would not have amortized the cost, nor would have benefitted from the energy savings in the long term. In addition, the site where Trent Basin eco-district is an old industrial side, and there was a lot of risks associated with it, such as costs from soil contamination, river banks, etc., that limited the investments. In the next phases of the project, the objective is to increase energy efficiency and find a way for the developer to be more interested.

In Fort d'Issy, the homes were sold very fast, at a very reasonable market price, in addition to some public housing. The fact that the price per square meter was very accessible showed that the cost of building the eco-district was largely viable.

To conclude, the interviews with Hikari and Trent Basin illustrated the trade-off between expensive energy installations to implement PEB and the prices of the real estate. The case of Fort d'Issy however showed that innovation should not go at the expense of reasonable real estate prices.

> *"The fact that the price of m² is very accessible shows that the investment was largely viable. Otherwise there would have been a price much higher than what was."* Interview Fort d'Issy

From a stakeholders' management perspective

This section aims to highlight the return on experiences on the interactions between stakeholders from planning to actual operation. We examine specifically the user's participation in decisions and the involvement of users in ICT technologies.

Wildpoldsried

In Wildpoldsried, transparency and the involvement of citizens were of utmost importance for successful project implementation. A dedicated committee informs the citizens each year about the heat demand and the corresponding costs for operation and maintenance of the district heating system. The citizens of Wildpoldsried are indeed important as they are financing the vast majority (96%) of the different projects.

The majority of citizens does not participate in demand response programs. However, a project titled "Pebbles" targeting "Peer to Peer Energy Trading based on Blockchain Infrastructure" has started in March 2018. The aim of that project is to "design and develop an integrative platform-based model for cooperation between technology providers, platform providers, platform users and distribution system operators." As a result, a community that can trade electricity corresponding to the individual needs of all participants shall be created.

Trent Basin

In Trent Basin, the type of users consists of many people downsizing their home, such as parents with no more children at home, with reasonable salaries. There are also a few young people.

> *"So, they [inhabitants] have been involved all the way. The fact that there was no existing community made it a bit harder."* Interview Trent Basin

In every step of the development, residents were consulted and informed. There were community meetings every three months and residents were asked for their feedback. Workshop were also conducted to tackle particular issues (e.g. what would they like to see on the screen that shows monitoring of the energy system). It was difficult to involve residents as it was a new community but the project has helped them to meet more and become a community.

In Trent Basin, this community aspect was considered a necessary condition to be energy positive and the project started with the objective to connect each home. A

community hub was created and in phase 1, the recently arrived owners had to decide to opt in or not. There was a survey about why inhabitants signed up for the community and the most frequent answer was to contribute to sustainable energy growth, as well as the energy savings from the energy efficient homes.
The citizens can have a say in the ESCO management of the production assets but are not part of its management board because would it be very difficult to redirect investments back to the assets rather than to the community account.
Regarding involvement in ICT technologies, different ways of engagements were implemented such as online application, face to face interaction and vocal interaction with smart meter. Therefore, different ways of engagement have worked for different people. Due to the diversity of engagement in ICT, offering a range of possibilities was a solution that worked well.

Hikari

The users of the Hikari buildings are either office renters either inhabitants of high socio-economic level. There was no role for users at the development stage of the project. During the operation, all the governance occurs at the level of the co-ownership, the structure that binds the owners of the homes and the office spaces.
Regarding ICT involvement, the users have the choice between accepting the automatic control of the building or disabling it and controlling it manually. There is no return on experience on this. A survey has shown nonetheless that some users have themselves taken additional measures such as paying attention to the quality of household appliances or type of lighting in their homes.

Samsø

In Samsø and more specifically the marina project, there was a lot of dialogue with the inhabitants. A lot of public meetings are held to create a dialogue between the project, the inhabitants and the politicians. In the original description of the SMILE project, new additional wind turbines were planned for the purpose of the project. There were however never installed because of resistance from the local people. Similarly, one of the villages on the island was reluctant to install a heating district, mainly for economic reasons, and hence it was not installed.
Regarding ICT involvement, all the inhabitants of the island have smart meters at their place. So far it has been kept at its most basic function: the meter measures the electricity consumption and sends it back to the electric network, with no price signals from the meter to electric appliances. There is no interaction between meters and consumers.

Fort d'Issy

In the development phase of the eco-district of Fort d'Issy, there was no residents since the homes were not constructed yet. In addition, when the project was delivered, there was little place for decision regarding thermal energy as by default all residents of Fort d'Issy are connected to the network. During the operation of the project, different associations were created with the inhabitants, that created a sense of community (e.g. co-properties of buildings, shared parcels of land association for gardening, car sharing platform, etc.).
All the homes of the eco-district of Fort d'Issy have the specificity to be equipped with an advanced home automation system. The system allows control from remote on several elements. Each housing has a touch screen with possibility to control from remote blinds, heaters, etc., and the possibility to program scenarios (e.g. close shutters every day at 8pm). The system can be connected to smartphones. There is no return of experience of the exact involvement in these technologies, but a survey more generally has shown the interest and pride of inhabitants in living in an eco-district, showing some level of environmental sensitivity.

Task 4: Recommendations

This task outlines success factors and open challenges, asking the question: “If you could start over, what would you do differently?”. First, the replicability of the different case studies will be assessed, based on the specificities of the sites. Finally, this task will give practical and prescriptive recommendations for the next generation PEBs.

Replicability

Before underlying typical success factors, this study should first make a judgement as to whether the applied solutions are easily transferrable to the other urban environment. Indeed, some of the cases analysed have shown specificities that are not especially the same everywhere.

In general, the concept deployed in Wildpoldsried can be applicable to other villages. As the concept consists mostly of investing in many renewable generation assets, that require space, such as wind turbines, it is not replicable in dense urban environments. In addition, it must be pointed out that the village has an excellent local resource potential (wind, sun and biomass).

In a similar vein, the island of Samsø also primarily opted for a concept with renewable generation assets requiring space. This general strategy was complemented by the SMILE project and more particularly by a pilot project applied to the marina of the island, which is not applicable to any urban area. Nevertheless, 270 marinas members of an association in Denmark also follow this project, so other marinas of other cities could be interested.

The case of Fort d’Issy takes place in an urban environment. However, opting for a geothermal option was a feasible option given the large surface available on the ground at the start of the project. Everything was yet to be built, which enabled to install a geothermal plant and design a whole geothermal system under the ground, connecting all the buildings. Additionally, the geothermal potential of the zone was quite high. Therefore, while Fort d’Issy consists of a dense urban environment, its development took place in a strongly enabling context regarding the geothermal technology.

> *“The big advantage we had was that we had a playground of 12 hectares. No expropriation, contracts to respect, buildings to keep, etc. We could almost go from scratch.”* Interview Fort d’Issy

The case of Hikari takes place in a very dense urban environment; in the hyper centre of the city of Lyon. Therefore, the project implemented very advanced efficiency measures, requiring high investments, that resulted in higher real estate prices. Such advanced energy efficiency measures would therefore only be replicable if the PEB is located at an attractive location and can be bought despite expensive prices.

