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Integrated local energy systems (Energy islands)

RENergetic

Community-empowered Sustainable Multi-Vector Energy Islands

Project Nº 957845

D7.1 – Preliminary European Analysis on Obstacles to Innovation Around Energy Islands

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Executive Summary

This deliverable contains a preliminary analysis of obstacles and barriers that one is challenged with when developing a self-sustainable energy island. This document covers the basis for further research from which the results will be presented and discussed in upcoming deliverables. The output of this preliminary analysis can be used as input for the work on replicability.

The first chapter describes the purpose and scope of this document in more details. The second chapter introduces the concept of a local energy communities that aim to become more self-sufficient by introducing renewable energy sources as main energy source. Renewable energy comes with new demands and uncertainties that need to be tackled. In this chapter, the possible legal problems and social challenges are described as well as a list of technical requirements for an energy management system. In chapter 3, the economic analyses framework that will be used is described. Starting from roles as main building blocks, a complete value network is constructed to visualize the flow of the different value streams. Finally, the first obstacles and barriers discovered during the creation of test pilot sites are described and summarized.

The objective of RENergetic is to demonstrate the viability of so-called 'urban energy islands'. Energy islands seek to achieve the highest possible degree of self-sustainability with regards to the supply of its energy demand, be it electricity or heat through local renewable resources. At the same time an urban energy island may offer ancillary services to the public grid surrounding it.

These islands place the consumer at the centre of the energy transition, giving them an active part in energy communities capable of producing their own energy, sharing the surplus with the rest of the public grid and optimizing consumption. RENergetic will demonstrate that Urban Energy Islands increase the amount of renewables in these areas as well as the energy efficiency of local energy systems. RENergetic will demonstrate the viability of this energy islands in three site pilots, each of them of a different nature: New Docks, a residential area in Ghent – Belgium, Warta University Campus in Poznan, Poland and San Raffaele Hospital and its investigation and research campus in Segrate-Milan, Italy. The impact of the Urban Energy Islands is assured as technical, socio-economic and legal / regulatory aspects are considered while safeguarding economic viability.

RENergetic will be carried out over the stretch of 42 months involving 12 European partners: Inetum (Spain, France, and Belgium), Clean Energy Innovative Projects and Gent University (Belgium), Poznan University of Technology, Veolia and Poznan Supercomputing and Networking Center (Poland), Ospedale San Raffaele, Comune di Segrate and University of Pavia (Italy), Energy Kompass GMBH (Austria) and the University of Mannheim and the University of Passau (Germany).

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VI. Summary	Bryan Verfaillie	

Table of Contents

Table of Figures

List of Tables

Table of Acronyms and Definitions

AI	Artificial Intelligence
API	Application Programming Interfaces
BMS	Building Management System
DHN	District Heating Network
EC	Energy Community
EI	Energy Island
EMS	Energy Management System
ESCO	Energy Service Company Provider
HRM	Harmonized Role Model
LEC	Local Energy Community
WP	Work Package
GSE	Gestore Servizi Energetici - Energy Services Manager
CAPEX	Capital Expenditure

I. INTRODUCTION

I.1. Purpose and organization of the document

The idea within the RENergetic project is to build energy islands that are self-sustainable using more and more renewable energy sources. Although these green alternatives are better for the environment and reduce the carbon emission, they demand a big financial investment.

This document should give a brief update on the state of the project at this moment. A lot of information has been gathered among the different stakeholders in the project. This deliverable aims to bring this information together, focussing on the obstacles and barriers in the creation of energy islands. This document covers the basis for further research from which the results will be presented and discussed in upcoming deliverables.

The remaining of the document is structured as follows. Chapter II introduces the concept of Local Energy Communities that want to become more self-sufficient by introducing renewable energy sources. Renewable energy comes with new demands and uncertainties that need to be tackled. In this chapter, the possible legal problems and social challenges are described as well as a list of technical requirements for an energy management system.

In chapter III, the economic analyses framework for evaluating different scenarios is introduced. Starting from roles as main building blocks, a complete value network is constructed to visualize the flow of the different value streams.

In chapter IV, the first obstacles and barriers discovered during the creation of test pilot sites are described. Finally, chapter V contains a summary of the currently identified obstacles and barriers.

A broader overview on what is covered in this deliverable can be found in the next section.

I.2. Scope and audience

This deliverable covers a preliminary analysis of obstacles and barriers one can be faced with when creating innovative energy islands. This deliverable is based on information gathered along different work packages in the RENergetic project. At the end of the project, this document will be updated into deliverable 7.6, which will contain a final evaluation on these topics.

From work package 2, especially tasks 2.1 and 2.2, the first information on previous research in this domain is gathered. This section captures the different approaches behind the creation of an energy island and their impact as well as the different strategies to incentivize the community, as social engagement seems to be an important factor. We take note of the most innovative and creative approaches. Besides the ideas, a first attempt is made to get insights in the needs of the local stakeholders.

From work package 3, we learn about the technical requirements for an ICT-system that helps to monitor and manage the energy consumption along the different energy vectors.

The different pilot sites (WP 4, 5 and 6) also have their contribution to this deliverable. They are building a local energy community to evaluate the different possibilities. During this process, they have faced or will face different obstacles and barriers. In this preliminary analysis, the first set of barriers and obstacles discovered so far are listed together with possible countermeasures.

Finally, work package 7 has its contribution in the legal analysis. Laws and regulations are complex and can be different amongst different countries if there is no central organisation. These laws can limit the possibilities of innovative energy islands and the differentiation between countries can complicate the replicability. Within the subtask 7.3 of WP-7, the possible legal barriers are brought under attention. Besides the legal aspects, WP-7 is also responsible for the Cost-Benefit Analysis framework. In this preliminary version, the methodology and approach are described that will be used during the next steps of the research. This will eventually come together in deliverable 7.4.

This deliverable targets a broad audience with an interest in innovative energy islands. This preliminary analysis provides insights into the further research and what can be expected in the future.

II. Situating Local Energy Communities

In this chapter, the concept of a Local Energy Community (LEC) is introduced. A LEC is the core concept withing the RENergetic project. The aim is to create sustainable energy islands that try to be self-sufficient. Becoming self-sufficient by using renewable energy sources requires another way of consuming energy. In this chapter, the social barriers, the possible legal issues that may arise, and technical requirements are described.

II.1. Local Energy Community

An Energy Island (EI) is defined as a geographically delimited system that is to a considerable extent self-sufficient with regards to all present energy vectors. On the energy supply side, this implies that a great share of the energy needed is generated within the energy island boundaries. On the demand side, it implies that the energy consumption is optimized throughout all energy vectors and demand profiles are adapted as necessary. In simple words, a Local Energy Community (LEC) is a community that decentralizes the energy production. The energy is produced closer to the place where it is consumed.

This research focuses on self-sufficient and sustainable LECs that produce their own energy via renewable energy sources, for instance, photovoltaic panels powered by the sun. Figure 1 gives an illustration of this concept.

The transition towards renewable and sustainable energy sources is driven by the global climate targets. First, the amount of greenhouse gasses must be reduced. Therefore, a lot of applications are electrified which increases the need for electricity. On the other hand, limited resources as fossil fuels and the polluting traditional power plants require alternative ways to produce energy.

Introducing a high level of renewable energy comes with technical challenges and societal conflicts to overcome. The production, storage, and demand along and within the different energy vectors should be carefully orchestrated. Smart devices and grids, together with management systems should allow to better correlate the energy production (plant loads) and the demand.

