IRIS

Integrated and Replicable Solutions for Co-Creation in Sustainable Cities

Project Acronym:	IRIS
Project Full Name:	Integrated and Replicable Solutions for Co-Creation in Sustainable Cities
Grant Agreement:	No 774199
Project Duration:	5 years (starting 1st October 2017)

Deliverable 1.3

User, Business and Technical requirements of Transition Track #2 Solutions

Work Package:	WP1: Transition strategy: five tracks to maximize integration synergy and replicability
Task:	T1.2: Integration synergy on Transition Track #2: Smart Energy Management and Storage for Energy Networks Flexibility
Lead Beneficiary:	CERTH
Due Date:	30 June 2018 (M9)
Submission Date:	05 July 2018
Deliverable Status:	Final
Deliverable Style:	R
Dissemination Level:	PU
File Name:	D1.3 User, Business and Technical requirements of Transition Track 2 Solutions.pdf

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 774199

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Version History

Version	Date	Modifications made by
0.1	13/10/2017	First draft created by CERTH for internal review
0.2	20/11/2017	Updated template shared with LH/FC representative partners
0.3	07/01/2018	Initial contribution by LH (pre-pilot)
0.4	15/02/2018	Consolidated version and feedback by CERTH
0.5	02/04/2018	Contribution by LH (demonstration)
0.6	02/05/2018	Final contribution by LH (all chapters)
0.7	04/05/2018	Consolidated version and feedback by CERTH
0.8	31/05/2018	Contribution by LH/FC (replication)
1.0	20/06/2018	First complete version by CERTH for internal review
1.1	04/07/2018	Final version by CERTH

Disclaimer

Executive Summary

The present document is the Deliverable D1.3 entitled as "User, Business and Technical Requirements of Transition Track #2 Solutions" of the IRIS project. The document presents the work undertaken in relation to Task 1.2 entitled as "Integration synergy on Transition Track #2: Smart Energy Management and Storage for Energy Networks Flexibility" of WP1, towards the definition of requirements and specification of the corresponding solutions (for example technical, operational, legislative, underpinning regulatory framework, business). In addition, the aspect of lessons learnt is included, aiming primarily at helping IRIS LHs and FCs to familiarize among themselves of what is the previous experience related to the IRIS solutions expected to be investigated in detail, in the course of the project. The depicted in this Deliverable information can act as the baseline for know-how and experience exchange both among the IRIS participating entities and as well on a second level, on an EU level.

The 3 LH cities (Utrecht, Nice and Gothenburg) are going to deliver various demonstration use cases, taking into account the local needs of their different environments (for example building energy inadequacy, needs for reducing the energy consumption and the household bills, noise and atmospheric pollution,). The demonstrations are based on pre-pilots of previous projects that will move a step further, trying to integrate the proposed solutions to a wider extent of area, following a scalable, but at the same time replicable pathway. All LH cities and FCs (Vaasa, Alexandroupolis, Tenerife and Focsani) will replicate the solutions using the experience by the demonstration activities, after being fitted to their local needs, overcoming their individual barriers and fostering their drivers towards transforming their cities into smarter, more energy efficient, less environmentally polluted, but most of all citizen needs centered.

The present deliverable, along with deliverables D1.2, D1.4, D1.5 and D1.6, is purposed to provide information concerning the demonstrations that are going to be undertaken in the Lighthouse cities (LH) during the IRIS project, using as a basis the pre-pilot areas of them. They have already a mature-enough based previous experience and considerable know-how of the specialties of most of these IRIS Solutions, since these have already been demonstrated (in a lower scale though), in their territory. This deliverable gives the Lighthouse (LH) and Follower (FC) cities, the opportunity to exchange know-how and opinions on how each of the IRIS solutions can be in the best way integrated in their site as a first point, and through the replication process in their city level. During the deliverable preparation phase, the IRIS partners established a strong collaboration both, at a local level (among the energy experienced partners of each LH and FC ecosystem), as well as, at the IRIS level (among key partners from LH and FCs). This collaboration and knowledge exchange resulted in the collection of a big amount of information about (a) pre-pilots, (b) demonstrations and (c) replications.

D1.3 takes into account the individual characteristics of each city and provides a detailed description of the pre-pilots along with a top-level description of the expected demonstration and replication activities, to be conducted within the next four (4) years of IRIS project evolution. The Deliverable covers a variety of topics that will be further analysed and elaborated in much more detail, in the context of WP3, WP5, WP6, WP7 and WP8. These work packages include activities that will present in detail the information provided by D1.3.

D1.3 is devoted to Transition Track #2 (TT#2). The main scope of TT#2 is to integrate and implement solutions that comprise energy management and storage technologies for cooling and heating along with electricity purposes promoting their synergy. In that framework the case of waste heat utilization (primary of low/medium temperature) is as well examined. As a further step, these solutions will be designed to be integrated into one smart micro-grid with the management support of an EMS in order to reduce energy curtailment by RES and increase their penetration in the energy mix. The main solutions presented in TT#2 refer to a) the promotion of RES based plants (e.g. PVs) being supported by standard electric batteries, b) the implementation of various low/medium-

temperature DHN technologies being supported by c) the use of EMS for the optimization of the distribution grid, as well as d) the integration of 2nd life batteries both for the LV/MV distribution grid, but also for transport purposes (the latter as part of TT#3). The established collaboration platform along with the already collected and reported in enough detail, information about the integrated solutions of TT#2 make it feasible for IRIS to have a quick start in order to successfully demonstrate and replicate the best practices, the participating partners already have.

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List of Acronyms and Abbreviations

Abbreviation	Definition
ADEME	French Environment & Energy Management Agency
B2B	Business to Business
BM	Business Model
BMS	Battery Management System
BOT	Build, Operate, Transfer
BRP	Balance Responsible Party
CBA	Cost Benefit Analysis
CEEI	European center for businesses and innovation
DERMS	Distributed Energy Resource Management System
DHCN	District Heating And Cooling Network
DHN	District Heating Network
EPCM	Engineering, Procurement and Construction Management
ESCo	Energy Service Company
ESO	Energy Storage Optimizer
FC	Follower City
FED	Fossil Free Energy Districts
HEMS	Home Energy Management System
HVAC	Heating, Ventilation and Air-Conditioning
ICT	Information and Communication Technology
IS	IRIS Solution
KPI	Key Performance Indicator
LEMS	Local Energy Management System
LH	Lighthouse
LT DH	Low Temperature District Heating
LV / MV / HV	Low/Medium/High Voltage
NCPT	Network Constraints Prediction Tool
NEM	Network Energy Manager
NPV	Net Present Value
nRMSE	normalised Root Mean Square Error
O&M	Operation and Maintenance
OIN	Operations of National Interest
OPEX	Operating Expense
PCS	Power Conversion System

PV	Photovoltaic
RES	Renewable Energy Sources
SHW	Sanitary Hot Water
SCADA	Supervisory control and data acquisition
SEMS	Smart Energy Management System
SME	Small-Medium Enterprise
TRL	Technology Readiness Level
TRT	Thermal Response Test
TSO/DSO	Transmission/Distribution System Operator
TT	Transition Track
vRES	Variable Renewable Energy Sources
V2G	Vehicle to Grid
WWTF	Wastewater Treatment Facilities
WWTP	Wastewater Treatment Plant

1. Introduction

1.1 Scope and objectives of the deliverable

The main objectives of Transition Track #2 (TT#2) aim at the integration and demonstration of smart energy management systems (SEMS) for the case of Renewable Energy Sources (RES) based systems, in the place of fossil-fuel based ones, associated with energy storage in order to:

a. maximise both energy and economic profits by the operation of RES for both power and heat, without of course excluding the potential case of cooling through the use of adsorption chillers. These are set in the place of less environmental friendly energy sources, which are based on fossil-fuels;
b. maximise self-consumption and local RES, while reducing grid stress and potential vRES curtailment, while contributing to flexibility provision to the electricity grid
c. unlock the financial value of grid flexibility and
d. examine to what extent the circular economy principles can be of technical and at the same time of economic interest (e.g. support of grid stability/flexibility, re-use and re-cycling of end-of-life materials), as in the case of 2nd life batteries.

The repository of Technical solutions, to be demonstrated, primarily and in short includes:

- a wide variety of RES energy production system configurations, mainly being based on PV and low enthalpy geothermal energy;
- stationary and multi-time framework (short-term, seasonal) energy storage technologies both industrial products, as for example Li-Ion batteries for electricity or PCM (Phase Change Materials, geothermal boreholes) for thermal storage, as well as innovative ones, as for example 2nd life batteries from EVs for electricity or the use of the own buildings' thermal inertia for thermal storage;
- use of low and medium temperature (LT, MT) waste and renewable heat source (as for e.g. the LT waste heat from of a Waste Water Treatment Plant) for its injection into either already existing (Utrecht) or new to be developed high energy efficient heating/cooling networks, again as a part of the symbiotic operation between various energy networks. This is in line with the currently on-going EU policy for the promotion of synergy between energy intensive industries (taking benefit of any available waste heat streams) and the building sector, which is in detail explained in TT#1 corresponding Deliverable;
- V2G charging infrastructure for the demonstration of the advantages it can offer, in relation to electricity grid flexibility management, which simultaneously can support the cost-effectiveness of e-car sharing mobility schemes (in more detail explained in the corresponding TT #3 Deliverable), and
- EMS and potentially ICT based technologies for the interconnection and continuous monitoring along with non-intrusive methods for failure tracking, for energy management systems at home, building and district level, primarily promoting flexibility and symbiotic operation among the various energy resources, as already being explained.

The present deliverable describes the pre-pilots, on which the IRIS solutions are based on, as well as the demonstrations and replications that are about to be delivered throughout the project, towards the primary objective of demonstrating and continuously monitoring the operation of flexible, energy efficient and symbiotic energy networks (electricity and heat). A main topic, which is as well included, is the identification of the various drivers and barriers among participating countries, representing different climatic regions (northern and southern European cities) and accordingly different requirements to the electricity and heating/cooling networks.

In this light, it is of benefit of the IRIS project that the various solutions already being pre-piloted and to be demonstrated, will be required to be adapted in different climatic regional cities of EU continent. Towards that, the inclusion of solutions related to storage, both mature and innovative ones, for which yet not much open-access information exists, will be as well an advantage offered by IRIS on a EU level.

In view of that, TT#2 IRIS solutions, already from the project submission phase, have been grouped in three different group of Solution, namely,

- IS2.1: Flexible electricity grid networks
- IS2.2: Smart multi-sourced low temperature district heating (DH) with innovative storage solutions
- IS2.3: Utilizing 2nd life batteries for smart large scale storage schemes

Table 1-1 : Planning of pre-pilot / Demonstration / Replication of the IRIS Solutions in the LH and FC

Transition Tracks	Integrated Solutions	Lighthouse Cities									Follower Cities			
		Utrecht			Nice Cote d' Azur			Gothenburg			Vaasa	Alexandroupolis	Santa Cruz de Tenerife	Focsani
#2 Smart Energy Management and Storage for Energy Grid Flexibility	IS-2.1: Flexible electricity grid networks	-	D	R	P	D	R	-	D	R	R	-	-	-
	IS-2.2: Smart multi-sourced low temperature district heating (DH) with innovative storage solutions	P	-	R	P	D	R	P	D	R	R	R	-	R
	IS-2.3: Utilizing 2nd life batteries for smart large scale storage schemes	-	D	R	P	D	R	-	D	R	-	-	R	-

1.2 Structure of the deliverable

The structure of this document is accommodated following a generic and adaptable enough structure, to fit to the needs of each Individual IRIS Solution description, as being proposed in the IRIS proposal. The same structure has been used for all corresponding Transition Tracks #1, #2 and #3 Deliverables. Specifically, the deliverable is structured and organized in the following chapters:

Chapter 2 introduces a basic methodology for the process of gathering information from the LH/FC cities and the involved stakeholders. It also presents the interaction phases with the participation of most of the stakeholders and the multiple well-organized ways that have been followed to, at a first level gather the necessary information and, at a second level consolidate and present it in an easy-readable manner.