Finally, the Trent Basin case has shown a high level of replicability. The eco-district was indeed developed on a brown field site, which is numerous in Europe and elsewhere. Regarding the thermal vector, similarly to Fort d’Issy, this setting will enable the design of a connected thermal system, with place available for a geothermal plant. In addition, it enables to use land for solar panels parks. Therefore, developing PEB on brown field site, can be an opportunity for PEB creation, rather than a burden.

The table below summarizes this section, displaying the relationship between the type of site where each of the studied projects occurred, and the replicability of their solution in an urban environment. Brown field sites such as Trent Basin were judged to be the most replicable, given their availability in Europe and elsewhere, and the surface available for energy networks and generation assets. The case of Hikari was also considered to have high replicability given that its hyper-centre location is very attractive, which enables to implement more advanced and expensive energy efficiency measures.

		Typology of site		
		Village	Empty site	Hyper-centre
Replicability of the solution	Low	Sites with a lot of space available (Wildpoldsried, Samsø)		
	Middle		Empty sites in an urban environment (Fort d'Issy)	
	High		Brown field sites (Trent Basin)	Very attractive sites (Hikari)

Table 19: Relationship between the type of site and the replicability of the PEB solution in an urban environment

Typical success factors

Aside site specificities, there is a series of common success factors that could be identified in the analysis of the five best cases of PEB. The success of each PEB can be attributed to several factors, ranging from technical, legal, financial and stakeholder management.

Regarding the technical factors:

§ All the cases have shown different configuration of their level of commitment to the three identified functions to achieve positive levels of energy (production, efficiency, flexibility).

  - The cases with the most surface available (Wildpoldsried and Samsø) have put a higher emphasis on the production function, with wind, PV and even biomass.
  - There is only one case which, in addition to positive level of electricity, has accomplished collective-self consumption of the locally produced electricity. To do so, Trent Basin has put the highest emphasis on the flexibility function. Its designers indeed argued that to achieve higher levels of energy positivity, no additional production was needed. Similarly, the lessons learned from Hikari, which could not offer self-consumption to its users, have led to another initiative in a block Lyon Confluence where, to enable self-consumption, a common battery would be installed. Therefore, we can conclude that the flexibility function is an essential success factor, combined with the presence of the other functions, to achieve positive level of energy in an urban environment were places for numerous generation assets is limited.
  - An easy way to optimise the efficiency of the buildings without too high investment costs, would be to optimise the orientation of the buildings related to the sun, as Fort d'Issy has done, with good return of experience. This is only possible when the buildings are not yet built.

- Dealing with mixed-usage buildings has shown no technical difficulties. On the contrary, in Hikari, thanks to the mutualisation of the load profiles, mixed usage has enabled to size adequately, i.e. downsize, the energy installations, reducing the initial investment. However, the mutualisation of the demand has not resulted in significant operational costs for the users yet.

Regarding regulatory factors of success:

- A supportive regulatory framework (feed-in-tariffs) is a critical success factor for a PEB. Supportive regulation that offers tariffs for selling electricity back to the grid is a condition to make the business model of PEB financially viable.
- A supportive legal framework for interdisciplinary research projects (Pebbles and IRENE) that are conducted by the local DSO, Universities and technology providers are additionally very important success elements. This enables to ensure the successful integration of innovations regarding the PEB into the energy market.
- In addition, the analysis has shown that there was, at the time of implementation of the case studies, little ways to ensure that local renewable production of the PEB can be consumed physically (except for individual assets, or through full islanding). Therefore, energy communities that aim to share the produced energy must use various contractual arrangements to allocate production to their users. For instance, Trent Basin used the intermediary of an ESCO and applied to be exempt from having a supply license. However, these arrangements are complex and not always available. Therefore, a critical success factor for a PEB that aims to also self-consume the produced electricity is the existence of adapted regulatory schemes to allow it. The recent adoption of the “Electricity Directive” and the “Renewable Directive” will most probably help in that direction.

Regarding financial factors of success:

- As highlighted in the regulatory success factors, feed-in tariffs, as well as tax exemptions, are key to incentivize PEBs. The question of the distribution of these revenues is also essential in order to bring all stakeholders on board.

Finally, these success factors depend on the management of stakeholders during the project:

- It is a key success factor to have the local authorities on board. There are at the centre of most of the initiatives. The analysis of some cases, especially Samsø and Wildpoldsried, has shown that some countries have a general tradition of forming cooperatives and other associations to achieve change at a local level. Therefore, a success factor consists of having legal opportunities to create partnership between local communities and local authorities;
- Innovation is also enabled in some cases thanks to preparedness of DSO and energy companies to collaborate and innovate. For instance, Wildpoldsried benefited from a strong local know-how because the company Sonnen – an innovative company with regards to solar and storage as well as energy services – has its headquarters in the village.
- Finally, transparency towards citizens, and participation of the latter was also a key for success.

Typical challenges

The analysis of the cases has also highlighted challenges faced in the project. We will here summarize the challenges and interpret them as lessons learned for recommendation for future PEBs.

From a technical perspective:

- The Hikari case has shown the lessons from using too complex innovative technologies. The complex installation of a cogeneration plant created some issues during the first two years. After this experience, it was strongly recommended to the other blocks of the district of Lyon Confluence to be connected to a common heat network, rather than developing complex and very small-scale thermal installations.
- To obtain higher level of positivity and even real time balance, battery systems need to be implemented. Nevertheless, it requires high investment costs and therefore support. In addition, the user involvement in flexibility measures requires additional efforts.

From a regulatory perspective:

- The analysis of the best cases of PEB has shown the complexity of regulation. The diverse realities of (collective) self-consumption and energy communities implies that active consumers, renewable self-consumers and energy communities touch upon many different areas of regulation, such as consumer protection and network regulation, including supplier and network charging arrangements.85
- The lessons learned from such challenges is to not underestimate the challenges from the legal aspect. It would be valuable to include in most projects a law partner to tackle the regulatory issues from the beginning.
- Energy sharing is still difficult to implement and therefore it is often less attractive. For blocks that want to be energy positive but do not consume physically the energy produced, it results in high levels of grid injections, which threatens the grid stability.

From a financial perspective:

- To be innovative, the PEBs require grants or exceptional conditions, which is not necessarily a replicable support. Indeed, the majority of project benefitted from public grants, which shows that PEB implementations are to some extent still in the stage of research and development and require support to find the adequate business models or technologies.
- The constraint of real estate attractivity was also highlighted. In the design of a PEB, there is a trade-off between investing strongly in production, flexibility and efficiency functions, and offering reasonable real estate prices.
- The business model is key to make the PEB replicable. Nevertheless, the business models of PEBs heavily depend on macro-level institutional factors, such as the feed-in tariff system. Feed-in tariffs are being gradually phased out in some countries, and the question on how to make surplus of energy valuable arises. The solution of selling the surplus electricity on flexibility markets has been raised. The PEB taking a balancing role however implies a higher level of technicity. Another solution is to increase the amount of self-consumed energy, which requires to tackle regulation complexity. In addition, due to the intermittency of local renewable

[85] CEER, Regulatory Aspects of Self-Consumption and Energy Communities, 25 June 20019. Available on : https://www.ceer.eu/documents/104400/-/-/8ee38e61-a802-bd6f-db27-4fb61aa6eb6a

energy sources, self-consumption would also imply more advanced smart meters with remote access to electric devices, which are not yet mature on the market.