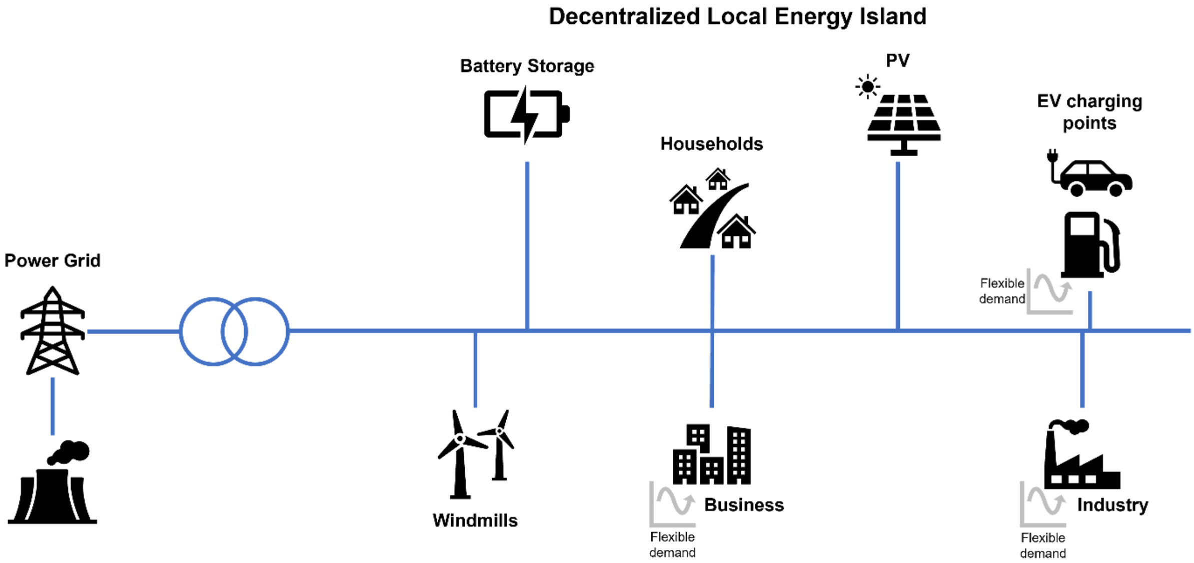

Figure 1 Illustration of a Local Energy Community with different renewable energy sources in the decentralized part of the grid.

II.2. Social Barriers

The challenge of engaging end users in pursuing the objectives of an energy island (EI) as defined in II.1. are manifold. First, end users have to be made aware of tasks that are lying ahead of them, then they need to be actively engaged to start using a tool, accepting external control (e.g. of EV charging) or even to change their behaviour. Finally, the arguments for striving for EI objectives must be so convincing that they maintain a high level of engagement throughout the context of the EI project and beyond. In essence, literature has shown that this is easier if people are not addressed as individuals but in the context of a group. In order to first successfully engage end-users and then maintain their activisms, a set of barriers have to be overcome. This will be elaborated in the following sections.

II.2.1. Literature Analysis

II.2.1.a. Barriers

There are two main categories of barriers: factual barriers that prevent the realization of EI independent of legal regulations, e.g., the lack of adequate infrastructure or permits, and socio-psychological barriers that are associated with apprehension and attitudes of potential EI participants.

Based on a huge set of case studies dealing with the installation of energy communities, the ECHOES project has shown that these factual barriers have a huge impact on the motivation of potential participants [1]. This topic is closely linked to the fortune of EIs. Beggio & Kusch [2] and Walker & Devine-Wright [3] investigate infrastructure based energy communities, both in the context of REScoop (the European federation of citizen energy cooperatives) and desk research. Aside from regulative barriers as e.g. preventing the peer-to-peer trading of electricity (see section II.3), the main factual barriers lie in:

- Administrative factors, such as market barriers, with respect to trade flexibility or the difficulty of obtaining access to green energy certificate, as well as billing and metering arrangements adversary to heat or electricity trading.
- Economic factors, e.g. when the economic viability depends on precarious funds, or badly designed economic frameworks without market incentives for heat production and trade, and high overall implementation cost. Competition for funding may be high in areas where more than one energy project is planned. This was viewed as a huge barrier in a paper based on desk research on energy communities [4]. Also, in general the price level of energy is comparably low so that in many regions energy cost comprise only a small part of the budget of a household: the share of energy expenditure at household budgets in Europe vary between 3-8% for middle income households in western and northern Europe and 10-15 for central and eastern EU countries [5]. All this leads to a low perceived value of energy [6].
- Technical factors as the missing of standards for the real-time collection of data or GDPR issues that leads to a gap between data available and data that would be needed to implement demand response (smart meters). Obviously, this stretches to a lack of reliable and consistent billing methods [4].
- Organizational factors as the lack of ground or space to put PV panels or a lack of communication among energy communities as well as a lack of information about opportunities to engage and/or invest. Also a lack of time to engage actively in energy communities was named frequently in interviews [7], [8]. The maintenance of ECs already started in some cases was made impossible by complex, sometimes hierarchical decision structures and communication problems [8], [9].
- Knowledge factors impede the creation, maintenance and/or development of ECs, especially when administrative processes and the technical setup are complex [8] .

Once these factual barriers are removed, more deeply rooted social and psychological factors become influential. These are mainly:

- A general lack of awareness and environmental concerns, which was found by the ECHOES project through in-depth interviews in a big set of case studies, as well as a case study of an environmental project in Devon that also focused on the lack of interest [10].
- A certain lack of community spirit that hinders collective initiatives, also a result of the ECHOES analysis.
- A general NIMBY (not in my backyard) attitude which is widespread among people generally supporting the idea of energy turnaround, but being unwilling to accept changes in their own surroundings [2].
- Some case studies found that specifically in Eastern European countries (like Estonia), there are negative stereotypes regarding collective ownership. In interviews, people named the forceful nationalization of property such as kolkhozy (cooperative-run farms) and sovkhozy (state-run farms) as their main reason for reserve [11].
- Resistance to change is one of the core barriers that has been found by many different studies, be it based on interviews as in the ECHOES project or relying on surveys as for instance in a study by Rogers [9]. It is usually paired with a desire to maintain the status quo, inertia and scepticism, fear, and anxiety. This is all the more impactful as people on general are rather satisfied with the current, utility-based set-up of the energy system where they do not need to take up responsibility but are supplied with energy whenever needed [8].
- Cultural values and social norms are one of the major barriers to join ECs, as nowadays REN production technologies are still considered not mainstream and thus go along with a low level of social acceptance [2]. This leads for instance to the situation where people generally feel less disturbed by the sight of PV installations than by wind energy converters [8].
- Finally, one finding by Bauwens [12] reports that individuals today are often only self-regarding, that means that they only care about their individual pay-off and do not engage into a broader good.
- With regards to demographic characteristics it was shown that the level of education and impact and gender play an important role with regards to the willingness to participate in ECs [8]. This means that basically young female, low income, low education people are virtually excluded from energy communities [13].

II.2.1.b. Overcoming the Identified Barriers

This long list of barriers shows that without active support from public players the prospects of EIs nowadays are still limited. With advancing legislation and regulation, this will change, but currently the factual barriers greatly limit the settings that energy islands can realize, especially with regards to EC with a formal underpinning. However, tackling the socio-psychological obstacles leads to a reduced meaningfulness of the factual barriers as people who are set on reaching an objective to some degree will find a way around.

Fortunately, psychological literature offers some starting points how to boost motivation and thus overcome a great part of the identified barriers, even though a lot of research gaps prevail. The main findings, also mentioned in the introduction, are that a community identity offers more support for individual motivation than just a person ploughing their own furrow; the main drivers here being the creation of in-group social norms combined with a higher level of perceived self-efficacy in the context of a group with common goals [2], [12]. This implies that the way that feedback is provided with regards to the achievements of these goals [14] should also be a core design aspect of an EI. The second key factor of overcoming the lack of motivation is to build up trust, as a pre-requisite for cooperation and goodwill [11], [15] in various aspects of setting up EIs. On the one hand trust in the community itself, but also trust in the public institutions surrounding the EI.