Chapter 3 provides a summary concerning the pre-pilot, demonstration and replication of IRIS activities, focusing on the varying technological solutions that will be demonstrated and replicated by the LHs and FCs, in the form of summarized Tables. This structure is expected to allow the reader of this Deliverable to gain a fast overview of the individual solutions being pre-piloted, demonstrated and expected to be replicated in each LH and FC.

Chapter 4 provides an overview of how IS1.2 being described in D1.3 is linked with the forthcoming activities in the rest of WPs. Since the information gathered in this Deliverable is acting as the baseline upon which the IRIS will be run, it is important for someone to know what is he/she should expect to be conducted during the next four (4) years of the project. Detailed and more concrete that currently available information will be gathered and monitored in the following WPs. Moreover, key aspects as Business Models development for each of the solutions being described here, also associated with corresponding legal and regulatory environment are expected to be populated by the next WPs.

Chapter 5 presents a very brief overview of the main conclusion derived about the IRIS solutions, after the consolidation of the information being gathered during this period of project running (i.e. nine (9) months) on the levels of a) pre-pilots, b) demonstration and c) replication areas.

Chapter 6 contains the list of references used during the description of the main body and annexes of the deliverable. The reference list is not much extensive, since the provision of primary information, written in this Deliverable originates from the ecosystems of the LHs and FCs.

Chapters 7, 8 and 9 are Annexes that provide the framework and different stages for the collection of data concerning the pre-pilot, the demonstration and the replication planning of the IRIS Solutions 2.1, 2.2 and 2.3, correspondingly. Each of these chapters, presents the application area and the available infrastructure of the pre-pilots, along with a first overview of the infrastructure expected to be used during the demonstration activities. Concerning the demonstration and replication activities, it introduces the potential area, the key technical components to be used, the data management plan, the regulatory framework, the bounds/drivers for each of the LHs/FCs and very top-level information about the business models expected to be developed and applied in the course of IRIS solutions demonstration, needed to foster their maturity and economic sustainability. In short, in the Annexes one can find quite detailed information about different aspects of each of the ISs.

1.3 Relation to Other Tasks and Deliverables

The following table depicts the relation of this deliverable to other activities (deliverables) developed within the IRIS project.

Table 1-2 *Contribution of D1.3 to deliverables from WPs 5-8*

Deliverable Number	Contribution
D5.1, D6.1, D7.1	Report on baseline, ambition & barriers for Utrecht / Nice / Gothenburg lighthouse interventions
D5.2, D6.2, D7.2	Planning of Utrecht / Nice / Gothenburg integration and demonstration activities
D5.3, D6.3, D7.3	General Framework of the integration and implementation plan of the respective IRIS Solution to be demonstrated in Utrecht / Nice / Gothenburg
D8.1	A Roadmap for replication of activities
D8.4, D8.6, D8.8, D8.10	Vaasa / Alexandroupolis / Santa Cruz de Tenerife / Focsani replication plan

D1.3 contains valuable information for the above-mentioned deliverables, as it covers a variety of topics that will be further analysed and elaborated in their context.

2. Methodology

2.1 Approach to gather information from LH/FC cities and involved stakeholders

The chosen approach served a twofold objective, while ensuring the smooth course of the IRIS project. At first, it drove the process of collecting multiple-type of information (for example technical, business, lessons learned), before being consolidated into a uniform layout, from all different stakeholders involved in the different IRIS Solutions, with the main contribution being provided from the LHs, since these are the most mature ones, having already pre-piloted the list of Solutions. In a second step, after the consolidation of the first gathered information, it allowed each city (both LC and FC) to have a better understanding of the details of each of the IRIS Solutions, allowing them to better map how the various Solutions can be demonstrated and/or replicated in their territories in a short term perspective, not more than ten (10) years, as far as available funds become available (concerning especially the FCs).

From the perspective of IRIS aimed goals, sharing of know-how and information in general among the IRIS partners was a major priority. Important was also to enable to adapt such know how to each actor's point of view. This is in the sense that industries' needs and requirements are different from those of the citizens themselves, and in view of that condition multiple aspects have been considered when preparing this deliverable, as those of a) technical, b) regulatory, c) social and d) business aspects.

As the deliverables require input from a large number of partners, a key element of the data collection process was the establishment of a strong collaboration among the horizontal partners involved in WP1 activities (i.e. CERTH the leader of T1.1, T1.2 and T1.3, CIVITY the leader of T1.4, and HKU the leader of T1.5) and key representatives of LH and FCs. Moreover, working teams (both technical and managerial) have been established among all LH and FC ecosystems for gathering, delivering and consolidating information for the various IRIS solutions of each Transition Track.

The communication among the local ecosystems and the horizontal partners took the form of bi-almost weekly virtual meetings. In addition, CERTH, CIVITY and HKU created questionnaires/templates and circulated them to LH and FCs, for the gathering of IRIS Solutions related information. The purpose of these templates was to update and gather more detailed information for each of the individual IRIS Solutions, based on the preliminary information included in the proposal document in section 1.3.8. The structure of this document was generic and adaptable enough in order to fit to the needs of each Individual IRIS Solution description, as being proposed in the IRIS proposal. The same structure has been used for all the three first Transition Tracks, namely TT#1, TT#2 and TT#3.

2.2 Phases in interaction with stakeholders

The deliverables preparation phase consisted of four phases, as depicted in Figure 2-1. Each phase involved multiple stakeholders from LHs and FCs, with the local ecosystems providing information based of the above-mentioned templates. In each phase the LH or FCs were asked to fill in specific sections of the template. Subsequently, after being delivered to CERTH, it evaluated the provided information and asked for further clarifications or corrections. A number of iterations/discussions ensured not only high quality information, but also a high quantity.

The phases with their results are described below and are further linked to each of the different sections of the annexes that present the different integrated solutions of TT2.

Phase 1: Detailed Description of Pre-Pilots **–>** Elaborated Outline of Pre-Pilots per Solution (Solution's Requirements, Geographical Overview, Key Technical Components, and Lessons Learnt).

Phase 2: Feasibility and Description of Demonstrations & Replications **–>** High-level picture of Demonstrated & Replicated Solutions in LH Cities (Brief Technical Description, Geographical Overview, and Objectives/Needs & Opportunities).

Phase 3: Business & Regulative Aspects of Demonstrations & Replications **–>** Framework Overview of Demonstrated & Replicated Solutions in LH Cities (Data Management, Regulatory Framework(s), Technology Bounds & Drivers, and Business models).

Phase 4: Replication of IRIS Solutions in FCs **–>** Impact of each IRIS Solution (Brief Technical Description, Geographical Overview, Objectives/Needs & Opportunities, Regulatory Framework(s), Technology Bounds & Drivers, and Business models).

The following Figure presents an overview of the Methodology followed.

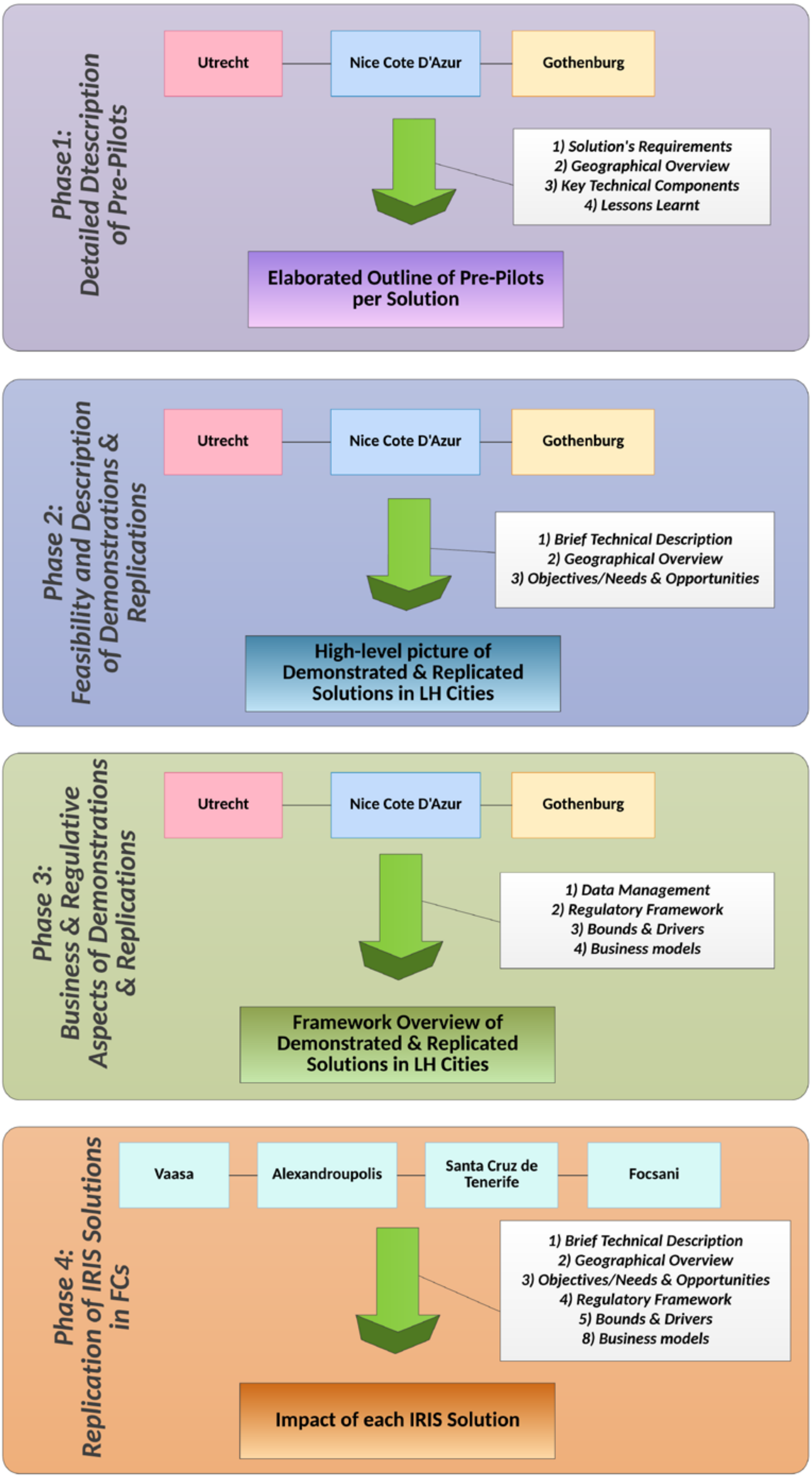

Figure 2-1 : Phases in the preparation of D1.2

2.3 Collaboration Procedures

A two-way collaborative relationship was established among IRIS partners that resulted in collecting the required information from both LH and FCs. The collaboration worked on two levels:

1. **At a local level** with regular meetings (every 2-3 weeks) among the partners involved in the implementation of the relevant integrated solutions, and
2. **At a project level** with bi-weekly meetings between CERTH, the representatives of LH cities (2 persons from each city) and the representative of FCs (Vaasa).

At the beginning of each phase, CERTH presented the requirements and the type of information that LH and FC representatives needed to gather. After an in-depth discussion, each city representative was able to guide the local partners on the collection of required information. In the local meetings, the city representatives appointed specific tasks to the partners based on their know-how and specialisation. Afterwards, the city representatives consolidated the collected information and were filling in the template, in a dynamic continuous way (according to any required updates). Subsequently, CERTH reviewed and further elaborated the contributions, made comments and asked for clarifications, during every next meeting. This iterative process lasted throughout the whole duration of Task 1.3.

A few times, bi-lateral meetings were organised between CERTH and each LH and FC, always according to the emerging needs and requirements, so that any clarifications and adjustments in the information was being made concretely and mutually agreed. In these meetings, all the relevant partners from the city were participating.