- The sharing of benefits in mixed usage buildings is something that needs to be analysed well, to treat all the participants as fairly as possible.

Recommendations to future generation of PEBs

From a technical perspective, the analysis has underlined that the three functions (production, efficiency, flexibility) required to develop a PEB have been emphasized in different manners by each of the five projects, depending on the resources available. It was concluded that in an urban environment where space is limited, the flexibility function is key to achieve a positive energy balance because it enables to consume and sell energy at optimal times. A first recommendation for future PEB would be to not undermine the importance of the flexibility function and include different solutions to involve users in this flexibility management. Another technical recommendation that can be highlighted is to explore technical synergies between the electricity and thermal vector. It can indeed enable cheaper storage solutions, as well as an additional way of consuming the surplus of electricity in also a flexible manner through storage. Finally, different user types in a same block is interesting to optimize investment size of assets and hence investments costs.

From a regulatory perspective, a supportive regulatory framework is a critical success factor for a PEB. In that regard, supportive regulation that offers feed-in tariffs for selling electricity back to the grid is a condition to make the current business models of PEB financially viable. Nevertheless, these feed-in-tariffs are not applicable everywhere, and are being phased-out in some countries. Therefore, the question on how to make the surplus of energy valuable arises. The solution of selling the surplus electricity on flexibility markets has been raised. PEBs taking a balancing role however implies a higher level of technicity. Another solution would consists of increasing the amount of self-consumed energy. However, the analysis has shown that there was, at the time of implementation of the case studies, little ways to ensure that local renewable production of the PEB can be consumed physically (except for individual assets, or through full islanding). Energy sharing is less attractive in the design of PEBs. Therefore, a recommendation for future PEB consists of designing their project in a context of clarified national regulation for collective self-consumption of electricity. In addition, due to the intermittency of local renewable energy sources, self-consumption would also imply more advanced smart meters with remote access to electric devices, which are not yet mature on the market. To conclude on the regulatory perspective, more generally, legal aspects were often considered as barriers in the good development of the project, and a recommendation for a future PEB would be to partner with a law firm and include the legal aspects from the beginning of the project.

From a financial perspective, the analysis has underlined that all the PEBs have required grants or exceptional conditions in order to develop innovative solutions. We highlight a few areas where innovation is welcome for further integration of PEB in the energy system:

- Innovation in flexibility products: there is opportunity for surplus of electricity from DER to be traded on flexibility markets. Further innovation to be able to trade electricity from DER in local flexibility markets would be necessary to further integrate PEBs in the energy system.
- Innovation to involve end-users in increased demand response : ensure consumers will not face significant technical barriers for the optimization of their day-to-day energy use
- Innovation that enable self-consumption in a PEB such as peer-to-peer trading or advanced smart metering

- Innovation in solutions to leverage synergies between the flows of different fluids

In addition, real estate constraints for new building blocks must be considered when investing in innovative energy solutions. Depending on the attractivity of the site, there is indeed a trade-off between energy investments (e.g. energy efficiency investments) and offering an attractive price of the real estate.

Finally, stakeholder management also has been an important dimension across the development and the operations of all the projects. In PEBs where there were already inhabitants, a meaningful consultative process was implemented where the plans were adjusted to meet the concerns of the local population. In addition, in some cases, collective ownership has built support for renewable energy. Finally, the involvement of public authorities, as well as distribution system operator, energy companies and local communities is a key factor of success in the development of a PEB.

The table below gives recommendations to future generation of PEBs.

Technical dimension	Regulatory / Legal dimension	Financial dimension	Stakeholder management dimension
Emphasis on the flexibility function is important to achieve positive energy balance in an urban environment. The cost of investing in flexibility assets as well as the efforts to involve the finals users of the flexibility solution are not to be underestimated.	Supportive regulatory framework with feed-in-tariffs	Trade-off between high level of positivity and price of the real estate	Transparency towards end users
Avoid too complex innovative solutions, to avoid technical issues in the lifetime of the PEB	Design the PEB in a clarified national regulation for collective self-consumption of electricity.	Consider that innovative PEBs still require grands or exceptional conditions	Involvement of DSO and energy companies
Mutualisation of consumption of different user types enables to downsize the installations	Interdisciplinary research projects to enhance innovative solutions	The sharing of benefits should be advantageous for end users as well	Partnership between local communities and local authorities
Develop synergies between electricity and thermal energy carriers	Partner with a law firm and include legal aspect from the beginning in the project	Consider solutions to trade on local flexibility markets	

Table 20: Summary of recommendation to future PEBs

Appendix

Appendix 1: Inventory of existing sustainable EBs worldwide

Name of the initiative	City	Country	Years in operation (at least 1)	Number of connected buildings (at least 3)	Usages buildings (housing, offices, commercial spaces, ...)	Presence Low carbon RES assets present	Presence local storage options	Presence of ICT technologies (smart energy grids, demand response, ...)	Presence of energy efficiency measures
mySMARTlife	Vanhankaupunginlahti (old Town Bay), Helsinki	Finland	>1	>3 (district)	Residential: 80%; Office: 20%	Geothermal energy; District heating; Heat pump system; Industrial waste Heat; Solar energy	Yes	Yes	Yes. e.g. Facades will be imaged with thermal leakage cameras during winter 2017-2018
Nice Grid	Industrial zone of Carros, Nice	France	demonstration is past	Yes. 8 clients	Industrial and housing	Solar panels	Yes (to ensure islanding)	Yes. Local control system of islanding	Yes. E.g. remote control of oiler
Plus Energy Village	Wildpoldsried	Germany	20	>3 (Population of 2600)	Yes	PV, five biogas facilities, 11 wind turbines, hydropower system, 2100m² solar thermal systems	Yes. Whilst some of their surplus energy is stored in batteries for use at times when no energy is being produced, much of it is sold	Yes. Wildpoldsreid has been used by Siemens and local universities as the testing ground for new intelligent control systems, or smart grids.	Yes. Buildings have been constructed from locally sourced timber, using Passivhaus techniques.
Project SCENe - Trent Basin	Nottingham	UK	2	31	Mostly residential, but also leisure activities (community	PV	Yes. The community battery	Yes. Smart technology for in-home	Yes. Sustainable homes with heat pumps and stores

Name of the initiative	City	Country	Years in operation (at least 1)	Number of connected buildings (at least 3)	Usages buildings (housing, offices, commercial spaces, ...)	Presence Low carbon RES assets present	Presence local storage options	Presence of ICT technologies (smart energy grids, demand response, ...)	Presence of energy efficiency measures
					hub)				
Smart Grid Gotland	Gotland Island	Sweden	>1	>3 Yes, island with 10,000 inhabitants.	Yes, island	Yes, mostly wind power but most recently also PV	Yes. The island of Gotland may become a good example how batteries can overcome the need for cabling infrastructure.	Yes, but from grid point of view	Yes, but from grid point of view
Smart Grid Hyllie	Malmo	Sweden	>2	Yes (district of 3000 km2)	Yes. Residential and offices	Yes, PV, heat pimps	Yes, 6 home batteries	Yes, intelligent power grid. 4 buildings with demand response	Yes, green roofs
Savona Campus Living Lab	Genova	Italy	>4 years	Yes. Campus	Yes. Library, canteen sport facilities, accommodation building, auditoriums, etc.	Yes. Smart Poly-generation Micro-grid (including . "Intelligent" & Sustainable Microgrid feeding the electrical and the thermal loads of the Campus	Yes	Yes. "Intelligent" & Active ZEB interacting in real-time with the SPM Energy Management System	Yes. Reduction of the Campus consumptions and the energy dispersions at the building level