This general understanding will be examined more closely in the context of RENergetic, in close collaboration with the RENergetic pilots and the inhabitants of the developing EIs.

II.2.2. First RENergetic Results

As the current focus of the project in terms of user engagement and necessary behavioural changes by local stakeholders, lies mainly on different demand response concepts, the barriers and motivators regarding to the acceptance of such systems have been examined closer. In order to better understand whether and how to influence the acceptance of automation or active behavioural change based on demand response and what barriers may arise in this process, existing scientific evidence was examined and interviews were conducted with local stakeholders (e.g., residents/students/faculty and staff) on site at the respective pilot sites. As the RENergetic Pilots will focus mainly on implementing Heat Demand Response and EV Demand Response, the main purpose was to clarify on barriers and motivators to overcome the barriers for these systems.

In the context of demand response in the heating sector, the associated barriers must be taken into account in order to increase acceptance. Even with a purely automated version of your demand response system, acceptance - in the sense of consent to such a system - plays an important role. In addition, it must be taken into account that a change in heating behaviour represents a greater hurdle than other areas of demand response: Literature suggests that acceptance of demand response systems varies between different devices or operations and the acceptance for heating is lower than for more flexible electric devices like dishwashers or washing machines [16]. Adams et al. [17] summarizes that perceived loss of control related to automation and demand response is one of the main barriers: this is due in part to the fact that the home is associated with a sense of privacy and autonomy, and demand response systems can be perceived as an intrusion into this sphere. The authors therefore emphasize trust, and predictability of the systems as well as a possibility to regain control as crucial criteria for acceptance. Another barrier is inconvenience, which is associated with changes in one's own behaviour patterns. This pattern is also reflected in the preliminary results of the interview analysis with various stakeholders in the respective pilot sites: a possible loss of comfort is cited as the biggest barrier to a heat demand response system at work or in the living quarters of the respective interviewees. This concern about discomfort is followed by concerns about loss of control and reduced ability to influence or hassle caused by the system. In contrast, financial incentives, technological possibilities, and social and environmental motivations are mentioned several times as possible motivators. The main issue here therefore seems to be implementing Heat Demand Response in such a way that individuals are not restricted in their comfort and continue to maintain some sense of control while being compensated for this change, whether through financial incentives or alternative incentive systems.

Regarding Smart Charging and EV Demand Response, literature showed that financial incentives seem to be quite effective when the rebate is of a significant size. Still, when meeting the right target group, environmental incentives show effective as well. Stressing health benefits could further be a way to more successfully communicate environmental benefits to EV users [18]. To overcome possible barriers in Smart Charging Systems, they have to provide guidance and assistance in minimizing effort for the user and should consider the users' objectives regarding the charging process [19]. This is especially true considering that loss of control can become a significant barrier, implicating that building trust and confidence is key for convincing users: The third party (between user and provider) involved in utility-controlled programs must be considered trustworthy [20]. These findings from existing evidence fit well with the preliminary findings from the stakeholder interviews conducted in the pilots with various local stakeholder groups. In a hypothetical EV DR scenario, barriers named include both uncertainty about the operation of such a system and the reliability associated with the system, loss of control, and potential limitations on the availability of the service and the time loss associated with it. In contrast, when individuals were asked about potential motivations for such an EV DR system, financial incentives were clearly the most frequently cited. However, it was also seen as a motivator if, contrary to the concerns mentioned, it can be ensured that the system is clearly predictable and can be clearly controlled with the help of technology. In addition, environmental incentives play an important role for some of the stakeholders.

In all reported results from the RENergetic Interviews, however, it must be included that this is a preliminary analysis from a subsample (N = 10) of the interviews conducted. More detailed findings will be obtained from the additional interviews and a possible survey.

II.3. Legal Barriers

The electricity market and heat market are strictly regulated. Price ranges are fixed and the responsibilities of each entity involved is clear. Creating an energy island where the production is decentralized might not fit well in the current regulations. Many other risks or barriers can exist within the laws and regulation. In this section, these risks and potential barriers are listed. Not all problems will be easy to solve but at least, it gives an idea of what should change or be addressed to favour the creation of LECs.

II.3.1. Work Method

The legal framework of all three energy pilots within the RENergetic project will be investigated. The focus is on the energy related legal hurdles faces and its solutions. The process can mainly be divided into three phases.

In a first phase, the goal is to collect information through publicly available resources and a questionnaire filled in by the pilots. This allows to identify the legal basis and the energy related legal hurdles the pilots are facing. The second phase will focus on finding legal answers for the faced hurdles and will therefore also look at solutions found in other projects. Both within national legislation as well as in European legislation. In the last phase, the reproducibility of the legal answers is investigated. We will check whether the proposed solutions can be easily applied in different countries (within the EU). The required preconditions therefore are collected and analysed.

II.3.2. Overview of the current identified legal hurdles

II.3.2.a. Ghent, Belgium – Nieuwe Dokken

The pilot site in Ghent is divided in three sections, all constructed in different phases planned from 2019 until 2024. The north field (phase 2, under construction), the central field (phase 1, operational) and the south field (phase 3 and 4, starts in 2024). A direct line will connect 120kWp on the roofs of the buildings in Northfield, and up to 50 additional EV-charging points. 125 additional housing units will be connected to the utility systems of DuCoop.

For the demo-site, the local implementation of the energy community's legislation in Flanders will be analysed, with the focus on the energy directive, regulation (VREG), and tariffication (Fluvius, DSO).

Legal hurdles

Most of the legal hurdles in the Ghent project concern the question of energy sharing in closed distribution network instead of the classic distribution network.

- Are there legal options for installing building-integrated PV panels on residential towers by means of a system of third-party financing whereby the project developer can also use the PV panels to achieve the intended share of renewable energy (EPB obligation), as well as the residents?
- In the case of the South Field, there is no direct line to the Central Field. This means that the PV panels will be connected to the distribution network via a separate transformer. Would it be possible for the residents as well as DuCoop to purchase this flow within a structure of 'jointly active customers'?
- In the case of the North Field, there is a direct line to the Central Field, over the public domain. Can we set up a system in which DuCoop/the residents of the northern field buy the power from the PV panels on Koopvaarders (e.g., as 'jointly active customers')?
- What are the options for DuCoop to offer its own or external local green energy to the residents through a group purchase or through a 'Renewable energy community' structure?
- Can demonstrable local balancing of the distribution network be taken into account?
- Is it also possible to work with a direct line over the public domain?

II.3.2.b. Segrate, Italy - OSR

The project is composed of two different sites, the San Raffaele Hospital (OSR) and Milano 2, a neighbourhood of the Municipality of Segrate. Milano 2 is composed of private buildings (housing, commercial activities, and offices) and public buildings. Both sites have a common heating system. This heating system is managed by “Comunione Calore” or Heat Community, that is legally a “comunione” or community and that is owned by the landlords (private owners and Municipality of Segrate). The Comunione Calore defined an agreement with OSR for the furniture of heat. The electric system is managed by the national agency (or its emissaries).

Legal hurdles

Most legal hurdles concern the questions of lack of definition and differentiation between RECs (Renewable Energy Communities) and CECs (Citizens Energy Communities), as well as feasibility of the provisions in real scenarios.

- Lack of documentation as the “Comunione Calore” was created in the late 1990s. So, no overview of past legal hurdles.
- There is uncertainty about the correct definition of an “energy community” or an “energy island”. This prevents the verification of the exact correspondence between the technical or scientific definition and the legal one.
- There is also confusion with the private operators on the different qualification of REC and CEC (in the EU directives). This confusion can also badly affect the clarity and certainty of the national legislation.
- Within the Italian legislation the provisions of RECs and CECs might not be applicable to thermic energy.
- The limitation of plant power for RECs is limited to 1 MW, which might limit the energetic capacity of the communities and the extension of the community.