Apart from the virtual meetings, a physical one has significantly contributed to the preparation of D1.3. This Working Session has been organised during the 2nd Consortium Plenary Board meeting in Gothenburg. It was entitled as “Transition Strategy: exchange on pre-pilots” and aimed to thoroughly discuss the pre-pilot information among core partners involved in WP1 and specific LH and FC partners that had a particular interest in pre-pilots executed in other LHs. CERTH had circulated a detailed presentation of the pre-pilots along with a questionnaire aiming to collect the cities’ interests on specific integrated solutions. After the working session, all interested and relevant partners had a better understanding of the planned activities and the replication potential of each of the IRIS solutions, along with the baseline state-of-the-art and know-how basis of that. In that respect, the LHs contribution was of primary value, since in fait they form the core know-how basis among all partners of the IRIS project. The following Table is presenting the time evolution of the relevant task activities throughout its whole life-cycle.

Table 2-1 - Timeline of the different phases during the course of the task activities

Phase	Oct 17	Nov 17	Dec 17	Jan 18	Feb 18	Mar 18	Apr 18	May 18	Jun 18
1	■	■	■	■					
2				■	■				
3					■	■ (*)	■		
4						■	■	■	
Final version									■

(*) Physical Meeting – Working Session on Transition Strategy: Exchange on pre-pilots

3. Overview of the Transition Track #2: Smart Energy Management and Storage for Energy Networks Flexibility

The application of renewable energy system (RES) technologies is currently considered as the most widely endorsed answer towards achieving the international climate protections goals, being agreed among most countries during the Paris Agreement [1]. Consequently, advancements in RES based systems has experienced over the last years the fastest growing research and development, followed by emerging business sectors focusing/contributing to greenhouse emissions mitigation. In fact, since 2011 RES innovation and action accounted for more than half of all capacity built in the power sector. Currently, the share of renewable energy in the total final energy consumption stands for 18.3% [2].

The Energy Union strategy articulates ambitions to transform Europe's energy system more energy efficient, more cost-effective and more resilient than now, by making it more flexible, decentralised, integrated, sustainable, secure and competitive, also putting consumers at its centre, promoting at the same time incentives and underpinning tools and smart algorithms towards transforming them into prosumers. The overall concept of such an approach is based on taking benefit of the advantages that a symbiotic operation of energy networks can offer. Besides technological aspects, which are of primary importance for the academic and business sectors, policy makers now are needed to consider additional issues, such as the effects of intermittent or variable Renewable Energy Sources (vRES) on the a) reliability and adequacy of the energy system, b) impacts of rules governing the curtailment or storage of energy, and c) of how much backup dispatchable capacity is required to guarantee that energy demand is safely met, not at the expense of more available resources expense.

In view of that, it has been well acknowledged that addressing the electric power system by itself, will not ensure the achievement of the development goals. Therefore, it is important to integrate all available means also from the heating, cooling and gas sectors and foster their integration with the power system. The recently published “Clean Energy for All Europeans”, indicates the main way forward, i.e. develop enabling mechanisms that can better reward flexibility from the side of generation, demand or storage, than from the side of consumption. As a result, a) heating markets have to foster the integration of power-to-heat technologies, b) shift from conventional generation to decentralized, smart and interconnected market has to be enforced and c) consumers be able to participate in markets, offering demand response (DR) directly or through aggregators. Consumers should be able to generate, store, share, consume or resell energy to the markets; thus explaining their role acting as self-resilient prosumers.

However, vRES inherent characteristic of intermittence and high fluctuation sets a series of limitations for their further penetration in the global energy market, since the increasing penetration of local renewable generation and the emergence for fast demand response enabling solutions, are placing new requirements on the transmission and distribution networks.

To try and address these requirements, changes are taking place in Europe’s power networks [3]. The priority is the ”smartening” of the electricity grid, which will increase the efficiency, reliability, flexibility, adaptability and reduce overall expenditure of electricity generation and distribution compared to the traditional power grid [4]. Several elements are key, to achieving smart networks. Such include:

- vRES and Distributed Energy Resources (DERs) integration within VPP (Virtual Power Plant) and aggregators;
- Demand Response (DR) including energy efficiency, demand shifting and peak shaving;
- Energy Management with valuable active end-user engagement in order to achieve the desired shifting of peak loads and Energy storage, either direct electricity storage in batteries

or conversion to other forms of energy which could be stored more affordably (for e.g. mechanical – flywheel or chemical – hydrogen).

The latter covers multiple-type of energy storage solutions (short/long term, electricity/heat storage, Power-to-X), which can cover demand fluctuations as well as enhance security of supply, and in that respect,

increase reliability and efficiency of RES based technologies.

Therefore, the smartening of electricity grid is expected to deliver numerous benefits, such as a) the ability to deliver peak load electricity or load-aware power generation near to real time, b) higher efficiency and flexibility and c) increased security of supply while reducing energy imports [6].

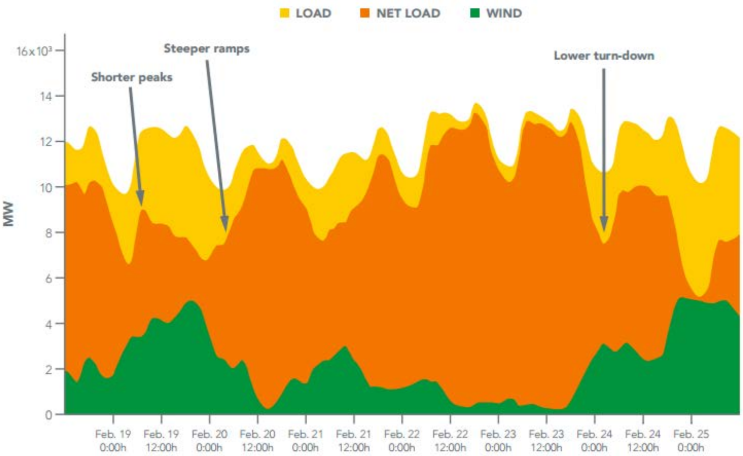

Figure 3-1 : Greater need for Grid Flexibility [5]

In this sense, grid flexibility [5] is central for the power grid's efficient operation as it allows for balancing demand and supply of electricity [7]. Due to the variable nature of RES and related problems of grid stability, high levels of flexibility are required to avoid vRES curtailment, which can reduce revenues and lead to missed emission targets. Figure 1 illustrates how the variable wind generation can impact the operation of the power grid, leading to steeper and shorter peaks with deeper troughs.

In that respect, as one main pillar for offering grid flexibility, Energy Storage (ES), both in terms of electricity and heat/cooling, is continuously attracting attention. It is expected that is will improve the integration of RES technologies, while enabling to handle in an efficient way the emerging and continuously uprising needs of the various energy carriers, such as electricity, heat and gas, when integrated on a distribution network. The application of storage solutions, allows to store the electricity and/or heat produced during 'off-peak' hours, and use it later on to meet demand peaks. This reduces the need for additional power capacity reserves, yet mostly based on fossil fueled power plants at the cost of a negative environmental footprint.

Today, various types of storage solutions are available, i.e. long or short term ones, some already in industrial use, while others are still at the research level and yet not commercialized. In the case of IRIS project both cases are included, as taking advantage from the inherent heat storage capacity of buildings for heating/cooling purposes or the use of innovative electricity storage solutions, as that of exhausted EVs batteries, as storage media both in the building and the district level. **Error! Reference source not found.** presents storage methods of a varying range of technology maturity. According to [8] typical storage solutions include storage technologies to address the challenges faced by the energy system as those of a) Mechanical Storage (e.g. compressed air heat storage, flywheel energy storage, pumped-storage hydroelectricity), b) Electrical-Electromagnetic Storage (e.g. capacitor, super-capacitor), c) Electrochemical-Battery Energy Storage (e.g. Flow battery, Rechargeable battery such as Lithium-ion and Lead acid battery), and d) Thermal Storage (e.g. Pumped-heat storage).

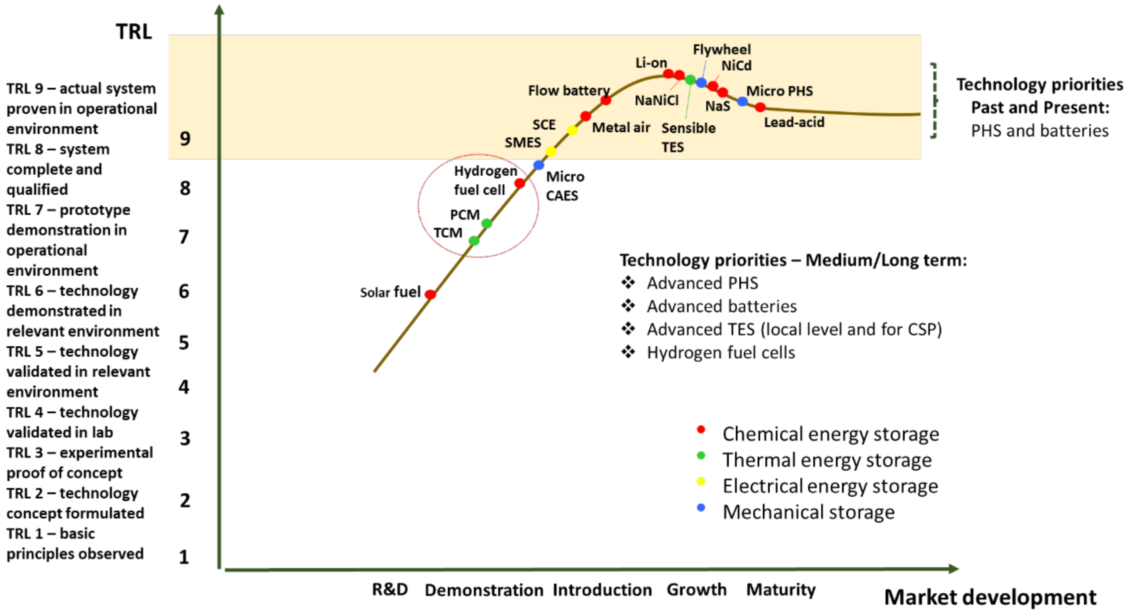

Figure 3-2: Maturity curve for representative Energy Storage Technologies

Having as a basis the requirements for grid flexibility, TT#2 addresses key challenges related to RES based energy production both in terms of electricity (e.g. PV) and heat (e.g. geothermal) supported by multiple types of both standard and innovative storage solutions, promoting the flexibility of grids through their symbiotic operation in some of the cases, always with the support of underpinning smart energy managements systems. In relevance with IRIS, those are identified as the key areas to be addressed for the introduction of local coupled multi-carrier energy systems and markets.

To consider as well the aspects of bankable business models that should support the promotion and enhancement in size and number (replication) of such solutions, IRIS will examine and demonstrate a number of Business Models applicable for each of the Solutions. For those, the current known information is too narrow and only the potential framework conditions and the aims these are expected to serve and achieve are available (for the moment the most of information is available for IS 2.1 and IS 2.3; though too limited to be of actual use). The available information, is presented in a specific Annex of this deliverable.

In short, the general idea of IRIS project is to test and optimize the operation of smart grids when operating with a high degree of RES, also promoting the idea of symbiotic operation among available energy networks (electricity-heat). Given that, the assessment of new proposed technology solutions is a very important step towards the further development of smart grids, as the approach on this should be as holistic as possible. Taking this into account, the assessment is proposed to be conducted by each IS, both in technical, environmental, economic and social terms. This is important, as in the near future, the operation of smart grids, should be in position to meet as much as possible the various requirements imposed by various stakeholders as for example the market operators and/or its potential customers.

The main objective of this Deliverable, is to set the ground of the solutions to be demonstrated and replicated in the framework of IRIS, allowing them to act as a first opportunity for exchanging know-how, ideas and experiences, before being in position to conduct a holistic evaluation of them, capitalizing on the demonstration activities results during the next two-three (2-3) years of the project. In addition, except from technical requirements and information, also other key aspects are fairly well addressed: a) data collection and management, b) related current available regulatory framework and c) business models, using as a basis the different bounds and drivers of each LH and FC towards becoming more energy self-sustainable, and smarter.

In view of this aim, as in detail explained in the previous chapters, the LH cities provided the IRIS environment with valuable experience derived by pre-pilots that are either almost or fully complete. This experience is shared among the LH cities who move a step further through the demonstrations of the proposed solutions of each IS. Finally, LH and FCs present their will for replication of the proposed solutions in their cities.