Name of the initiative	City	Country	Years in operation (at least 1)	Number of connected buildings (at least 3)	Usages buildings (housing, offices, commercial spaces, ...)	Presence Low carbon RES assets present	Presence local storage options	Presence of ICT technologies (smart energy grids, demand response, ...)	Presence of energy efficiency measures
HIKARI	Lyon	France	>3 (inauguration of the IKARI building in 2015)	3 (12500 m2)	HIGASHI (East), an office building with shops on the ground floor, MINAMI (South), an apartment building with 36 dwellings and shops on the ground floor, NISHI (West), 3060 m2 of offices and 4 top-end penthouse apartments and shops on the ground floor	PV on roof and façade, CHP (rapeseed oil) --> 1.485 GWh primary energy	Yes. SCiB batteries developed by Toshiba	Yes. Integrated energy distribution, with in the putting in place of a control and monitoring system for the building.	Yes. Regulating heating and air conditioning, opening and closing of windows
Campus Evenstad	Evenstad	Norway	2 to 3	17, but only one building ZEB	dormitory housing, administration, education, sport	PV, CHP, grid, CHP, solar thermal, electric boilers, ...	batteries, EVs	Yes. Development of a smart energy management system to reduce the peaks in energy consumption and thereby the load on the net.	Yes. Engage campus users in activities which minimize energy consumption

Name of the initiative	City	Country	Years in operation (at least 1)	Number of connected buildings (at least 3)	Usages buildings (housing, offices, commercial spaces, ...)	Presence Low carbon RES assets present	Presence local storage options	Presence of ICT technologies (smart energy grids, demand response, ...)	Presence of energy efficiency measures
Smart Energy Aland	Aland Island	Finland	5	many islands	mixed	solar, wind, heat, CHP, bioenergy, wave power, geothermal	yes in the future. Today DH network as thermal storage	Yes. Åland has completed a roll-out smart meters and advanced communication capabilities, forming a solid foundation for piloting novel demand response technologies.	Yes. Smart homes
Fujisawa SST	Fujisawa	Japan	>1	Yes. Residential, commercial facilities, community centers, parks and broad avenues.	Yes	Yes. PV	Yes.	Yes. Smart metering & Energy Exchange	Yes. Smart houses
READY Site Växjö	Växjö	Sweden	>10	City	Yes. Residential, industries, shops, university	biomass (forests), CHP, DH	Yes. Some renovated buildings are to be tested as a pilot, being equipped with smart district heating sub-centrals in order to use the building as accumulator.	Yes. Växjö uses a common and open ICT platform enabling all the required types of services and communication.	Yes. Retrofitting the building envelope

Name of the initiative	City	Country	Years in operation (at least 1)	Number of connected buildings (at least 3)	Usages buildings (housing, offices, commercial spaces, ...)	Presence Low carbon RES assets present	Presence local storage options	Presence of ICT technologies (smart energy grids, demand response, ...)	Presence of energy efficiency measures
Isle of Eigg	Isle of Eigg	UK (Scotland)	>10	Island	Mixed	wind, solar (back up diesel genset), hydro	battery	yes, to handle surplus --> turn on electric heaters. Use of smart meters to tell them how much they are using. Traffic light system to tell residents when there is low RES production so that they lower their consumption	houses use max 5 kW (kettle + washing machine for example), businesses max 10 kW at one time.
Isle of Muck	Isle of Muck	UK (Scotland)	>10	island (38 inhabitants)	mixed	PV + wind, diesel genset back up	thermal storage when excess production, battery		
Feldheim	Feldheim	Germany	>20 years	42	residential (37), farms (1 with 3 buildings), manufacturing firm (1)	wind, PV, biomass, biogas	battery	a system compensates for fluctuations by means of energy storage device	Yes. Scottish and Southern Energy Innovation and Energy Efficiency Award
Fort d'Issy	Issy-les-Moulineaux	France	Yes >3	Yes; energy optimization at the neighborhood level	housing (60000 m²), retail (2300 m²), school(5241 m²), swimming pool (2000 m²)	Yes. PV	Yes	Yes. Smart grid, remote control	Yes, for Hauts de Seine

Name of the initiative	City	Country	Years in operation (at least 1)	Number of connected buildings (at least 3)	Usages buildings (housing, offices, commercial spaces, ...)	Presence Low carbon RES assets present	Presence local storage options	Presence of ICT technologies (smart energy grids, demand response, ...)	Presence of energy efficiency measures
Ashton Hayes Smart Village	Ashton Hayes, Cheshire	England	>13	Yes. Village	Residential, school,	PV	Yes, via community electric vehicles	Yes. installing additional metering on the network	Yes e.g. upgrade of boilers
SMILE islands, Samsø	Samsø	Denmark	>20 (since 1997)	3,724 inhabitants	Residential, school, farm	PV, on-shore and off-shore wind turbines. District heating plants running on woodchips, straw, and solar heat	Yes. Battery and thermal	Building Energy management system	District heating

Table 21: Inventory of existing sustainable EBs worldwide

Appendix 2: Performance of sustainable EBs initiatives listed in Task 1

Technical KPIs and scores

Name	City	Country	Energy consumption of buildings (kWh/m2/y)	Maximize building efficiency (Y/N)	Energy autonomy (%)	Smart storage capacity (Y/N)	Maximize Load Control (Y/N)	Energy vectors (Y/N)	Mobility (Y/N)
mySMARTlife	Old Town Bay, Helsinki	Finland	Unknown	Thermal aspects: new heat exchanger for the district heating system, extra insulation Increasing heat recovery in ventilation Electric: renovation of general lighting	Unknown	Building mass is used as heat storage to balance consumption peaks	EMS: Smart controls for management of apartment level heat demand. The heating management system manages room level temperatures. BMS: Demand response requests from district heating system are given to the smart heating management system as input.	Electric and thermal	Unknown
				3		2	3	3	
Nice Grid	Nice, industrial zone of Carros	France	Consumption: 20 to 2300 kW Production: cumulated peak: 430 kWc (kWh unknown)	None	8 hours independent in real time Unknown on a yearly basis	Electric storage + thermal storage (hot water balloon)	EMS: Linky meters installed at inhabitants' dwellings BMS: control system provides	Electric and thermal	No

Name	City	Country	Energy consumption of buildings (kWh/m2/y)	Maximize building efficiency (Y/N)	Energy autonomy (%)	Smart storage capacity (Y/N)	Maximize Load Control (Y/N)	Energy vectors (Y/N)	Mobility (Y/N)
							functionalities such as communication with the battery, monitoring the electrical quantities of the networks upstream and downstream, the protection plan, the maintenance of the voltage and the frequency of the micro-grid, the reconnection to the upstream network		
				0		3	3	3	0
Plus Energy Village	Wildpoldsried	Germany	Unknown	Green buildings, and utilization of ecologically sustainable construction materials with a focus on wooden structures in new buildings	2013: electricity consumption: 6480 MWh electricity generation: 30,349 MWh[86] *2018 electricity production: 46,546 MWh 2018 electricity consumption: 6,131 MWh*[87]	Battery storage: 138kWh	BMS: Testing ground for new intelligent control systems, or smart grids.	Electric and thermal	Electric cars + focus on walking
				2	2	2	2	3	2