- The exclusion of big enterprises and the exclusion of medium enterprises from CEC's could be considered as a restriction of the free competition within the electric energy market.
- Energy distribution can only be carried out by RECs through existing facilities. However, CERs are entitled to realize a storage system.

Regulatory and administrative hurdles

- There have been several administrative hurdles when constructing the energy system. This includes the plurality of additional administrative competencies, the prevalence of cultural and/or environmental interest, and long duration of the procedure.
- Then there were several hurdles when connecting the plant and Energy Community accreditation with the GSE (Gestore Servizi Energetici - Energy Services Manager), this is the public entity created by the Italian State in order to follow up on the implementation of the renewable energy policy. This includes the required documentation, the existence of two informatic portals in which the second does not allow to change the data of the first.
- Lastly there was a hurdle with the energy remuneration by the GSE. This mainly comprised of having to provide the GSE many data and documentation, without which it is not possible to obtain any remuneration for the produced energy.

II.4. Technical Requirements

To get a better insight in our consumption pattern and to optimize the usage of our energy, especially when the demand may exceed the supply, there is the need for a tool. The software packet should allow us to visualize the consumption patterns and allow to steer the consumption wherever this is possible. For example, the heating of an office depending on the available heat a moment without compromising the comfort of the occupants.

II.4.1. The Vision on EMS

RENergetic ICT Solution is developed to bring different users together and allow them to participate in optimization of energy consumption inside the energy island.

Every energy island consists of different types of buildings with diverse equipment installed. Almost in all modern buildings, an energy management system (EMS) is installed. It collects data from connected sensors, meters, and other hardware. Using these software systems, energy managers of buildings control equipment in electricity and heat, ventilation and air conditioning domains. Most of EMS utilize proprietary solutions and non-standard interfaces. Usually, these systems are also limited in means of external communications because of the security reasons. Uncontrolled access and modifications for EMS could put into the danger the operation of the whole building or complex. Despite this, it is still possible to get the data from EMS systems about energy consumption and generation.

That is why the main goal of the RENergetic system is to complement EMS in energy islands. Based on the data about energy consumption and supply, the RENergetic ICT solution provides forecasting of energy demand and supply in energy island, as well as recommendations for equipment settings which will optimize energy usage within the island.

To ensure compatibility with most of existing systems and architectures of energy islands, it is proposed to utilize a modular structure of the ICT solution, which is shown in Figure 2. Modules, responsible for gathering data from energy island equipment, provide a standardized application programming interfaces (APIs) for data input. Where it is possible, another set of APIs could be provided for pushing recommendations created by the RENergetic system into the energy island existing EMS. Another part of the system, called RENergetic portal is responsible for providing an intuitive user interface for different users in the energy island. For instance, energy managers could see a forecasting of the energy consumption or generation in the units at the energy island. Users, like residents, for instance, could participate in heat demand response program by inserting their preferences on temperature inside the building.

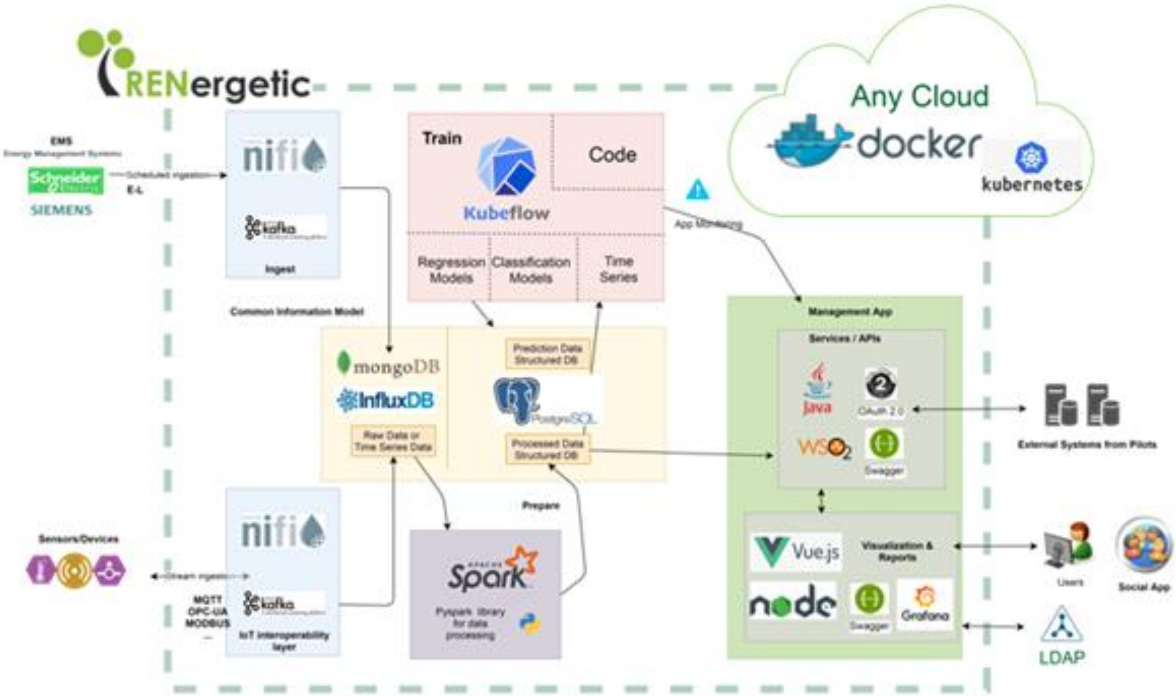

Figure 2 RENergetic ICT Architecture

Subsystems are the parts of the solution, which are responsible for the optimization in specific energy domain. The main focus of the system currently is on electricity and heat domains. For these domains, in addition to energy supply optimization, also subsystems for demand response systems are introduced. These systems allow involving non-technical users into the energy optimization tasks. For example, residents could express their preferences for a room's temperature or for electrical vehicle charge process in the RENergetic portal. According to the architecture depicted on the Figure 2, the logic related to the subsystems and RENergetic portal is contained in the Management App block. The ICT architecture will be described in more details in the deliverable **D.3.1 Description of the interim version of the ICT tools developed for energy island communities**.

Another important part of the architecture, is a machine learning engine as shown in Figure 3. Most of the subsystems rely on the data from forecasting algorithms for heat and electricity energy consumption and supply. Artificial Intelligence-based solutions could be also used in other parts, such as an optimization of energy supply and scheduling of consumers.