The next sections describe the scope of each Solution of TT#2, as well as the activities that are to be undertaken. Handy tables provide information about:

- **Pre-pilots**: Key points that describe the proposed solutions and the pre-pilot activities, as well as their area and the lessons learnt.
- **Demonstrations**: Key points that describe the proposed solutions and their demonstration, as well as the area of each LH city that will accommodate it.
- **Replications**: Key points that describe the proposed solutions and their demonstration, as well as the area of each LH and FC that will accommodate it.
- **Perspectives**: Brief information is provided about the needs that have occurred and the opportunities that are presented in the LH and FCs for the IRIS activities of TT#2. Moreover, bounds and drivers concerning the undertaking of demonstration and replication activities in LH and FCs are listed. Finally, the methodology and objectives of the data collection in the demonstration activities by the LH cities is presented.

3.1 IRIS Solution 2.1: Flexible electricity grid networks

3.1.1 Scope and Description of Innovative Elements

European cities focus both on the increase of the energy generation by RES, while focusing on the improvement of the supply and demand management to diminish as much as possible curtailment. The curtailment problem is becoming more intense with the continuous increase shift from a centralized model of energy production towards a decentralised one, not being previously or simultaneously supported by storage or energy conversion (Power-to-X) solutions. Information about these issues have been given in the previous section.

One of the business models, envisioned to be further developed lies on the demonstration of a new technology concept called “Local Energy Management” (LEM) that understands and allows the effective management of the core issues of interwoven and interdependent energy sub-networks and sub-systems of smart grid environments. In that respect, the LEM introduces the following innovative elements:

a) enhanced management through a flexible and optimized operation of smart grids in the context of an urban district associated to an energy mix (electric and thermal energy) based on a large share of renewable and distributed energy systems (TRL7);

b) integration of innovative concepts (e.g. Virtual Power Plants, micro-grids) together with off-the-shelf components and technologies (e.g. smart meters, EVs, storage components) (TRL9) and

c) algorithms, and open data/information dealing with demand-response optimized schemes, consumer empowerment (including active participation), autonomous management/self-consumption, combination and interoperability between distributed (local) energy resources and storage equipment and systems (TRL8).

The IS2.1 primary core elements are based on the pre-pilot in NCA, having taken place in the district of Carros, while all 3 LH cities have defined their own demonstration activities. Among the FC, Vaasa has shown interest in the solution for replication in their city.

IRIS activities involve the demonstrations based on pre-pilots by the LH cities and the replications by LHs and FCs. The following table represents the participation of each LH city in the IRIS activities concerning IS2.1:

Table 3-1 : IS2.1 pre-pilot, demonstration and replication activities by the LH

	Pre-pilot	Demonstration	Replication
Utrecht		Management and storage	
Nice Cote d'Azur	Management and storage		
Gothenburg			

3.1.2 Overview of pre-pilot, demonstration, replication of LH Cities

		Utrecht	Nice Cote D' Azur (NCA)	Gothenburg
Pre-Pilot	Key Figures / Points		Testing of **4 Use Cases**: 1. Electricity peak consumption reduction (peak shaving) a. *3 Summer offers* b. *2 Winter offers* 2. Management of PV injection into the grid 3. Grid-islanding 4. Testing of the techno-economical interest of batteries	
	Area		Carros, the northern part of the Nice Eco-valley	
	Lessons Learnt		• Negative flexibilities (demand reduction) in winter were much easier to implement than the positive ones (demand increase) in summer. • Implementation of intra-day peak shaving actions was more difficult than day-ahead or longer term planned actions. • The actual existing regulatory framework based on a TSO centred market design, did not allow the generation of a viable retribution from the proposed flexibility services at the distribution grid level • Two main configurations could be seen as the most promising ones: 1) LV grid scale batteries located at a feeder departure from the secondary substation, which enabled the mitigation of the grid constrains on the main affected LV grid section; 2) flexibility solutions implemented as near as possible at the origin of the potential source of grid constrains thus, at best directly within the premises of a	

			producer/consumer client.	
Demonstration	Key Figures / Points	A group of apartment buildings is planned to be fed by five medium voltage to low voltage distribution stations. The district energy management system will have a double function: 1. While retrofitting the apartment buildings, solar panels and charging points for electrical vehicles will be installed. The EMS will measure the changes in energy flows during the process. This will enable to analyse and assess the impact on the electricity system when, due to replication, the solutions in the demonstration area are duplicated on a large scale. 2. The real time measurements of the electricity flows will be an essential input for the relevant Dutch aggregators to beneficiate from flexibility, in order to support Stedin (Dutch DSO) keep the maximum flow within acceptable values.	Use of Local Energy Management System (LEMS) for the economic optimization of the various functions of the grid. The functions of the LEMS are: 1. Monitoring 2. Forecast 3. Optimization 4. Valorisation Several Use cases will take place, enabling the optimized management of renewable sources, storage systems, demand side and electric vehicle charging infrastructure.	**Use case #1: AWL** Demonstration of a 350 V DC building microgrid utilizing 140 kW rooftop PV installation and 200 kWh battery storage. **Use case #2: Energy management system at the Viva Housing Association** Management and coordination of multiple energy sources in a housing project at sub-district scale (132 apartments in 6 buildings). Particularly, management of the geothermal resource (boreholes), the heat pumps and DH network, in ways that are financially beneficial for the housing association but at the same time contribute to quality and balance of the distribution grid.
	Area	Kanaleneiland Zuid	1. Nice Meridia district 2. Grand Arenas district	1. AWL building at Chalmers University 2. Riksbyggen's sub-district Viva Housing Association
Replication	Key Figures / Points	• PV panels on the rooftops of the apartment buildings; • Home Energy Management Systems (HEMS) provided by Eneco (Dutch group of companies, acting as multiple	• Aggregation of local flexibilities for grid services (DSO, TSO or Energy Market - Aggregator) through the LEMS • Smart charging of electric vehicles for flexibility provision to the grid;	Akademiska Hus is considering replicating the PV/DC infrastructure solution

		type technology providers); • Energy savings resulting from refurbishment towards "near zero energy building"; • Smart electric driven reversible heat pumps for the production of heating and hot water LT DH for heating and hot water;	• Operation and maintenance of a coupled PV and Battery storage system in tertiary buildings.	
	Area	Rest of Utrecht, Netherlands.	The greater Eco Valley area.	Campus/building of the School of Business, Economics and Law at the University of Gothenburg.
Perspectives	Opportunities & needs	• Opportunities: Maximize profits of renewable power production; Maximize self-consumption reducing grid stress.	• Opportunities: Maximize profits of renewable power production; Maximize self-consumption reducing grid stress; Promote the deployment of: • the LEMS; • Battery storage systems; • Smart charging.	• Opportunities: Promote the deployment of: • DC electricity network; • Battery storage systems; • Software Equipment.
	Data Collection	• Real time energy consumption on the household level; • Real time energy consumption and production on the apartment building level; • Real time electricity production of the PV panels; • Real time consumption of locally produced electricity with the PV panels.	Data will be collected in the range of minutes to hours for all systems conversion systems connected to the LEMS. The generated data will be stored locally at the EMS installed on site and/or in the data servers of a third party B/EMS provider and/or the LEMS server itself.	Data to be collected is expected to include: • Overall system efficiency; • PV current and voltage; • Charging current to batteries; • Amount of electricity supplied externally.
	Bounds & drivers	• Technical: Equipment to monitoring performance of the electricity grid; • Legal/financial: New legislation needed is currently being prepared aiming at providing incentives to consume or store locally produced	• Legal/financial: EU regulations; investment aids from ADEME in renewables; Tax reduction on energy bill for DHC networks (DHCN), providing at least 50% of energy from renewable sources; Nice's Charta on ready to grid buildings; Nice's environmental Charta on constructions	• Technical: A fast development of grid flexibility related technology is needed (e.g. energy storage, supported by energy management systems); • Legal: evolving subsidy schemes; • Social: Champions and influencers could create a positive social context for

		electricity; • Social: Uncertain role of households.		acceptance of the solutions; • Financial: Potential cost reduction (uncertain if considering life cycle costs); • Environmental: Increased RES penetration (uncertain impact on LCA).

3.1.3 Overview of the replication of Follower Cities

	Vaasa	Alexandroupolis	Santa Cruz Tenerife	Focsani
Key Figures / Points	The LEM will introduce the following innovative elements: • enhanced management as well as flexible and optimized operation of a distributed smart grid. This is especially required when share of renewable energy (wind and solar) is increasing, (TRL7). From the "Sundom Smart Grid pilot" some preliminary information and knowledge is already available; • integration of innovative concepts (e.g. Virtual Power Plants, microgrids) together with off-the-shelf components and technologies (e.g. smart meters, EVs, storage components) (TRL9) and • algorithms, and open data/information dealing with demand-response optimized schemes, consumer empowerment (including active participation), autonomous management/self-consumption, combination and interoperability between distributed (local) energy resources and storage equipment and systems (TRL8).			
Area	Sundom village			
Opportunities & needs	• RES (PV) availability in the Replication area • Software solutions and services			
Bounds & drivers	Good basis to continue with replication. Local companies involved have good knowledge and co-operation with the University. Also the basic infrastructure with optical fibre network and data centre is in place and already tested. Project has also received good feedback on citizen engagement.			

3.2 IRIS Solution 2.2: Smart multi-sourced low temperature district heating with innovative storage solutions

3.2.1 Scope and Description of Innovative Elements

IS 2.2 is mostly linked with the building sector in the IRIS project, as most of the solutions being addressed aim at serving to its needs. Heating and cooling in buildings and industry accounts for almost around 80% of the EU's energy consumption [9]. Specifically, In EU households, heating and sanitary hot water alone account for 79% of their total final energy consumption. Especially in northern Europe, the demand for heating is predominant. Approximately 70% of the buildings that exist today pre-date any energy efficiency directives or policies [10] and even for buildings being built today, up to two thirds of the energy consumed is not covered by any codes or standards. In Europe alone, around 83% of the housing stock is constructed before 1991 [11], thus further complicating the introduction of RES based solutions for them, since they have not been originally designed to be easy adaptable in such.

Nevertheless, the energy consumption and carbon emissions of them can be significantly reduced by implementing sustainability measures both in terms of implementing energy efficient technical equipment (for example energy efficient lighting, efficient Heating, Ventilation and Cooling (HVAC) systems, Building Energy Management Systems (BEMS)) and conducting interventions at their envelope (for example retrofitting external façades, renewable energy systems), given the prerequisite that they experience renovation. As a matter of fact, the situation can be fostered through the use of energy efficient but also RES based integrated solutions, relevant to their heating and cooling. Decision makers in both private and public sectors are frequently challenged to identify the optimal selection of building upgrade measures that can minimize energy consumption while meeting budgetary restrictions. To drive decision makers and building owners to meet this challenging aim, there is a raising pressure to apply RES based technologies, also capitalizing on the latest development on LT/MT heating networks [12], which especially at the district level may arise to be more beneficial and less expensive than introducing a higher thermal efficiency of the building itself.

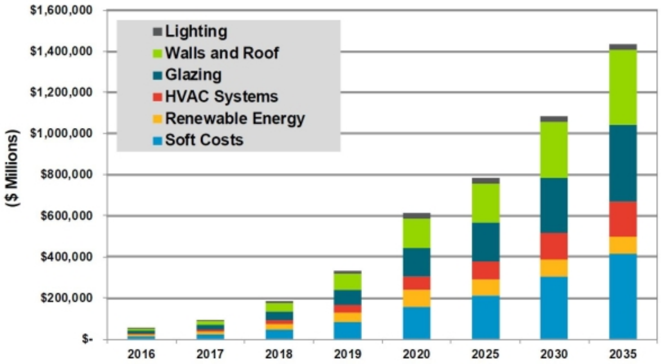

Figure 3-3: Total zero energy building revenue by production/service, World Markets: 2016-2035

As stated in the "Heating and Cooling Strategy" [13], heating markets have to be open up to competition and foster the integration of power-to-heat technologies. It is underlined the need to integrate electricity and heating grids, through the operation of "power-to-heat" technologies and thermal storage (specifically in storage tanks and pits, but also thermal storage using the thermal inertia of networks and buildings) to shift demand and integrate renewable energy. The correct integration and operation of these technologies in DHCN, still represents a major challenge. Such type of systems, can't be operated under traditional operation systems, but need the development of new SEMS.