[86] http://www.100-res-communities.eu/ger/content/view/full/132863
[87] Updated from Task 3

Name	City	Country	Energy consumption of buildings (kWh/m2/y)	Maximize building efficiency (Y/N)	Energy autonomy (%)	Smart storage capacity (Y/N)	Maximize Load Control (Y/N)	Energy vectors (Y/N)	Mobility (Y/N)
Project SCENe - Trent Basin	Nottingham	UK	Each home designed to meet the 2016 Fabric Energy Efficiency Standard (FEES) for space heating of 39 KWh/m2/y for apartments and mid terraces and 46 KWh/m2/y for end terraces.	- Thermal: Insulation: mix of double and triple glazed windows and doors to minimize thermal bridging, combined with high levels of insulation. - Efforts on mechanical ventilation systems - Low energy lighting employed and class 'A' energy efficient appliances	The developers rejected the idea of an autonomous community energy system with private wire distribution as the sole energy source for Trent Basin residents on the grounds that it would leave them with a lack of choice *RES yearly production: 416 MWh, yearly consumption: 125 MWh. % of needs covered on a yaerly basis: 333%*[88]	Yes. Electric: 500kW/2100kWh battery	BMS and EMS: Trent Basin-Community Information Model (TB-CIM) is an interactive online platform that displays historical and real-time energy data	Electric and thermal	Public transport development: corridor for electric busses Development of carpooling/ car sharing locations Modal split: one parking space per property, pedestrian measures
			3	3	0	2	3	3	3
Smart Grid Gotland	Gotland Island	Sweden	Unknown	None	Unknown	Yes. Electric	Yes. Micro and Macro	Electric	Yes. EV
				0		2	3	1	1

[88] Updated from Task 3

Name	City	Country	Energy consumption of buildings (kWh/m2/y)	Maximize building efficiency (Y/N)	Energy autonomy (%)	Smart storage capacity (Y/N)	Maximize Load Control (Y/N)	Energy vectors (Y/N)	Mobility (Y/N)
Smart Grid Hyllie	Malmo	Sweden	Less than 60 kWh of primary energy per square meter	-Thermal aspects: maximize building's ability to store heat -Air-tight building structure, supply and exhaust ventilation systems with heat recovery -Smart grids and lighting control with motion detectors	Unknown	Electric cars used as energy storage devices to compensate for fluctuations in the power grid Thermal storage: buildings that store heat	BMS: power grids equipped with numerous sensors with many data points where energy is being produced and needed. This reduces the costs of network expansion. EMS: apartments equipped with a smart meter and electricity tariff adjusted according to current availability.	Electric and thermal	Public charging points with vehicle-to-grid approach Space for about 1,000 bicycles and free parking.
			2	3		3	3	3	2
Savona Campus Living Lab	Genova	Italy	Energy Efficiency Class A4[89]	-Thermal aspects: regulation of heating/cooling system -Complex regulation system controls the air conditioning and lights equipment -Design: windows	Electric: 50% Thermal: 100% Average (2017): 75%	Yes. One electrical storage systems (140 kWh).	"Intelligent" & Active ZEB interacting in real-time with the SPM Energy Management System: EMS+ BMS	Electric and thermal	Standards and V2G charging stations 73 bike parking lots

[89] https://www.gate-away.com/news/expert-building-energy-efficiency-rating-explained/ in anyway below 29 kWh/m2/y

Name	City	Country	Energy consumption of buildings (kWh/m2/y)	Maximize building efficiency (Y/N)	Energy autonomy (%)	Smart storage capacity (Y/N)	Maximize Load Control (Y/N)	Energy vectors (Y/N)	Mobility (Y/N)
				blinds opening and closure					
			3	3	0	2	3	3	2
HIKARI	Lyon	France	Primary energy consumption: 2199 MWh /year 2199*1000/12300 m2= 178 kWh/m2/y[90] *Heat: 30.9 kWh/m²/year*[91]	-Label BEPOS Effinergie -Strategic orientation -LED lighting and motion sensor all-in-one panel - Radiant air conditioning	Production: 1941 MWh/year. Consumption: 2199 MWh/year march 2016-february 2017: KPI = 1941/2199 = 88% *August 2016-July 2017 Electricity: RES yearly production: 343 MWh; Yearly consumption: 410 MWh. % of needs covered on an annual basis: 83% Thermal: RES yearly production. 317 MWh. Approx. 30% of yearly needs covered.*[92]	- Heat storage tank using substance with latent heat of fusion. - Storage batteries with a capacity of 100kWh	EMS and BMS: production and consumption of the islet are monitored, and housing equipped with home automation (HEMS system for residents with functions including condition checking, remote control, automatic control and schedule control of air conditioning, lighting and blinds) allowing the visualization of consumptions and the control of electrical appliances.	Electricity and thermal	Cycling sites at the bottom of each building

[90] https://www.nedo.go.jp/content/100871965.pdf
[91] Updated from Task 3
[92] Updated from Task 3

Name	City	Country	Energy consumption of buildings (kWh/m2/y)	Maximize building efficiency (Y/N)	Energy autonomy (%)	Smart storage capacity (Y/N)	Maximize Load Control (Y/N)	Energy vectors (Y/N)	Mobility (Y/N)
			1	3	1	3	3	3	1
Campus Evenstad	Evenstad	Norway	Between 70-95 kWh/m2/y[93]	Some efficiency measures included, but not detailed. Airtightness of building included[94]	Production: Elec: 40 kW CHP, 70 kW PV; heat: 100 kW CHP, 300 kW wood chip, 315 kW electric boiler, 100 m² solar thermal Consumption: 10,000 m2 * 83 kWh/m2/y = 830 MWh (data found of one building only) Heat: 100% fully autonomous Elec: 30 % autonomy Elec. is about 42% of total energy demand 42%*30%+(100%-42%)*100% = 58 %	Thermal storage. Batteries are planned.	None	Electric and thermal	In the future
			2	1	0	2	0	3	0
Smart Energy Aland	Aland Island	Finland	Unknown	Unknown	< 100%	District heating	Unknown	Electric and thermal	None
					1	1		3	0

[93] ZEB_36_PilotCampusEvenstadadministrationandeducationbuildingas-builtreport.pdf
[94] https://ntnuopen.ntnu.no/ntnu-xmlui/handle/11250/2467668?locale-attribute=no