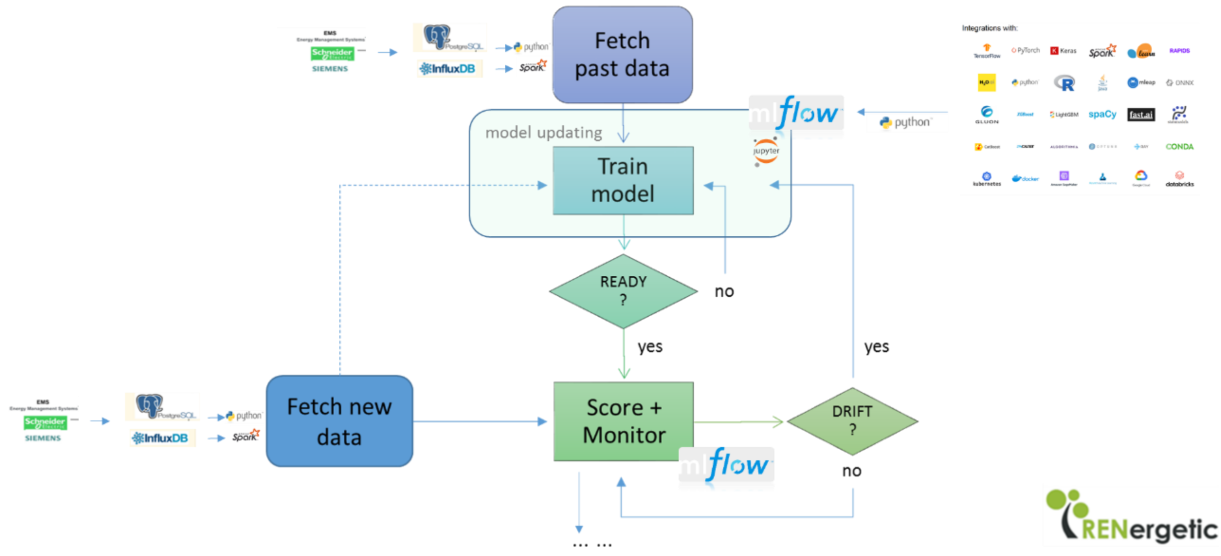

Figure 3 Machine learning framework to deliver forecasting

The described approach (see Figure 2 and Figure 3) ensures that the solution is replicable. It means that it could be deployed in any server infrastructure and perform forecasting and recommendation algorithms, as well as demand response programs, regardless of the type of equipment installed in energy island.

II.4.2. Preliminary Risk Analyses

The RENergetic system strongly relies on the communication with installed equipment in the energy island. That is why most of the risks concerning operation of RENergetic ICT solution are connected with linkage between developed system and existing hardware and software in energy island. The risks could be divided into the following three groups.

II.4.2.a. Input Data

Almost all subsystems rely on the data incoming from the energy island, for example, data about energy (heat and electricity) supply and consumption on the different levels (energy island, building, floor or even room). Because of different architectures of each energy island, the data could come in different format. That will be solved by common data model and APIs introduced in the RENergetic system.

In addition to the format of the data, its update frequency is also a very important factor. If the period between data updates will be days, the quality of the predictions coming from forecasting module will decrease significantly, which will decrease the efficiency of the recommendations from optimizations algorithms. For some demand response applications, it will be impossible to operate without frequently updated data. Thus, the system will not operate properly if the input data is not updated frequently.

II.4.2.b. Artificial Intelligence Models

Performance of the artificial intelligence-based (AI-based) model development for forecasting module depends on the available data for training and capacity to produce reliable and accurate models. Replicability of forecasting models from one pilot to another pilot (local-to-local) is limited to transferability of models and datasets, sharing of algorithms and hyperparameters set ups with the necessary new fine-tuning of the overall models. The risk is to rely on a model built locally and pretend that the model shall work with the same capacity in another local area. That is why, for each energy island, a shared model (from one pilot to another) shall be trained and refit again due to intrinsic data drift. The RENergetic system will propose the solution for easy integration of this model in the system and guidelines for training process. Although, the performance of this process will depend on the amount of data available for training. If there is no historical data available for the energy island, it is not possible to create a well-suited model for forecasting module. Moreover, AI experts should perform a periodic check of model performance regularly. Thus, system will not operate properly if the forecasting model is not trained accordingly and not supervised over time. Optionally, the project would provide also a recommendation list to detail what might be the process of fusing data across local pilots to generate a single cross-pilot model capacity prediction.

II.4.2.c. Deployment of the RENergetic Solution

The RENergetic system is developed to be portable from the software point of view. It means that it is easy to deploy a RENergetic ICT solution in any cloud infrastructure, which will support containerized applications to be run. In order to set up the system in the correct way, the information about architecture of the energy island (installed equipment and its parameters) should be given to the system. For each unit in the energy island, the sources for data about its energy consumption or generation should be provided. If needed, an integration of RENergetic system with existing software in the energy island should be considered. Thus, system will not operate properly, if the information about installed equipment and its parameters are not given to the ICT system.

III. Cost-Benefit Framework

In this chapter, the methodology to formulate and evaluate business models is described. First, the general setup and methodology is introduced. This is a generic set of definitions that occur frequently in cost-benefit analysis. Next, the first defined roles and stakeholders related to LECs are listed.

III.1. Framework of Analysis and General Definitions

In this section, the general terms and concepts are introduced for a better understanding of the framework.

III.1.1. Role

A role is the smallest building block in the modelling and present a specific responsibility or task that must be undertaken in a energy island. A role should be seen as an undividable task.

III.1.2. Stakeholder

The actors, in this case called the stakeholders, indicate who is performing a certain role.

A stakeholder can fulfil multiple roles and if required, multiple (similar) stakeholders can fulfil the same role. However, in the latter case, they will never perform the role together. For example, if there is a role of energy producer which entails the production of energy, there can be multiple stakeholders that produce energy, but they do it independent of each other. Stakeholders can comprise different roles depending on the real site at hand. This is visualized in Figure 4, where stakeholder A and B perform the same role, independent from each other.

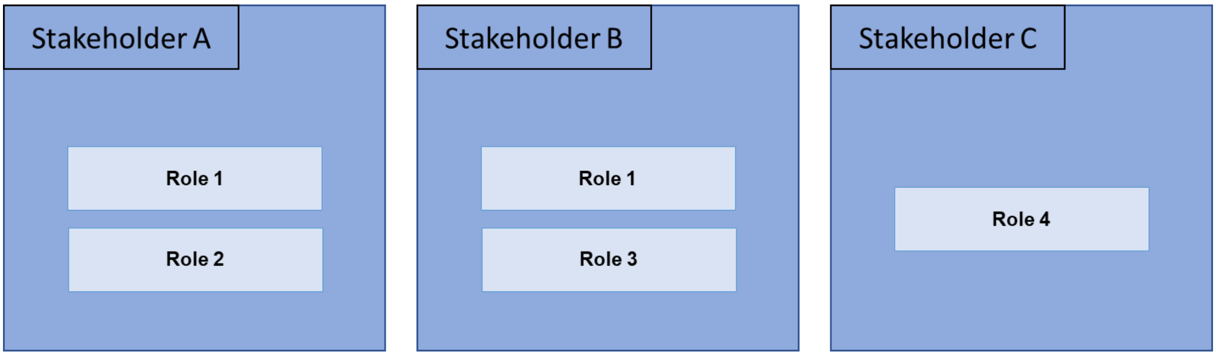

Figure 4 Example stakeholder configurations with different assigned roles.

III.1.3. Value Networks

III.1.3.a. Value Network

A value network visualizes the interactions between roles by means of value streams.

Each value stream represents a transfer of value, either tangible or intangible, in the direction of the arrow. Tangibles are goods, services, or revenues typically transported through a contractual transaction. Intangibles refer to knowledge or benefits which support the tangible stream but are not contractual [21]. An example is shown in Figure 5.