IRIS aims to replicate and demonstrate two (2) main cases, i.e. those of re-design/transformation of already existing high-temperature DHNs to LT ones (replication for Utrecht and demonstration for NCA and Gothenburg) and the optimized operation of DHCN sourcing enthalpy either from waste heat streams as in the case of Waste Water Treatment Plants) and/or introduction of renewable source (geothermal energy).

A Solution addressed in IRIS is to overhaul and operate a system originally designed as a high temperature one (90-120°C) as a mid-temperature one (30-50°C). This can be achieved through technical improvements, as has been stated in the pre-pilot that Nice provided in IS2.2 (TRL8). On top of that, an innovative service platform for increasing energy-efficiency in existing DHNs will as well be deployed. In addition, the themes that will be addressed are:

i) decision support platforms, which will be designed to transfer any available waste heat source stream to the best fitting sink of energy, following a process sheet upon which they are designed, using as the main decision parameters a) the availability and enthalpy levels of energy source and b) the needs and temperature requirements of the energy sink;

ii) intelligent, self-learning and automatically optimised controls for DHN (e.g. smart valves);

iii) DHN fault detection and diagnostics tools capable of identifying fast and accurately the pipeline parts that malfunction;

iv) the potential use of cloud based energy management services, on top of current in place energy management systems for DHN operation (TRL8->9), for which information and potential ideas will be exploited in the course of IRIS Transition Track #4.

In the theme of LT DHCN, IRIS will focus on the waste heat utilization on multiple-scales starting from the level of kWs as in the case of waste heat sources in the building sector (oven, washing machines), up to the scale of even potentially MWs (the case of a Waste Water Treatment Plant proposed by Utrecht, also being in detail examined in IS1.3) among others (TRL7->8). By operating in a LT mode this energy sources can be exploited (with the use of heat pumps) which otherwise could not be used within a traditional HT DHN.

Furthermore, the question of the use of innovative technologies for both short-term and long-term thermal storage will be addressed. For this, Gothenburg aims to use: a) building's thermal inertia as a short-term thermal storage medium (TRL7->8), b) geothermal bore holes for long-term storage (TRL7->8) and c) test phase-change materials for storage applications (TRL6->8), also including the case of own building thermal inertia (TRL6->8).

All 3 LH cities have considerable experience through activities that having been already conducted in their pre-pilots, at least as concerns DH network (not only MT, but also LT). Moreover, NCA and Gothenburg are foreseen to demonstrate such, in the course of IRIS project. All LH cities and FCs, except for Tenerife, have shown the interest for replication.

The IS2.2 primary core elements are based on the pre-pilots in all 3 LH cities, which concern LT DHN by various sources (waste water and geothermal energy). The LH cities of Nice and Gothenburg have defined their own demonstration activities. Among the FCs, Vaasa, Alexandroupolis and Focsani have shown interest in the integration of LT DHCN and heat storage solutions for replication in their cities.

IRIS activities involve the demonstrations based on pre-pilots by the LH cities and the replications by LH and FC. The following table represents the participation of each LH city in the IRIS activities concerning IS2.2:

Table 3-2 : IS2.2 pre-pilot, demonstration and replication activities by the LH

	Pre-pilot	Demonstration	Replication
Utrecht	Waste water		Waste water
Nice Cote d'Azur	Boiler	Geothermal	
Gothenburg	Geo-storage		

3.2.2 Overview of pre-pilot, demonstration, replication of LH Cities

		Utrecht	Nice Cote D' Azur (NCA)	Gothenburg
Pre-Pilot	Key Figures / Points	MT DHN supplying heat from different energy sources, supplies medium temperature heat for space heating and SHW to 1440 homes and 12.000 m^2 of office and business buildings.	HT DHN supplied by 3 natural gas boilers of a total installed capacity of 21 MW. Through a system of 28 substations, it supplies heat mainly to the collective housing units owned by Côte d'Azur Habitat (originally 31 housing units were planned) and to several municipal buildings (one school and a swimming-pool).	**Use case 1:** Smart management of heating and cooling on the campus area. Combine heating, cooling and recovery of waste heat from cooling heat pumps. **Use case 2:** Shallow geothermal storage in LT DH at Medical Campus. The use of geo storage through boreholes provides a seasonal balancing of temperatures: heat injected from the cooling process during summer, can be extracted for heating in the winter season
	Area	Harnaschpolder in Delft	Les Moulins neighbourhood	**Pre-Piot Area #1**: Chalmers Power Central on the Chalmers Campus (Johanneberg) **Pre-Piot Area #2**: Building on Medical campus
	Lessons Learnt	• choice of performing material for the heat pump is crucial, as inherent bacteria being contained in the flow medium may corrode it; • the WWTP based DH underpinned by the current tariff regulations is not yet cost-effective.	The project is on-going, thus there are no solid conclusions yet concerning: • the technical and economic performance of the DH solutions tested; • the ability to make thorough retrofitting to a neighbourhood so as to accommodate such solutions.	• Environmental and financial benefits; • Building's overall energy performance is significantly better than most similar existing buildings and twice as good as the level prescribed by regulations.
Demonstration	Key Figures / Points		Public call for tender launched for the development of a geothermal sourced LT DHCN. Main characteristics: • Shallow geothermal heat source at approx. 25°C; • Supply of heating, cooling and possibly SHW (approx. 45, 7 and 60 °C respectively); • Energy will be delivered through a double-way substation;	**Use case #1: Chalmers campus** • Phase 1: Demonstration with a PCM storage of 375 kWh; • Phase 2: According to the results of Phase 1, the plan is to continue with a demonstration of a PCM storage of 1700 kWh. **Use case #2: Riksbyggen Viva** Six buildings will be supported by a shallow geo energy

			• The layout of the system is not defined yet as the location of the heat pumps (centralized, semi- or decentralized substations); • Electricity will be partly supplied by PV panels (20%) and will be used to partially cover electricity consumption of circulation pumps and heat pumps; • The business model of the system operator, should enlarge its scope towards a district level approach and embrace also smart grids and associated services.	solution with 19 boreholes of about 230 m depth. Those are also used as seasonal storage. The DHN will also provide cooling for nearby office buildings in summertime.
	Area		Nice Meridia, West territory of the Metropolitan area of Nice	1. AWL office building, Chalmers campus, Johanneberg; 2. Riksbyggen Viva Housing Association , Johanneberg
Replication	Key Figures / Points	Examination of the feasibility to utilize the heat produced at a waste water treatment plant after first increasing its temperature up to 70°C.	Use of DHCN in a wider area with support by other energy sources as sea water or waste heat recuperation from industrial or public processing plants (e.g. Waste Water Treatment Plant as in the example of Utrecht).	Akademiska Hus is developing the Gibraltarvallen area on the Chalmers campus, currently used as parking area. They looking at several possible alternatives for a heat source, including the recently launched Ectogrid™ system from E.ON. Ectogrid™ uses a variable LT waste heat feed to provide both cooling and heating (using heat pumps) for DHCN.
	Area	Overvecht in Utrecht	Nice Meridia phase 2, wider territory of Nice Eco Valley	Chalmers Campus area, Johanneberg, and the new districts in the city with low-energy buildings, such as Lindholmen or Frihamnen
Perspectives	Opportunities & needs	No available data yet.	• Achieve environmental targets set by city administration regarding RES integration in heating sector; • Identification of viable connection and retail tariffs to "normalize" the approach; • Combining heating network operation and smart grid services for Smart Cities and districts.	Needs • Increase overall efficiency; • Overall cost reduction. Opportunities • Use of Management tools and optimization methods; • Use of ambient temperature feed and common feed for heating/cooling.

	Data Collection	No available data yet.	Any technical and functional specifications connected to an operation and management system, are dependent on the retained operator from the public call for tenders.	Data collected after being processed will include: • Local cooling/heating demands of connected users; • Temperatures of supply and return feeds; • Availability of external energy sources; • Weather forecast information; • historic time series of production/demand loads; • Indoor temperature, electricity and domestic hot water used at the apartment and building level; • Electricity production from solar cells; • Heat provided by the heat pumps; • Estimation of heat losses.
	Bounds & drivers	No available data yet.	• Legal: French heating sector regulations • Financial: investment aids from ADEME; Tax reduction on energy bill for DHCN, providing at least 50% of energy from renewable sources. • Regulation: Public call for tender specifications; Nice's Charta on ready to grid buildings; Nice's environmental Charta on constructions	Technical: Heat pumps have become much more efficient and cheaper. This promotes the use of LT networks, where heat pumps are used to obtain higher temperatures. Lower temperatures demand larger installations to achieve sufficient thermal comfort. Legal: More accurate regulations. Financial: Lower costs of installation and lower operational costs. Low grade waste heat is financially beneficial. Environmental: Environmentally beneficial due to increased efficiency

3.2.3 Overview of the replication of Follower Cities

	Vaasa	**Alexandroupolis**	**Santa Cruz Tenerife**	**Focsani**
Key Figures / Points	The City of Vaasa is interested in: • the operation of LT networks • the decision and business model support • intelligent, self-learning and automatically optimised controls	Interest in: • operation of LT networks • innovative algorithms for increasing energy-efficiency in existing DHNs • utilization of LT waste heat such as the		Operation of a centralized HT DHN, which includes a cogeneration plant, transport network, thermal substations and distribution network. The replication project includes measures for increasing energy efficiency, heat storage and eventually heat utilization

	for DHN • DHN fault detection and diagnostics when it affects energy efficiency • cloud based energy management services for DHN	excess heat from buildings • short-term and long-term thermal storage		for cold generation.
Area	Ravilaakso	Low enthalpy geothermal field of Traianoupolis		Focsani
Opportunities & needs	• Increased use of renewable energy resources • New smart buildings integration • Thermal storage solutions • DHN fault detection and diagnostics • Software solution and services	• Increase RES penetration on a district level for heating/cooling • Minimize energy losses • Store excess energy for cooling/heating purposes • OPEX and security of supply risk reduction. Increase operating hours • Smarten the DHCN through the SEMS		• Increase energy efficiency of the DHN by implementing a heat storage tank • Use of heat during summer time for cold production • Reduce heat and water losses • Increase overall system efficiency, better fault detection, improve service quality
Bounds & drivers	The existing DHN does not include any smart solutions.	• <u>Technical</u>: The reinjection into the geothermal reservoir is a barrier • <u>Legal</u>: Licensing procedure for DHCNs is complex and requires simplification in order to attract investors and operators • <u>Social</u>: DHCN are not common in Greece • <u>Environmental</u>: Reduction of CO_2 emissions		<u>Legal</u>: High efficiency cogeneration needs the support for business investments incentives, by the underpinning current existing regulatory framework. Heat tariffs are still regulated by the local and national authorities. <u>Social</u>: Energy poverty for a part of the population, disconnections from DH are possible. <u>Environmental</u>: Reduced environmental impact

3.3 IRIS Solution 2.3: Utilizing 2nd life batteries for smart large scale storage schemes

3.3.1 Scope and Description of Innovative Elements

As already being stated and in enough detail being explained, the EU commitments for strong vRES penetration, requires the improvement of the electric grid flexibility (IS2.1). In that respect, both conventional electric storage solutions, but also innovative ones are expected to play a leading role for the resiliency of electricity network in support of currently operating hydro plants. Li-ion battery production in Europe is expected to rise dramatically in the coming years. In addition, much of the raw materials used for manufacturing most of the standard batteries (e.g. Li-Ion) are imported from outside of the EU. The mining of the materials used in batteries cathodes are currently strongly linked controversial aspects as environmental impact and pollution. The global warming potential of mining and processing nickel is ranked as the eighth highest out of 63 metals studied [14]. This is the current situation, though proper recycling can recover Critical Raw Materials at their end-of life, creating a resource independent value chain with greatly reduced environmental and health impact. Unfortunately, the recycling process for Li-ion batteries is not yet mature enough to be efficient and economically viable. As a consequence, most of these batteries are destined for landfills [15]. Second-life use of EV batteries can potentially postpone the need for mass recycling of Li-Ion batteries by approximately 10 years [16] allowing the infrastructure and technologies needed for collecting and recycling them to grow and mature. In addition, the use of 2nd life batteries from EVs, to support the electric grid flexibility of both the building and district level of production/consumption peak shaving, supports additional aspects addressed by the IRIS Transition Tracks #1 and #2.