Name	City	Country	Energy consumption of buildings (kWh/m2/y)	Maximize building efficiency (Y/N)	Energy autonomy (%)	Smart storage capacity (Y/N)	Maximize Load Control (Y/N)	Energy vectors (Y/N)	Mobility (Y/N)
Fujisawa SST	Fujisawa	Japan	Unknown	Unknown	Unknown	Storage battery unit for each household	Unknown	Electricity	EV power charger
						2		1	1
READY Site Växjö	Växjö	Sweden	50-55 kWh/m2/y residential-commercial	Unknown	90 % in heat produced on-site by biomass CHP, 78% of Elec is still imported 30 % Elec, 70 % heat in demand 30 % * 22 % + 70 % * 90% = 70 %	None	None	Electric and thermal	None
			2		0	0	0	3	0
Isle of Eigg	Isle of Eigg	UK (Scotland)	Unknown	Unknown	100% in real time (but not positive).	1 battery	Off grid, so load control needed. Each house can only consume max 5kW and each commercial building max 10 kW	Electricity controlled by island, heating mostly wood, wood pellets and diesel	None
					2	2	3	3	0
Isle of Muck	Isle of Muck	UK (Scotland)	150 kWh/day for 38 inhabitants	None	100% in real time (but not positive).	Battery and thermal storage	Yes, needed in real time	Electricity and heating (wood pellets and diesel)	None
				0	2	3	3	3	0

Name	City	Country	Energy consumption of buildings (kWh/m2/y)	Maximize building efficiency (Y/N)	Energy autonomy (%)	Smart storage capacity (Y/N)	Maximize Load Control (Y/N)	Energy vectors (Y/N)	Mobility (Y/N)
Feldheim	Feldheim	Germany	Unknown	Thermal aspects: district heating network	PV: 2700/y; biogas: 4 million kWh/y; wind: 250 million kWh Yearly autonomous: the town only uses a small fraction of the generated power themselves and sells the rest back to the grid	Electric (capacity 10 MW), for storage of surplus amount of power	None	Electric and thermal	Plug-and-pay EV charging station
				1	2	1	0	3	1
Fort d'Issy	Issy-les-Moulineaux	France	Electricity: 2500 MWh/an Thermal: 11000 to 12500 MWh/an + cooling: 170 MWh Yearly energy consumption = 111 kWh/m2/y *65 kWh/m²/year*[95]	- Insulation with straw and woolen wood - Efficient exposure - Natural ventilation	Electricity: no information Thermal: 78% self-supply Heating water: 40% self-supply	Electric storage, but at the distribution level	Home automation tools (BMS) installed in dwellings with meters to visualization (EMS) of the energy bill in particular)	Mostly thermal	Free floating electric cars parking sharing modal split measures
			1	3	0	1	3	1	3
Ashton Hayes Smart Village	Ashton Hayes, Cheshire	England	1857 GWh per year (calculated in 2012). 350 homes. Assumptions: 235m2/house=22,57 MWh/m2/y	-Electric equipment: increase in energy savings light bulb (+12,81% in 2009) -Thermal equipment: insulation,	3% (12274 kWh) supplied by the village PV in Q2 2012	Electric storage via EV	EMS: monitoring data provide greater insight into demand profiles can allow more efficient means to manage thermal overloads	Electric	Car energy emissions have decreased by 40% and 98%

[95] Updated from Task 3

Name	City	Country	Energy consumption of buildings (kWh/m2/y)	Maximize building efficiency (Y/N)	Energy autonomy (%)	Smart storage capacity (Y/N)	Maximize Load Control (Y/N)	Energy vectors (Y/N)	Mobility (Y/N)
				new boiler					
			3	2	0	2	1	1	1
SMILE islands, Samsø	Samsø	Denmark	Unknown	Unknown	6% of electricity imported Heat supplied from four district heating plants running on woodchips, straw, and solar heat, or by individual heating devices using further biomass, oil, solar collectors, or electricity *437% of the electricity needs covered on an annual basis. 96% of the needs covered on an instantaneous basis.* *71% of thermal needs covered from RES production*[96]	Battery storage and thermal	Building Energy management system and more general system	Electric and thermal	Electric vehicles and boats
			0	0	1	2	3	3	1

Table 22. Technical KPIs and scores

[96] Updated from Task 3

Financial KPIs and scores

Name	City	Country	Energy community (Y/N)	Access to financial support mechanisms from a developer point of view during the construction (Y/N)	Access to financial support mechanisms for the end-user during operation of the project (Y/N)
mySMARTlife	Old Town Bay, Helsinki	Finland	Participation of citizens	Unknown	Unknown
			1		
Nice Grid	Nice, industrial zone of Carros	France	None	Grant: 11 million from public (national:4 million and european:7 million)	Unknown
			0	1	
Plus Energy Village	Wildpoldsried	Germany	Local stakeholder engagement; 300 citizens involved in community wind turbines, association of farmers in biogas operation and sale of heat to community, planning of wind turbines by local farmer in collaboration with communities, over 300 private PV plant	25 % of the total investment volume of around 2.2 million Euro is shared amongst the town's citizens Grant: 100,000 € financed through the Government of Bavaria, while the largest amount was acquired through loans in conjunction with guaranteed remuneration tariffs in 2016 pocketed (about €6m) from subsidies and selling their surplus electricity.	Feed-in tariffs: thanks to Germany's renewable energy law (EEG), which prioritizes wind and solar power over coal and gas, the surplus of electricity in Wildpoldsried is delivered into the grid.
			3	2	1

Name	City	Country	Energy community (Y/N)	Access to financial support mechanisms from a developer point of view during the construction (Y/N)	Access to financial support mechanisms for the end-user during operation of the project (Y/N)
Project SCENe - Trent Basin	Nottingham	UK	Model of involvement in discussion. Trent Basin residents have a choice to join the community energy system Sustainable focus, not only financial Storage managed at community level	Grants: Utilizing funding from the Energy Research Accelerator (ERA) and Sustainable Community Energy Network (SCENe) National Grid contributes to the commercial viability of the community energy system, through the potential to benefit from revenue streams derived from transactions with the National Grid.	Feed-in tariffs: The National Grid is prepared to pay a premium price for energy that it uses when demand peaks or supply falls. Hence the commercial viability of the community energy system is much enhanced by being able to sell energy to the National Grid at a premium price and buy energy from the National Grid to top up the battery when demand is low and energy prices are low. Profits made by the ESCO will help to cut energy bills for residents who opt in to join the scheme and share its benefits. The panels are installed by experts and maintained free of charge.
			3	1	2
Smart Grid Gotland	Gotland Island	Sweden	No	Grant (15 million kronor=45% of total project budget) from Swedish Energy Agency	A subproject called Smart Customer Gotland examined potential of flexible consumption, with the intention of using price signals as a motivator for such an engagement. It explored three components of the electricity price that could establish price signals: the grid tariff, the electricity tariff, and an occasional price reduction called the wind compensation. It was in exploring these different components that the subproject ran into challenges caused by the regulations of the electricity

Name	City	Country	Energy community (Y/N)	Access to financial support mechanisms from a developer point of view during the construction (Y/N)	Access to financial support mechanisms for the end-user during operation of the project (Y/N)
					market. (there is not a local spot price on Gotland)
			0	1	0
Smart Grid Hyllie	Malmo	Sweden	Not primarily	Unknown	Some kind of incentive: When more electricity is generated than consumed, prices fall
			0		1
Savona Campus Living Lab	Genova	Italy	Only one organization concerned: university	Funded by Italian Ministry of Education, University and Research (value of the project: 2,4 million Euros): 90% Italian Ministry for the Environment and the Protection of Land and Sea, 10% UNIGE	Thanks to improved energy performances, the campus can financially support research activities and yearly upgrade the two pilot plants SPM + SEB The energy bill of the Campus has been reduced since a lower amount of electricity has been withdrawn from the public grid and the use of natural gas for boilers has been limited.
			0	1	1
HIKARI	Lyon	France	None	Private finance (NEDO). The next step is to make it economically feasible.	Unknown
			0	0	