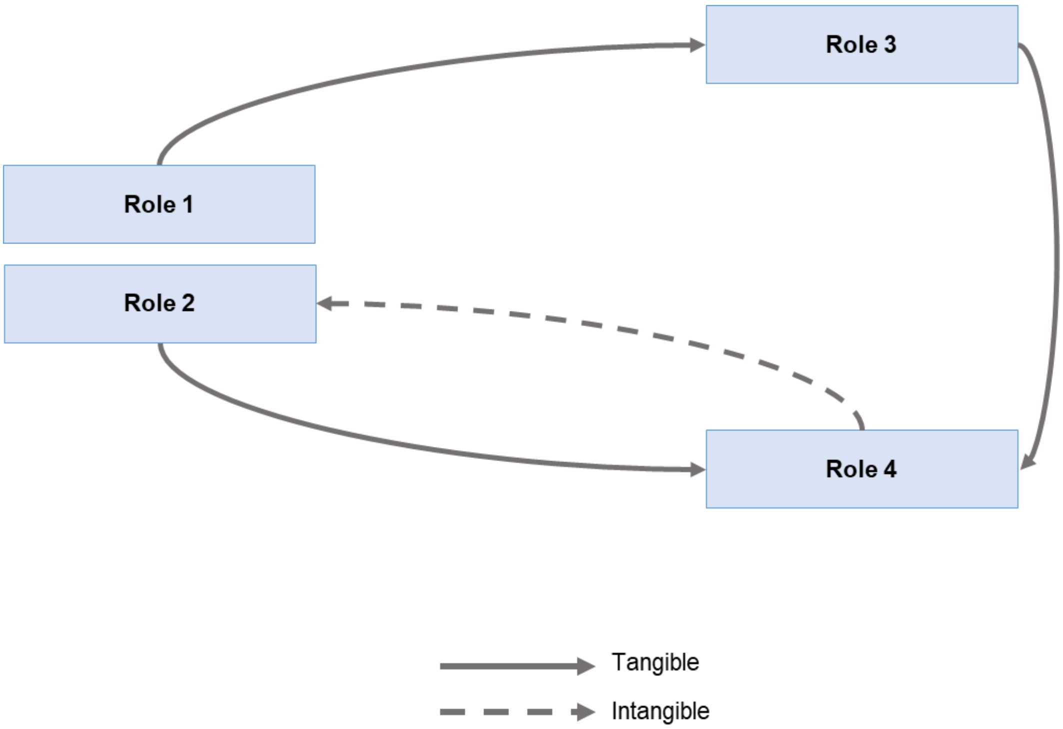

Figure 5 Value network example displaying the interactions between roles. The interaction can be tangible or intangible.

III.1.3.b. Value Network Configuration

Stakeholders take up different roles, indicating responsibilities in a value network configuration. Where there is only one value network (interaction of roles), there can be multiple value network configurations where different actors take up different roles. Figure 6 shows an example of a value network configuration.

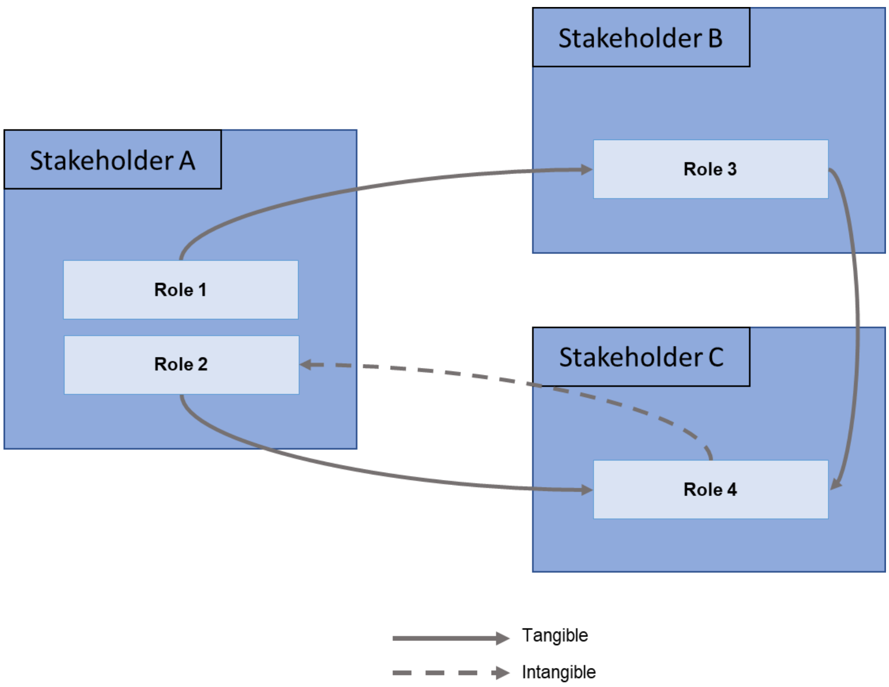

Figure 6 Example of a value network configuration

A business model represents the incoming and outgoing value streams of a stakeholder in a specific value network configuration. The Business Case is the quantitative evaluation of a business model. It combines all incoming revenues with outgoing costs in an economic analysis. A useful tool is the business model canvas of Osterwalder to identify all the streams relevant for the business model [22].

III.2. Value Network Analysis for LECs

In this chapter, the construction of the value network is discussed. For building and analysing different business models, we need to be able to model how the island is constructed and which interactions take place between the stakeholders. To do this, roles are defined that describe the main tasks that are performed within the island.

These roles will be the main building blocks of our economic model. The idea is to model the costs and benefits for each role and then assign the role to a specific stakeholder for analysis. This enables us to configure and analyse different scenarios.

The RENergetic stakeholder analysis has mainly three objectives:

1. Mapping functionalities and system rights with the according roles (interfacing WP3).
2. Offering some basic information for the engagement of, and communication with relevant stakeholders inside, and in some cases, outside of the energy island (interfacing WP2).
3. Understanding the basic interests and constraints for the creation of business models (interfacing WP7).

III.2.1. Roles within the RENergetic Value Network

In an energy island, there are a lot of important roles that are part of the flow of transactions. A role can have influence on three different aspects: business, technical and/or social.

A role can be labelled with a business tag, if a product or service is offered for which a fee can be demanded. The social tag is added when a role has social objectives, for instance engagement. A technical tag is added to a role when it involves the energy monitoring and managing. A role can have multiple tags but some roles can be purely business, social or technical oriented.

Below, the roles are defined and labelled with the appropriate tags. In these definitions, no distinction is made between energy vectors. The roles can thus be applied to the electricity network as well as the heat network. When applied to construct the economic model, it is however necessary to make this distinction as they have different costs and benefits.

Additionally, for the sake of monitoring the energy island's success, as well as defining functionalities and rights and creating engagement strategies, it is necessary to understand if a role is exerted inside (local) or outside (external) the energy island.

Harmonized Electricity Market Role

The roles defined in the energy island are mainly based on the ones defined in the Harmonized Electricity Market Role Model (HRM) [23]. This HRM defines a common terminology to facilitate dialogue between energy market participants from different countries.

The roles used here are based on the ones defined in the HRM meaning that, when possible, the exact definition is used. If needed, the definition is slightly altered to cover the needs within the energy island better. The HRM is very extensive and not all the roles specified in the HRM are necessary in the context of an energy island. The reason is that HRM is targeted solely at the electricity grid, whereas energy island roles need only a subset of electricity roles (e.g. Imbalance Settlement Responsible is not needed inside the energy island). On the other hand, additional roles may be needed which are not foreseen in the HRM (e.g. roles with environmental or social objectives).

III.2.1.a. Roles in the Energy Island

Within the study of energy islands, the following roles have currently been identified:

- **Energy Consumer:** consuming energy in the energy island. This can be an individual or bigger institution. Three sub roles can be identified: heat consumer, electricity consumer and electrical vehicle consumer.
- **Energy Producer:** producing energy in the energy island. Sub roles can be added for each type of producer that is relevant for this research. For example, different renewable sources as wind, water and sun or fossil fuels versus nuclear power plants.
- **Waste Producer:** producing waste in the energy island. Different sub roles can be created to differentiate between the source of waste. For instance, wastewater and compostable waste.
- **ESCO or Energy Service Provider:** Offering a service in the energy island. This role can be subdivided depending on what is exactly offered. An upcycling ESCO that recycles a waste product to something new. A provision ESCO who offers a service to the community, for example charging poles. Energy management ESCO who offers management services to the island. Data Provider ESCO who provides information to other parties in the island.
- **Network Development:** construction of the smart island
- **EMS Software Development:** development of the tools to monitor and manage the energy consumption.
- **Regulatory Framework Provider:** setting up the regulations on different levels, either on island level, national level or even more global.
- **Investor or Project Developer:** This role injects capital into the island in order to support the transition towards a sustainable energy island.
- **Community Management:** the participation of the community is important for the success of an energy island. The community needs to understand the impact of their behaviour and be stimulated to adapt their consumption needs to a more flexible demand.
- **General Grid Operations:** connectivity and management of the existing grid.
- **Energy management:** In automated environments, a computer system has control over the consumption and can reduce the demand in energy by switching machines off or on, or reduce the temperature.
- **Energy Monitoring:** To change the behaviour or adapt the consumption overall, the consumption must be monitored.
- **Energy Forecasting:** In order to be able to plan energy orchestration or give behaviour recommendations, future energy demand and supply must be forecast.