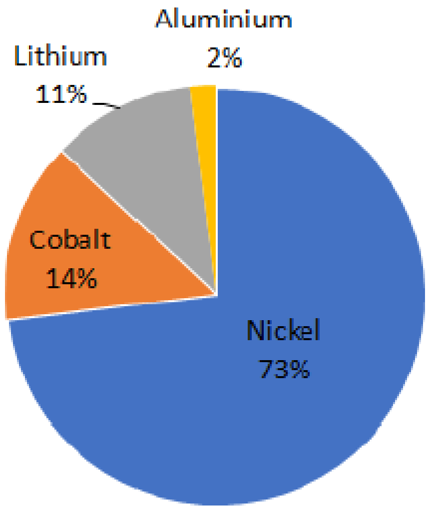

Figure 3-4: Percentage of materials mass used in batteries cathodes

In relation to that, it is foreseen to use batteries originating from the EVs industry, which are not suitable anymore for their original application but yet adapted to the energy sector. It is not defined if the batteries to be used will be chemically revamped or not. By any mean, this will allow to address the priority set by the EU policy for circular economy and related business development, as stated before. Moreover, such re-utilization could create potentially new revenues streams among the batteries' overall life cycle and those revenues be reversed into the value chain, reducing the overall costs for their commercialization for the end users.

The innovative elements will include the use of a **EVs batteries** as storage systems in the place of conventional new battery systems of Li-Ion (***TRL7->9***). Furthermore, not only batteries coming from the electric car industry will be used, but also batteries coming from electric-busses (***TRL8->9***), the latter a case offered by Gothenburg. The demonstration will go one step beyond and will contribute in the assessment to what extent the question about the re-use of EV batteries, which can also be used in relation to V2G charging infrastructure **(TRL8->9)**, does have a real business meaning and technical long-term sustainability. The main technical challenge to be addressed here, is the assessment of the what should be optimal charging and discharging cycles to apply during the batteries' 1st life, so that 2nd life is yet possible and this also considering profitable business underpinning models. It is probable enough that the V2G application will degrade the batteries faster than a traditional EV application and as a result the associated charging infrastructure (e.g. inverters, transformers, buses), but this remains to be in more detail explores in the course of the demonstration activities in the three (3) LHs.

The 2nd life batteries IRIS solution demonstrations are based on a pre-pilot delivered in France (not in NCA for reasons being explained in the Annex). All 3 LH cities are interested in the demonstration and replication of this Solution, since at the moment is of considered to be a worth investing technology. From the FCs, Tenerife has showed an interest to replicate.

IRIS activities involve the demonstrations based on pre-pilots by the LH cities and the replications by LH and FC. The following table represents the participation of each LH city in the IRIS activities concerning IS2.3:

Table 3-3 : IS2.3 pre-pilot, demonstration and replication activities by the LH

<table>
<tr><th></th><th>Pre-pilot</th><th>Demonstration</th><th>Replication</th></tr>
<tr><td>Utrecht</td><td></td><td rowspan="3">Grid and EV</td><td>Grid</td></tr>
<tr><td>Nice Cote d’Azur</td><td></td><td></td></tr>
<tr><td>Gothenburg</td><td></td><td>Building</td></tr>
</table>

3.3.2 Overview of pre-pilot, demonstration, replication of LH Cities

		Utrecht	Nice Cote D' Azur (NCA)	Gothenburg
Pre-Pilot	Key Figures / Points		Reutilisation of 2nd life batteries was one of the main axis of development, under the development and testing of a "smart secondary substation". Thus a grid scale application.	
	Area		Issy-les-Moulineaux and subsequently on the district of Fort d'Issy.	
	Lessons Learnt		The CBA is still underway.	
Demonstration	Key Figures / Points	District V2G and storage system: management of solar energy, V2G charging infrastructure for e-cars and e-buses, along with a stationary storage using 2nd life batteries. Such stationary storage system will be integrated in several garage-boxes part of the demonstration district.	Battery storage system with a capacity of about 50 kWh, based on e-vehicle batteries, so Li-Ion technology. The latter, will be integrated into additional 100-150 kWh battery storage system, based on new Li-Ion batteries. The so composed storage system will be connected to the BEMS.	A 200 kWh battery storage will be installed in a sub-district/housing cooperative of 132 apartments. This will be integrated into a system composed of PV generation systems and EV charging stations.
	Area	Utrecht	A 5000 m² energy-efficient building, located in Nice Meridia	Riksbyggen Viva Housing Association, situated next to Chalmers campus Johanneberg
Replication	Key Figures / Points	A city wide deployment of PV panels is foreseen. The use of 2nd life batteries could potentially be of interest to ensure local and self –consumption of such RES while providing peak shaving services to the grid.	Integration of 2nd life batteries from e-vehicles in a "self-consumption" endeavour based on PV generation system and electric storage.	Replication, on a National level of the newly deployed national Tool for "Sustainable Management". This tool suggests measures and actions in order to increase the sustainability performance of a building (linked also to TT#1), where potentially 2nd life batteries can be used.
	Area	Utrecht	Nice Méridia or even the wider territory of	Riksbyggen Viva Housing

			Nice Eco Valley	Association
Perspectives	Opportunities & needs	A strong penetration of vRES increases the need for storage and smart management of locally produced electricity to reduce congestions experienced at the secondary sub-station level of the electricity grid. 2nd life batteries are expected to have a major role in the cost effectiveness of storage solutions. A data platform enabling dynamic estimate of the flexibility of a microgrid based on RES should enable an optimized management.	• Penetration of 2nd life batteries in self consumption endeavour in tertiary and industrial buildings • Standardization of 2nd life battery systems	More relevant information will be given in D8.1
	Data Collection	No available information yet.	Dedicated metering system is foreseen. Data will probably be also forwarded to the CIP.	No available information yet.
	Bounds & drivers	Technical: No experience yet in operating 2nd life batteries Legal: Current regulations in the Netherlands are not providing incentives for the use of 2nd life batteries behind the meter for grid applications Financial: Investment in 2nd life batteries behind the meter is not yet viable. Incentives are needed. Environmental: Can potentially lead to lowering CO_2 emissions.	The deployment of 2^{nd} life battery needs the integration of a new actor in the building related existing economic landscape: the battery supplier, probably related to the EV industry. BMES or dedicated EMS will have to be developed and used to support the operational level of these type of batteries, as their load cycling (charging/discharging) behaviour and overall degradation is potentially different from the standard ones.	The Gothenburg bounds and drivers are not available yet. Information will be provided in D5.4.

3.3.3 Overview of the replication of Follower Cities

	Vaasa	Alexandroupolis	Santa Cruz Tenerife	Focsani
Key Figures / Points			Not yet available. Relevant information will be given in D8.1.	
Area			Not yet available. Relevant information will be given in D8.1.	

Opportunities & needs			Not yet available. Relevant information will be given in D8.1.	
Bounds & drivers			Not available yet. Information will be provided in D5.4.	

4. Next Steps (in cooperation with WP3 and WP5-WP8)

D1.3 is the first step towards the creation of a detailed transition strategy for smart energy management and storage for energy networks flexibility (TT2). This transition strategy will be further developed in many tasks where the information provided in D1.3 sections will further be analysed and elaborated. In particular, the following deliverables will be based on D1.3:

- **D1.7: Transition Strategy, Commissioning Plan for the demonstration & replication (M12):** This report will provide a detailed transition strategy plan, comprising of the demonstration, replication and opinions exchange planning among cities / administrations / cities planners and all involved stakeholders, on the basis of the analysis of all the defined solutions in the five IRIS transition tracks.
- **D5.1 / D6.1, D7.1: Report on baseline, ambition & barriers for Utrecht / NCA / Gothenburg lighthouse interventions (M12):** These reports will provide precise and realistic specification of ambitions, activities and planning for each of the interventions planned. These are expected to be run using as a basis the already started activities of WP1 related to the extraction of requirements for the 5 Transition Tracks. These will include in more detail the a) baseline definition of citizen energy and mobility behaviour, b) setting up of the monitoring principles and c) the business modelling development.
- **D5.2, D6.2, D7.2: Planning of Utrecht / NCA / Gothenburg integration and demonstration activities (M12):** This report will provide the coordination structures and procedures concerning governance, communication, monitoring and impact analysis, local risk assessment, periodic reporting, and planning of integration and demonstration activities in each of the LH cities.
- **D5.4, D6.4, D7.4: Launch of T.T.#2 activities on Smart energy management and storage for flexibility (Utrecht / NCA / Gothenburg) (M24):** Report describing the set-up of demonstration activities and initial experiences of operation regarding the IRIS solutions and citizen engagement activities in T.T #2 in each of the LH cities
- **D8.1 A Roadmap for replication of activities (M25):** The roadmap (business/financing plan) will summarize the replication of activities for demonstration plans and post-project replication with a Gantt chart and a Work Breakdown Structure (WBS), as well as a schedule per task, responsible partner related subtasks, related deliverables, and dependencies on other tasks.
- **D8.4, 8.6, 8.8, 8.10 Vaasa / Alexandroupolis / Santa Cruz de Tenerife / Focsani replication plan (M36):** A replication plan (business/financing plan) for post-project replication in each of the FCs.
- **D3.7: Financing solutions for cities and city suppliers (M24):** A Report that will map and present financial pathways for IRIS solutions.

5. Conclusions

D1.3 provides preliminary planning of the demonstration and replication activities of TT#2, entitled as "Smart Energy Management and Storage for Energy Networks Flexibility". The document defines each solution's requirements/specifications (for example geographical, technical, operational, legislative, regulatory framework, business) before the solutions are being deployed and demonstrated in the selected LH cities and potentially replicated in the FCs. The deliverable's preparation process initiated the exchange of knowledge and opinions between the LH and FC cities on how each of the IRIS solutions can be in the best way integrated into their territory/city.

The deliverable includes a quite detailed description of the pre-pilot areas, based on the available information of the applied technologies from the relevant experienced consortium partners. The description comprises the initial requirements and technical specifications concerning the application of each of the IRIS Solutions, as part of the TT#2. The document supports the Transition Track's aims to increase the RES integration in the energy mix with the use of storage technologies and energy management tools. In addition, it gives insight for the replication of the conceived IRIS solution, which will be demonstrated, taking into consideration not only the individualities and the specific needs of the LH cities but also the needs and the objectives of the FCs which are not yet clearly illustrated.

The present deliverable is not a study, but a collection of data and information concerning the early planning of the IRIS demonstrations and replications. Thus, there are no actual yet available concrete "conclusions" to which the IRIS partners can be driven to. The primary purpose of that was, among others, the exchange of ideas and know-how among the partners, in order to create a clearer view of the demonstration and replication activities between and among the LHs and FCs.

Nevertheless, some general comments can be derived from the cross comparison of the different endeavours:

<u>IS 2.1, primarily being characterized for the case of Flexible grid networks:</u>

- Among the 3 LCs, it comes to light that there is a need and expectation to better integrate locally produced vRES (for the 3 LHs PV is the most used one, varying consistently in terms of foreseen installed capacity) on the LV/MV distribution grid (up to level of DSO);
- In all demonstration activities of all three (3) LHs, the electrical storage aspect will be included, as being already highlighted;
- A dedicated EMS is expected to be an essential service is order to enable a successful integration of different technologies: PV, stationary storage facilities, charging infrastructure for EV (even V2G for the support of electricity grid flexibility), power-to-X technologies (X in the case of IRIS stands mainly for Heat with the use of heat pumps);
- However, among the different countries, the system configuration changes in sound with local regulations, which however are currently generally perceived as not favouring this type of solution. In that framework, most of the LHs highlight the need for an update of the current fragmented EU and/or national level legislation framework;
- In a context of limited regulation and incentives to such type of local systems, the overall financial viability can be questioned. This is in opposition to the expected positive environmental impact and increased performance that are expected by all LHs and FCs, when implementing those Solutions.