Name	City	Country	Energy community (Y/N)	Access to financial support mechanisms from a developer point of view during the construction (Y/N)	Access to financial support mechanisms for the end-user during operation of the project (Y/N)
Campus Evenstad	Evenstad	Norway	No	Enova financial support for wood chip-based CHP (Y)	no
			0	1	0
Smart Energy Aland	Aland Island	Finland	None	unknown	unknown
			0		
Fujisawa SST	Fujisawa	Japan	Yes (sharing of electricity)	Unknown	Unknown
			1		
READY Site Växjö	Växjö	Sweden	No	Unknown	Unknown
			0		
Isle of Eigg	Isle of Eigg	UK (Scotland)	Yes (sharing Elec)	National + European (+ some inhabitants)	Yes, cheaper electricity for the inhabitants compared to before with Diesel engines
			3	2	1
Isle of Muck	Isle of Muck	UK (Scotland)	Y	1m£ funding	Unknown
			3	1	

Name	City	Country	Energy community (Y/N)	Access to financial support mechanisms from a developer point of view during the construction (Y/N)	Access to financial support mechanisms for the end-user during operation of the project (Y/N)
Feldheim	Feldheim	Germany	High involvement of the community The citizens of Feldheim are the owners of the energy company	Heating: 50% public subsidies (EU, national 75% EFRE, 25% stage budget) electricity: None	Price reduction: Operating company is owned by the citizens of Feldheim. After the one-time payment of EUR3000 for the connection to the heating network, consumers pay a basic charge of EUR 29.95 plus 0,075 EUR/kWh for heat, and EUR 5.95 plus 0,161 EUR/kWh for electricity. The measures resulted in an overall energy cost reduction by 15% compared to standard tariffs .heat: 10 percent less than before. Feed-in tariffs: power of wind turbines fed in the grid with feed-in-tariff rate.
			3	1	2
Fort d'Issy	Issy-les-Moulineaux	France	Primary purpose: provide environmental, economic or social community benefits to its members or shareholders or to the local areas where it operates rather than to generate financial profits. Test via inhabitants participating	Contractual management of district heating network + subsidies from ADEME and region ile de France	Subscribers benefit from an attractive pricing, thanks to the VAT reduced to 5.5% (70% of residents declare having realized savings on their bills (but we do not know if due to energy consumption reduction))
			2	2	1
Ashton Hayes Smart Village	Ashton Hayes, Cheshire	England	1 dimension: Consulting with the residents of Ashton Hayes has been crucial throughout the project to get their views and feedback	Grant: government grant of £400,000 n August 2010. The grant, awarded by the Department of Energy and Climate Change under its Low Carbon Communities Challenge project, is used to install a sustainable combined heat and power boiler to supply heat and electricity to Ashton Hayes Primary School and feed the surplus into the community	None

Name	City	Country	Energy community (Y/N)	Access to financial support mechanisms from a developer point of view during the construction (Y/N)	Access to financial support mechanisms for the end-user during operation of the project (Y/N)
				microgrid	
			1	1	0
SMILE islands, Samsø	Samsø	Denmark	Energy community	Unknown	Unknown
			3	0	0

Table 23. Financial KPIs and scores

Environmental KPIs and scores

Name	City	Country	Reduction in annual final energy consumption (Y/N)	Local renewable share in electricity, heating, cooling production (%)	Carbon dioxyde emission (kg eq. CO2/m2/year)
mySMARTlife	Old Town Bay, Helsinki	Finland	Unknown	Unknown	Unknown
Nice Grid	Nice, industrial zone of Carros	France	22% reduction of electricity consumption during peak days for residential consumers. Unknown because only off-peak	100% PV during islanding	Unknown
Plus Energy Village	Wildpoldsried	Germany	Unknown	Elec: 456% Heat: 66% 100% of the public buildings are heated by means of	Unknown

Name	City	Country	Reduction in annual final energy consumption (Y/N)	Local renewable share in electricity, heating, cooling production (%)	Carbon dioxyde emission (kg eq. CO2/m2/year)
				biomass. The renewable energy sources of Wildpoldsried include 11 wind turbines, a biomass plant sourced by local farmer's bio-waste, 3 small hydropower systems, and more than 2,100 m²of solar thermal systems	
				3	
Project SCENe - Trent Basin	Nottingham	UK	aims to cut local energy grid demands by up to 35%. Unknown as only a statement	% of PV unknown. Not independent for sure.	Unknown The buildings at Trent Basin perform 20% - 30% better than the Building Regulations currently stipulate, and are claimed to reduce carbon emissions by some 15%
			0	0	
Smart Grid Gotland	Gotland Island	Sweden	Load shifting	Capacity of renewable energy sources currently limited to 195 MW 160MW wind power installed on the island of Gotland	Unknown
Smart Grid Hyllie	Malmo	Sweden	Unknown	Significant share of the energy production locally produced in solar photovoltaics. New Hyllie-destined wind power production is planned in the region and E.ON has commissioned the Flintrännan biofuel-based district-heating plant in Malmö.	Unknown
Savona Campus Living Lab	Genova	Italy	Yes but no numbers	Electricity: about 40% from renewables Thermal: about 5% from renewables (geothermal plant started to operate)	To be about 810 tCO2/year => 13,5 kgCO2/m²/y As-is: 890 tCO2/year
				1	1
HIKARI	Lyon	France	Energy consumption has been reduced by 15%. Unknown because no clear point of comparison	Production : 1503 GWh/year -A co-generation power station (that produces both electricity and heating) operating on canola oil produced in the region - A photovoltaic power station supplying the remaining needs in electricity for the three buildings (production capacity: 200 kWh - A chiller produces ice water from heat supplied by co-generation and the coldness of water drawn from the water table by geothermal drilling	HIKARI is classified in Category A in CO2 emission according to BEPos (1.8 kg-eq CO2 / m²/year

Name	City	Country	Reduction in annual final energy consumption (Y/N)	Local renewable share in electricity, heating, cooling production (%)	Carbon dioxyde emission (kg eq. CO2/m2/year)
				Electricity: PV (1/3), co-generation (67%), remaining from the grid = 3% Thermal: cogeneration with Colza (87%) and remaining with gas boiler 67% of electrical needs and 87% of heating needs are covered by the CHP installation (remaining electricity is ensured by photovoltaic units and remaining heat by gas boilers) Average of local renewable share = (3%+87%)/2=58,5%	
			0	2	2
Campus Evenstad	Evenstad	Norway	unknown	see KPI energy autonomy --> 58%	Net zero carbon building --> 0
				2	3
Smart Energy Aland	Aland Island	Finland	unknown	Will be 100 %. Unknown today but should not be very high.	Unknown
Fujisawa SST	Fujisawa	Japan	Unknown	30%[97]	Unknown
				1	
READY Site Växjö	Växjö	Sweden	50% of some buildings 24% for elec and 43% hot water through smart metering. Unknown reduction from other energy efficiency measures	60 % (mainly biomass locally produces, wind, hydro, biogas, PV, geothermal)	Unknown 2.4t CO2/capita 2005
			0	2	
Isle of Eigg	Isle of Eigg	UK (Scotland)	Unknown	RES share electricity: 98% RES share heat: assumed to be 50 % (some solar thermal for residential, most heating of communal places (shops, churches, ...) in winter done electrically) Assumptions: 20 % elec, 80 % heat consumption on island (Typical UK values) RES share = 20 % * 98 % + 80 % * 50 % = 58 % RES share	Unknown