III.2.1.b. Stakeholders in the Energy Island

In a next step, the different roles are assigned to different stakeholders, i.e. actors. This is done for a generic version of an energy island model. A stakeholder typically takes on more than one role. Currently, the following stakeholders have been identified:

- Consumer or End-User

  - Residents: Private Owners, SME Owners, Tenants.
  - Visitors.
- Local Energy Provider.
- Energy Island Manager.
- Sustainable Energy Evangelist.
- Service Provider.
- Grid Operator.
- Municipality.
- Project Developer/Investor.

III.2.1.c. Value Network

Underneath a first generic version of the value network of an energy island is shown in Figure 7. This figure shows the different stakeholders and the assigned roles. The arrows between the stakeholders visualize the value flow of these interactions. An arrow from stakeholder A to B means that A offers something tangible to B, like a service or product. To reduce the number of arrows, a revenue stream in the opposite direction is assumed for each tangible arrow.

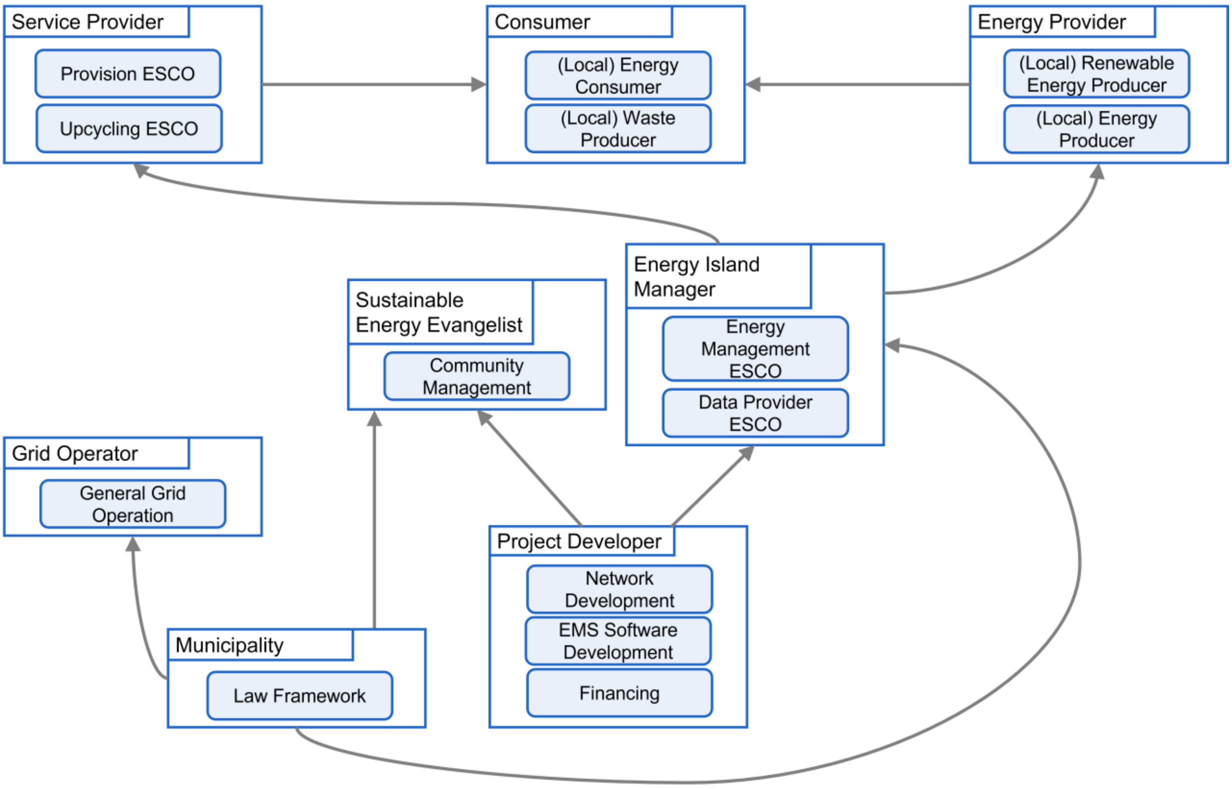

Figure 7 Generic Value Network Configuration for an energy island

For example, the Service Provider offers a service like charging an electrical vehicle to a Consumer for which a fee is paid to the Provider. Similarly, the Energy Provider can provide electricity to the Consumer for which it receives a payment.
The Energy Island Manager offers the Providers the opportunity to operate within the island for which a fee can be demanded. In addition, the island can deliver data to these Providers to optimize their operations.

IV. Preliminary analyses of obstacles and barriers

In this chapter, the obstacles and barriers identified by the pilots are captured. These obstacles and barriers have popped up during the creation process of the different pilot sites.

IV.1. Ghent: current identified obstacles and barriers

The 'Nieuwe Dokken' pilot site in Ghent is constructed in a residential area. It will offer place to 400 households, 30 offices and some public buildings as a day-care center or sports complex. Phase 1 of the project is already finished with a lot of central installation in operation.

Current identified obstacles and barriers:

- Putting Building-integrated Photovoltaics (BIPV) in high-rise buildings is confronted with fire safety regulations. Fire regulations have become more stringent since the Grenfell accident, and a new building standard will be implemented in Europe, requiring fire safety class A2 materials for facades. Although the proposed BIPV materials prove to comply to A1 fire resistance class standards in fire safety test, they are now recognized as Bs1d0 fire resistance class.
- Economic business case for building integrated PV, acceptance of the materials with architects, project developers, building permit authorities and fire safety regulations.
- The gathering of data is dependent on the construction planning (number of end-users, EV-charging points in use, etc.).
- Delay and limited implementation of Local Energy Communities (LECs) legislation in the regional framework (grid regulation, DSO framework and tariffication, and renumeration of self-consumption of locally produced renewable energy).
- Cost of communication technology infrastructure is rather high. The IT-network is complex and requires a lot of cabling, gateways, sensors, and more and it only increases when the island grows.
- Uncertainty and complexity of communicating the concept of LECs towards end-users and other stakeholders (project developers, industrial partners).
- Complexity and interdependency with other stakeholders (e.g. heat delivery from external industry source).
- Technology implementation (availability of bidirectional EV-infrastructure, cars that are able to charge bidirectionally).
- Placing a heat grid takes a lot of paperwork between different instances.

IV.2. Poznan: current identified obstacles and barriers

The pilot in Poznan is a strong academic campus formed by the Poznan University of Technology (PUT) and the Poznan Supercomputing and Networking Center (PSNC). The district offers place to more than 500.000 citizens. The intention is to increase the share of renewable energy sources, for instance, by using heat from the datacenter to heat other buildings on the campus. In addition, PUT and PSNC also own properties on Kakolewo airport located 70 km west from Poznan, which gives additional opportunities to increase the share of PV panels. All managed with the Building Management Software (BMS).