<u>IS 2.2, primarily being characterized for the case of Smart multi sourced LT/MT DHN:</u>

- The demonstration covers small to medium scale systems and multiple operating temperature regimes. The feasibility of LT networks is not questioned, neither its increase in performance over HT. The gains from a continuous operation time and lower maintenance costs are of a common shared interest; even for replications.

- By the use of power-to-X technologies (mainly producing Heat with the use of heat pumps), together with LT renewable (e.g. geothermal) and waste heat recuperation sources, it is expected to further enhance the share of RES in the local system. Shallow geothermal primes as the predominant RES, while waste heat recuperation is as well considered of high importance.
- Heat storage is addressed in all its applications, a) from intra-day applications (network and buildings as storage), to seasonal storage (boreholes) and of b) multiple scale starting from some kW to several MW. Even PCM based storage is going to be tested. However, innovation is less on the technological side, than on the management system to be deployed.
- Differently from the previous IS, not yet a mature regulatory, legal or incentive based concern has been put forward for the demonstration activity, as concerns the LHs. Differently in the replication actions of the FC, where regulation and social acceptability seem to be of concern.

<u>IS 2.3, primarily being focused on the use 2nd life batteries, to support electric grid flexibility:</u>

- Among all demonstrations, the foreseen 2nd life battery based storage systems are used to maximize the local integration of PV power, together with its further valorisation in combination with EV charging infrastructure.
- Compared to standard (e.g. Li-Ion) storage solutions, their application provides a potentially interesting business case, as they can benefit from the development of related business models, which principles rely on the valorization of a product value, after its end-of-life (circular economy principles). Among the investigated Solutions, this can be considered as the most innovative, since not much information is yet available, even when considering low-medium TRLs (3-6) solutions/technologies;
- The main question that is addressed is the cost benefit balance compared to storage systems based on new batteries. The main unknown determinant is the “remaining” performance/life time after their “1st life” use;
- Two main aspects stand out: absence of dedicated regulation and poor return of experience. This underlines the very early stage of the technology and the interest the demonstration of such solution.

The related Deliverables that are based on the present one (D5.4, D6.4, D7.4 and D8.1) that will deliver the demonstrations and replications are expected to drive to more solid conclusions.

The optimal collaboration and communication between the local ecosystems and the horizontally involved partners contributed significantly to the competition of the deliverable’s objectives and set the ground for achieving the project’s overall goals.

D1.3 is the first step towards the creation of a detailed transition strategy for the smart renewables and closed-loop energy positive districts. This transition strategy will be further developed in the context of WP3, WP5, WP6, WP7 and WP8. These work packages include tasks that will present in detail the information provided by D1.3.

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7. ANNEX for IRIS Solution IS-2.1: Flexible electricity grid networks

7.1 Pre-pilot Areas description and Available Infrastructure

Disclaimer

In the Pre-Pilot description section, data is provided about the scope, structure, results and conclusions of the past related activities. The herein stated information represents the state-of-the-art on which IRIS is going to proceed as a one step further. For the case of more information needed, the interested stakeholder should contact the responsible entity of the pre-pilot site.

7.1.1 Nice Cote D'Azur Pre-Pilot

The pre-pilot took place in Carros, in the northern part of the Nice Eco-valley, and has been developed under the Nice-Grid project [17]. The project had five (5) main objectives, corresponding to five (5) main **Use Cases**, with four (4) of them being relevant to this Transition Track:

1. **Electricity peak consumption reduction (peak shaving)**
2. **Management of PV injection into the grid**
3. **Grid-islanding**
4. **Testing of the techno-economical interest of batteries**

The above cited use cases were further broken down into a total of 12 technical use cases. Those were all monitored through the following KPI (Key Performance Indicator) system:

#	Technical KPIs	Unit
1	Max reduced peak power	kW
2	Fraction of peak power and average power for each of the 4 feeders departing from the primary substation (HV/MV)	MW (%)
3	Energy losses of the batteries and auxiliary consumption	MWh
4	Max power capacity of the grid	kW (%)
5	Tension variation on the grid due to PV integration	V (%)
6	Duration of the islanding	minutes
7	Voltage differential due to the islanding	V (%)
8	Frequency differential due to the islanding	Hz (%)
9	Total harmonics distortion on the islanded grid	THD
10	Reliability of the energy demand forecast	kW (%)
11	Reliability of the PV production forecast	kW (%)

#	Social KPIs	Unit
12	Ratio of clients recruited for the experimentations	%
13	Ratio of participants who abandoned the experimentations	%

#	Environmental KPIs	Unit
14	Carbon emission reduction	tCO_2eq
15	Deferred health impacts thanks to the amelioration of air quality	YOLL/DALY
16	Length of avoided network infrastructure	km

The global numbers of the project, included:

- 300 customers recruited for the experimentations;
- The deployment of 2350 smart meters;
- A cumulative installed PV capacity of 2,125 MWp;
- A total battery storage capacity of 1,5 MW and the
- Achievement of successful complete islanding of a part of the grid for 5 hours. This aspect is considered to be a technological breakthrough for the EU.

The Project was led by ENEDIS and had a duration of 5 years. The consortium consisted of members representing various stakeholders.

Figure 7-1: Consortium partners of the Nice Grid project

Table 7-1: Consortium partners of the Nice Grid project and their role

Consortium Member	Role in the Nice-Grid Project
ENEDIS	Project leader and operator of all DSO related experiments
General Electric	Development and provision of the distributed energy resources management system (DERMS) > real time management
EDF	Develop and implement flexibility solutions for private customers and enterprises
SAFT	Battery installation and operation for the grid connected stationary batteries experimentation
ARMINES	Electricity demand forecast and distribution system optimisation
RTE	Ensure the development of energy market relevant use cases and

	interface with DSO
DAIKIN	Implementation of reversible heat pump equipment and related control strategies of equipment in tertiary buildings
NetSeenergy	Development and implementation of aggregation platform for EDF
NKE	Implementation of metering and control equipment
SOCOMEC	Development and implementation of solar inverters

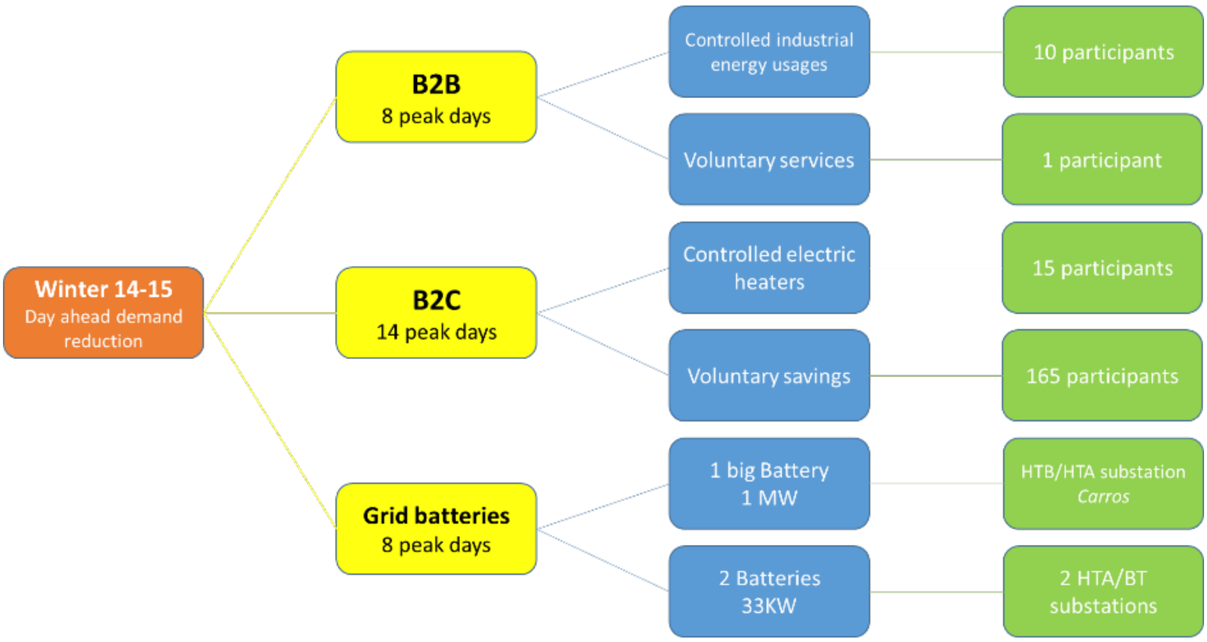


Figure 7-2: Synthetic representation of the experimentation for the day-ahead flexibilities

All experimentations were controlled through an energy management platform designed ad-hoc for the project. In the graph below, the overall software architecture can be evinced. The main core of the platform was the so called “Distributed Energy Resource Management System” (DERMS), which was composed of two (2) main components, i.e. a) the “Network Energy Manager” (NEM) and b) the “Network Constraints Prediction Tool” (NCPT), both developed by GE-Alstom. The latter defined the forward flexibilities needed, after optimisation of demand (EDF) and supply forecasts (ARMINES) and the identification of possible grid constrains on specific grid locations, based on a power flow tool (external to the DERMS). This information was transmitted to the NEM, which basically functioned as a market place where flexibility offers and demands were matched for each grid sub-portfolio, identified by the NCPT, and the retained bids dispatched to the different aggregators. These in turn dispatched the activation orders to the different underlying assets.

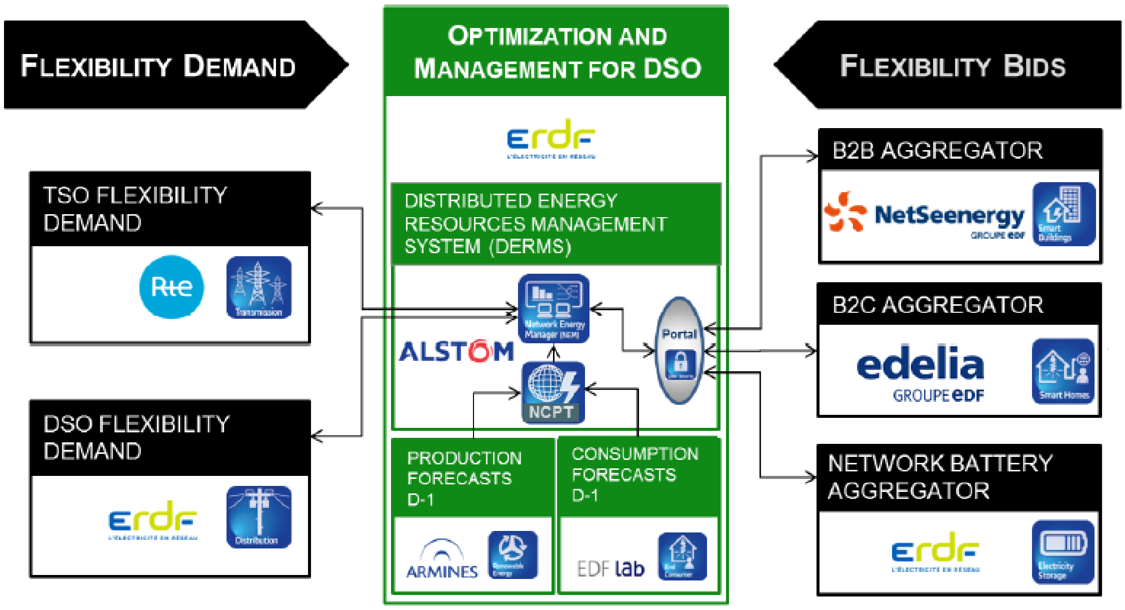


Figure 7-3: Overall control system architecture and responsible companies for each soft-ware component

Following, a description of the 4 Use Cases is included:

1. **Use Case #1: Electricity peak consumption reduction (peak shaving)**

This Use Case aimed at defining, dimensioning and subsequently testing a list of necessary flexibility technologies capable of responding to grid constrains through day-ahead and intra-day markets. Particularly, services for supply-demand balancing in MV and LV grids were tested. The developed Use Cases needed the recruitment of voluntary clients in order to ensure the real life experimentation. Tailored offers were designed for both residents and businesses. In particular, as a motivation for Carros' residential consumers to participate in the active demand response experimentations, several offers were proposed to them, with the primary objectives being a) encouraging PV self-consumption during the summer period and b) encouraging peak reduction demand during winter.