[97] https://www.livingcircular.veolia.com/en/city/fujisawa-sustainable-paradise

Name	City	Country	Reduction in annual final energy consumption (Y/N)	Local renewable share in electricity, heating, cooling production (%)	Carbon dioxyde emission (kg eq. CO2/m2/year)
				2	
Isle of Muck	Isle of Muck	UK (Scotland)	Unknown	Unknown but should be high	Unknown
Feldheim	Feldheim	Germany	Unknown	100 % heat and electricity from renewable energy sources at low costs: 43 wind turbines (71 MW, solar park (2,26 MW), biogas plant (499 kW for elec, 533 kW for heat), 297 kW heat buy woodchip heating system	yearly reduction of around 208,000 tons of CO². 100% Co2-neutral
				3	3
Fort d'Issy	Issy-les-Moulineaux	France	Thermal: if the choice had been made for a conventional gas installation, consumption on the entire eco-neighborhood would have reached up to 13,000 MWh of gas per year. => reduction in gas consumption = 10% (own calculation) Electricity: unknown	Thermal: geothermal covers for 78% of thermal needs. 22% (own calculation) remaining by electricity that feeds heat pumps Water: 40% of hot water needs covered by renewables average of heating and cooling = 59%	Unknown Save 2,000 tonnes of CO2 per year.
			3	2	
Ashton Hayes Smart Village	Ashton Hayes, Cheshire	England	Unknown	3% of electricity supplied by PV (in 2012)	Unknown Carbon dioxide emissions cut by 23% between 2006 and 2012. In 2012: 213 tonnes of carbon emissions associated to the village electricity supply. 2012: 213 tonnes of carbon emissions.
SMILE islands, Samsø	Samsø	Denmark	Unknown	Electricity: 94% is produced by wind and PV and the remaining 6% is imported. heating:The biomass heating share is 69% in the reference system with 35% of the heat supplied through district heating, but still 18% from oil boilers; The electric and solar heating shares are at 11% and 2% (94+69)/2=85%	CO2 emissions are below 10 kt per year compared to the reference model with 59.5% and 28.5 kt. 114 km =10000/114000=87,17 kg of CO2/m²/y

Name	City	Country	Reduction in annual final energy consumption (Y/N)	Local renewable share in electricity, heating, cooling production (%)	Carbon dioxyde emission (kg eq. CO2/m2/year)
				3	1

Table 24: Environmental KPIs and scores

Appendix 3: summary of interview questions

INTERVIEW QUESTIONS

INTERVIEW QUESTIONS

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From: Tractebel Impact - SS EMEAI

To: Sustainable Energy Blocks project manager (Target audience)

Date September-October 2019

☐ Confidential ☐ Restricted ☒ Internal ☐ Public

SUBJECT: Interview project leaders on (Positive) Energy Blocks initiatives

We are a consulting company appointed by the European Commission to investigate best cases of existing Positive Energy Buildings Blocks (PEB) into detail, that stand out in terms of innovation and performance. The goal is to understand technical and regulatory specificities as well as understand the process of development and operation or each initiative, in order to give recommendations to future Positive Energy Blocks.

The definition of PEB has been introduced under H2020 Programme, with the following characteristics:

- Annual positive energy balance
- Actively manage their energy consumption and energy flows
- Optimal use of elements
- Integral part of the district/city energy system
- Scalable

After evaluating a wide range of sustainable Energy Blocks, the project XXX has been identified with the European Commission as a best case of Energy Blocks that has reached or is close to the level of being Energy Positive, and that could be replicable in an urban setting.

The interview will cover the four following dimensions, with the goal to highlight best practices and lessons learned at technology/financial/regulatory level to remove barriers:

- Technical solutions used to achieve (or not) positive energy levels

- The financial viability on the business model
- The regulatory and legal dimensions (e.g. administrative risks, synergies with existing policies, consistencies of existing standards)
- The interaction strategies between stakeholders (e.g. in terms of involvement)

Technical specificities

In this part we will discuss your experience related to the technical aspect of the energy block. Here are some examples of questions we could discuss together.

- Since when is the project in operation in terms of energy? Has there been changes since then?
- What are the typical production and consumption activities of the (positive) Energy Block, regarding the electricity and the thermal vector?
- Does the Energy Block in your project produce more electricity/thermal energy than it consumes? On which time basis (yearly, monthly, hourly)? If not, why not?
- Did you already have technical issues with the technologies installed? If so, how did you resolve them?
- Would you install different technologies or what would you change if you could go back in time?
- Are the costs for energy efficiency technologies (e.g. isolation) worth the energy reduction obtained? What would you do differently?

Financial viability of the business model

In this part, we would like to hear about your experience regarding the financial viability of the business model, with a focus on the energy system (rather than the whole project). Here are some examples of questions we would discuss during the interview.

- Did you have any issues to finance this project? If so, how did you resolve them?
- What are the financial mechanisms leveraged from the perspective of users during the operation (e.g. feed-in tariffs, joint energy transaction, subsidies, etc.)?
- What are the multiple benefit streams from an energy perspective (e.g. savings from self-consumption, profit from selling to the grid, etc.)?

Regulatory framework

In this section, we want to understand the regulatory framework in which your project is operating and if it consists of a barrier or an enabler, regarding several energy aspects. Here are questions that we would like to discuss during the interview.

- In your project, what is according to you the level of suitability of the legal framework for the integration of:
    - o self-consumption of local RES production?

  - o energy flexibility policies such as incentives for shifting peak consumption?
  - o managing surplus of energy production?
- Are there currently demand response schemes at your (positive) Energy Block? If so, how would you say demand response is implemented at your premises (e.g. use of detailed smart meter data for behavioural changes in electricity consumption, time of use or dynamic tariffs, financing schemes negotiated for the project)?
- Have the inhabitants of the buildings been pro-active in these existing demand response schemes?
- How do you perceive potential change in rules and regulations? Is the operation of the project threated by the potential changes in rules and regulations?

Stakeholders' management

In this last section, we would like to know more about the management of stakeholders (role of stakeholders, integration of ICT with users, citizen participation during the development and operation of the project.

- Who are the key stakeholders in the initiatives, from an energy perspective (e.g. citizens, SMEs, local authorities, etc.)? What is their role (investors, aggregators, community managers, energy efficiency services, etc.)? What is the role of the citizens regarding energy?
- The implementation of ICT solutions can be related to the involvement of the users in the control over the energy use in the building. What is the level of consumers' engagement towards ICT? If you could do something differently regarding the involvement of users in IT solutions, what would you do?
- To what extent residents/users have been involved in the development and operation process (before the project was operational)? Did you find it useful? Would you do something differently?
- To which extent does the project, from an energy perspective, offer clear advantages to stakeholders? Are those advantages specific to the energy autonomous aspect of the project?

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