Current identified obstacles and barriers:

- Connection of the PV installation in the airfield area is limited due to technical constraints of the distribution grid. The transmission grid operator ordered to connect the installation to a transformer station, that is located far away from the planned place of PV generation at Kakolewo airfield. The potential cost of a cable connection exceeds the cost of the installation itself.
- The time for processing the PV system application for connection conditions to the distribution grid is very long, above six months. It is the time needed for the operator to check the possibility of connecting the PV installation to the grid.
- In order to start operations in the field of electricity generation, it is necessary to sign a number of agreements as well as to obtain a concession for electricity generation and trading.
- Data from BMS – personal data protection, e.g., information about the presence of the user in the room.
- Problems with downloading data from BMS - data protection and administrative issues.
- No funding for the construction of a pipe between buildings - that was the initial assumption. Postponing the heat recovery investment over time.
- Need to simulate the operation of the system (heat recovery from data centre to PUT's buildings).
- Divergence of pilot members' goals.
- Covid-19 – Other facility uses. Fewer users and Energy demand. Impediments to data analysis.
- Lack of involvement of energy island participants. Not using the system suggestions.
- Settlements between energy island participants. Partially variable price based on agreements between units. Partly price regulated by the Energy Act.
- Services of sales of the waste heat to the district heating network as well as heat demand response requires further elaboration of the terms of contracts.
- According to the Polish energy law, the district heat network (DHN) in Poznan is an efficient system since heat is generated in cogeneration. That is why Veolia does not need to buy green heat from the market for Poznan DHN.
- The output temperatures of the recovered heat are too low to be transferred directly to DHN. Therefore, heat pumps are required which increases CAPEX. There is a risk of insufficient financial resources for the project realisation.
- Increased CAPEX will impact the price of the heat unit. According to the Polish energy law, energy companies are not obliged to buy green heat for the DHN provided that the offered heat price is not higher than average heat price from other sources of Poznan DHN system.

- The most amount of heat will be provided during the summer season when there is the least demand. In this period the DHN of Veolia might not be able to absorb the heat from the island.
- The point of heat delivery from the RENergetic island is a heat chamber located on the border of assets between VEOLIA-PUT. It is necessary to obtain permission from the city for the chamber infrastructure extension.
- PSNC can make a contract for recovered heat directly with Veolia.

IV.3. Milan: current identified obstacles and barriers

The pilot site is located in the North of Italy and contains the Ospedale San Raffaele (OSR) and Milano 2, a neighbourhood of the Municipality of Segrate containing private and public buildings. The OSR co-generator is the main source for electricity and heat and runs on methane. The main goal is to get more insight in the consumption of the different buildings involved and reduce the high demand.

<u>Current identified obstacles and barriers:</u>

- Communication between OSR energy management and Co-generator management is limited. They do not share the same vision in energy island perspective.
- Communication and Collaboration for operational parts in OSR energy management and RENergetic project is limited. OSR does not see high gains or advantages in this project in the short or long term. The risk is lack of trust in the solutions proposed.
- The OSR organisational maturity level to use RENergetic solutions is limited both competency wise as well as from a resistance to change present operations
- Time to implement RENergetic solution is a key risk factor. The internal procedures to validate such solutions is limited.
- Segrate part of the Pilot is in commercial terms relations with OSR. It is served by heat energy from the OSR's co-generator. They are not part of RENergetic budget. This complicates the relationships.
- No consumption energy data from Segrate is shared withing the RENergetic consortium due to contractual aspects.
- Problems with downloading data from DESIGO and Schneider systems- data protection and administrative issues.
- Most of the RENergetic Epics and Users stories need reduction as the resources to operate on each single user story are unknown in effort terms, mostly time.
- Covid-19 in OSR (a COVID ready hospital) complicates matters a lot in terms of operations in the field.
- The work of AI applied to energy monitoring does not impact on the monitoring obligations due to the legislation on mandatory energy audits or on the reporting for the purposes of requests for white certificates.
- In both cases, real measures and not predictions based on AI algorithms are needed to comply by regulations.

V. Aggregated Obstacles and Barriers in Innovative Energy Islands

In the previous chapters, all obstacles and barriers currently identified in the creation of a LEC are described. Table 1 summarizes the biggest hurdles identified over the different pilot sites.

	Ghent	Poznan	Milan
Legal	Limited implementation of EU legislation on LECs in regional framework	Personal data protection	Complicated relation with stakeholders and agreements
	GDPR on collected user data	Long administration process for PV connection to the grid and then a concession to use this energy	Data protection
	Administration overhead in getting permits as many instances are involved	Determining the terms of the contract for waste heat and heat demand response services	
		Require permission from the city for infrastructure extension	
		According to the Polish energy law, the heat network operator (Veolia) does not need to buy green heat from the market as it is an efficient energy system.	

Technical	Strict regulation on (fire) safety of materials used in buildings	Limitations of the grid for connecting RES	Limited time to test solutions
	Data collection depends on construction planning and high cost for technology	Limited data available and the need for simulation	

Social	Communicating the concept and goals of LECs to end-users		Lack of trust limits collaboration
Business	Allowance of variating tariffs (remuneration)	Lack of funding for infrastructure	Need for clear gains and advantages to convince stakeholders
	Expensive technology	PSNC on its own, can make a contract for recovered heat directly with Veolia.	No collaboration if not paid
	Complex relation with participants e.g. heat delivery from industry	The offered heat price cannot be higher than the average heat price amongst other sources of Poznan DHN	
		Most waste heat is available in the summer when the DHN does not need the heat	
Other	Communicating the concept and goals of LECs project developers and industrial partners	Divergence of the goals of pilots	Communication between partners is difficult due to different visions

Table 1 Summary of identified obstacles and barriers among the different pilot sites.

Table 1 indicates some key barriers and obstacles that occur in each pilot site. A first common obstacle is the collection of data and the need to process this data with respect to people's privacy. Linked to this data, many tools and simulations require accurate datasets for better results but the amount of data is still limited or difficult to access.

On social level, it is clear that the communication of LECs must be clear and convincing as the collaboration of stakeholders and end-users depends on it. This is also seen in communication to stakeholders within the pilots and between pilots. The table also shows that the technology is expensive and lack of financing or clear revenue models can be critical for the creation of an island.

These are the first barriers that pop-out during the first months of this project and will be further investigated to find potential solutions. New obstacles that arise will be added in a follow up version of this document.

VI. SUMMARY

In this preliminary European analysis on obstacles to innovation around energy islands, obstacles and barriers on different levels have been described. Installing a LEC, as defined in II.1. , that introduces a bigger share or renewable energy sources to become self-sufficient and sustainable sounds promising. However, a lot of obstacles and barriers can be found. From the social barriers analysis in II.2. , it is clear that besides factual barriers, deeply rooted social and psychological factors must be tackled. Unawareness, lack of community spirit, and resistance to change are the main factors that might hold down the roll-out of LECs once the factual barriers are resolved. Further research will work on methods to overcome this hurdles. From legal point of view, covered in II.3. , it comes clear that there are many questions on how energy can be bought and sold in a close community, and who can participate as the law is not clear or not evolved yet to include this new energy market. Solutions will be investigated in the coming months. Optimizing the energy consumption in a community requires the accurate knowledge of the consumption and tools to analyse and steer the usage. This is brought together in an EMS system (II.4.) where a set of standardized APIs must allow the different technologies to collaborate.

In chapter III, the introduction to a cost-benefit framework is given together with a first analyses of the roles and stakeholders in LECs. This is a starting point for economic analyses and potential business models that support the creation of EIs. Lastly, chapters IV and I focusses on specific obstacles and barriers discovered by the different pilots sites. This points out that the collection and processing of personal data requires special attention as well as communication between stakeholders in LECs, including residents, and between LECs. Another barrier that must be resolved is the high cost to implement these renewable energy sources.

This concludes this deliverable and updates on these topics can be expected in a future update at the end of the project with deliverable 7.4.

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