The 3 summer offers, included the Cases of:

• **Solar Bonus offer:** During the 40 solar days in summer 2014 and 2015, indicated by alerts sent on the previous day via text and/or e-mail messages, EDF invited its volunteering customers to shift their electricity consumption during solar hours between 12:00 noon and 4:00 PM. At the end of each summer, EDF sent the customer a gift-voucher for a tariff equivalent to the off-peak tariff for their power consumption during solar hours.

• **Smart Water Tank offer:** The hot water tanks were managed remotely to maximize the integration of solar generation. Basically, water tanks were used as energy storage, through electrical heating. Throughout the time period of the day when the PV panels generated electricity at full-rate, the water tank was turned on, in order to store any excessive energy, available. This recharge proceeded in addition to its usual operation at night, thus preserving customer comfort.

• **Smart Solar Equipment offer:** This offer involved an additional financial incentive of a roof PV system coupled with a battery system for residential customers, in order to ensure a sufficiently sized pool of customers to enable the demonstration. Batteries have a maximal capacity of 4 kWh, alimented by an SMA inverter and a maximal power of 4 kW.

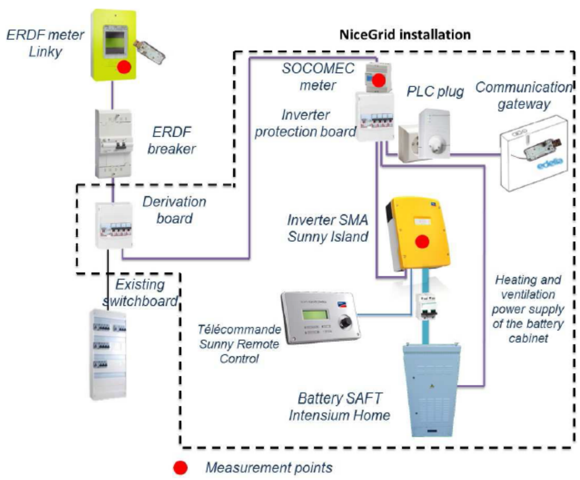


Figure 7-4: ICT architecture of the residential battery control system

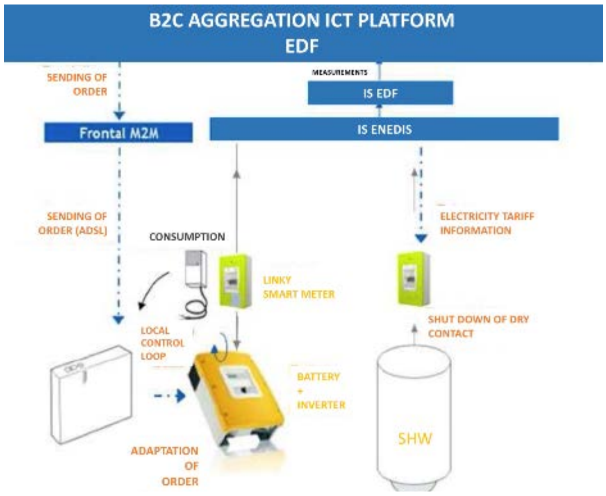


Figure 7-5 : ICT architecture for the control of residential customers equipped with batteries and hot water storage

The 2 winter offers, included the Cases of:

• **Behavioural Load Management:** In the winters of 2014 and 2015, households, which significantly decreased their power consumption between 6:00 and 8:00 PM (during 20 peak demand days), received gift-vouchers in reward for their efforts.

• **Electric Heating Control via the Linky smart meter:** designed to switch-off or reduce the heating system during peak periods without impacting the participant's comfort

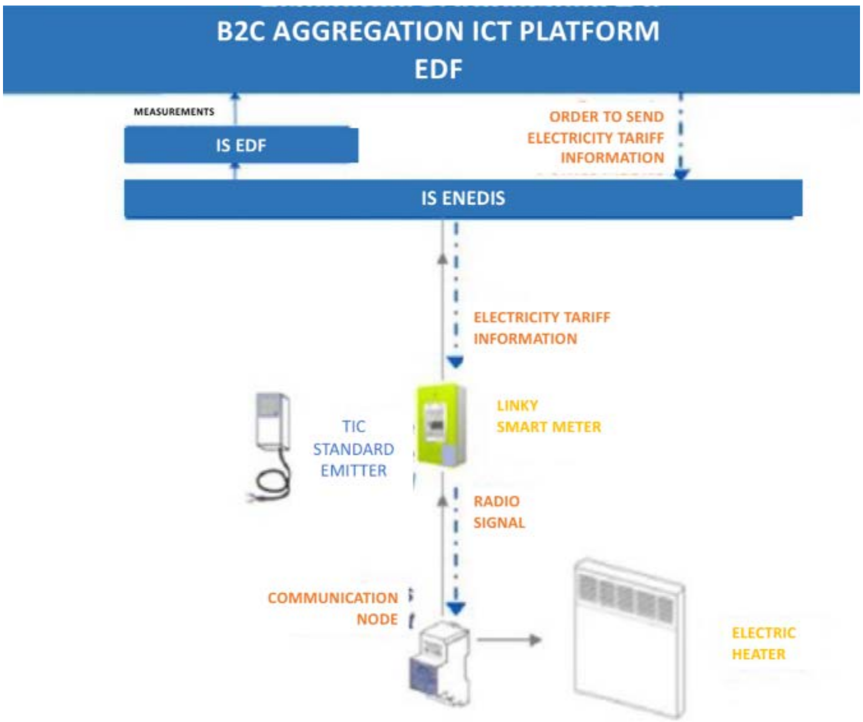


Figure 7-6: ICT architecture for the control of residential customers equipped with electric heaters

The **respective motivations** for the local businesses were proposed by EDF and were the following:

• **Controlled Load Management offer via remote control of their energy uses** (for example heating, HVAC, domestic hot water) and/or processes (for example steam ovens, refrigeration units, furnaces), together with remote consumption tracking.

• **Behavioural Load Management offer,** controlled manually, following load management requests.

In addition to these action plans, with support from the Nice Côte d'Azur metropolitan authority, smart meters and light dimmers were installed in Carros to reduce power to the public lighting upon load management requests.

2. **Use Case #2: Management of PV injection into the grid**

Defined control strategies at client premises with PV production capacities to avoid the generation of potential grid constrains, notably have been related with grid voltage and flow inversion on the secondary substation level. These experimentations were tested along the perimeter of the residential customers, who have been equipped with electric water tanks and/or batteries (Figure 3-4) and the "islanding area" (Figure 3-5).

This use case has been applied to the summer period, so that the electricity injection to the grid from PV panels is at its highest. The low voltage network has been equipped with metering devices to identify if the last branches of the network might suffer of grid constrains under high PV energy injection and identify the impact of the different demand side and storage management measures.

For the residential customers, a set of offers were adopted, all focused to displace the maximum possible consumption within the daytime hours (corresponding to the PV production curve). Such included a) a Solar Bonus offer, b) a Smart Water Tank offer, and c) a Smart Solar Equipment offer (description in previous use case). In addition, different control strategies of the battery charging/discharging cycles have been tested, in order to identify their capacity to displace energy consumption to the daytime. The adopted constrains were guided as "to stay within the charging level boundaries of min. 15% and max. 95% of a battery's capacity and take into account the individual customers' nominal power subscription levels to avoid a circuit breaker tripping".

Concerning the solar district experimentation, the aim here was to identify on one side the capacity to dynamically pilot the grid scale batteries recharging towards maximising the absorption of PV and on the other, develop a "solar substation" which could optimize the injection of PV into the grid by piloting the tension control system by integrating the measurements from a solar sensor. Both aiming to avoid the reversing of the tension at the secondary substation level.

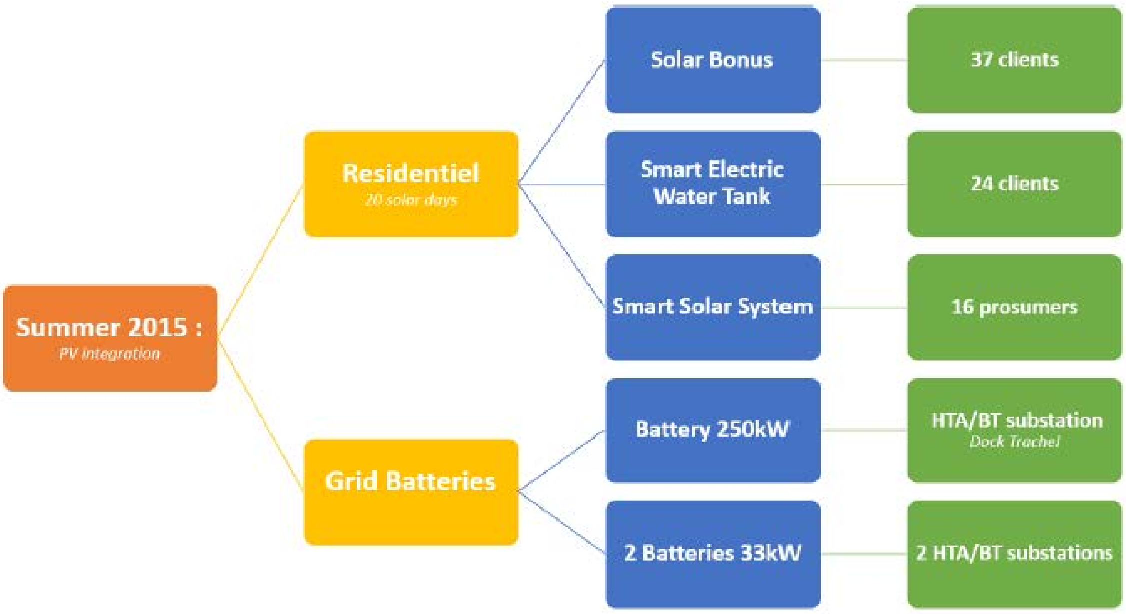


Figure 7-7: Synthetic representation of the experimentation for UC #2

3. Use Case #3: Grid-islanding

In this Use Case, a technical feasibility of the islanding of a portion of the grid (LV) at the primary substation level by using only a storage system equipped with a Power Conversion System (PCS), electronics and a battery, connected to different demand (enterprises) and production sources (PV systems), was conducted. The islanding had to be proven sustainable for two scenarios of operation: **1)** Scheduled disconnection for 5 hours and a **2)** black-start of the islanded grid after a black-out event. The UC was applied to the "islanding area" (description below).

In both cases, supply-demand balance, grid tensions and grid frequency had to be within the regulatory boundaries, without creating additional signal perturbations as harmonics/flicker. Following safety and security regulation, the system had to ensure the safety and protection of the people and equipment within the area.

This use case was split into two main steps, i.e. a) a first test within the premises of the "Concept Grid" facility, where a full-scale smart grid test facility of EDF R&D is located, and b) in a second step the experimentation on the "islanding area". The first test was a smaller scale test of the Nice Grid islanding use case, to explore the technical feasibility of the endeavour and identify the related technical and regulatory risks which could be incurred. A total of 200 test trials have been conducted.

As can be evinced by Figure 7-11, the system was composed of two substations, i.e. a) one representing the "substation + battery system" and b) a second one including the low voltage network of the islanding area. The first one was equipped with a storage system composed of the inverter and battery containers, connected with a low voltage network to the second one, emulating the low voltage grid, connected to two houses equipped with PV system and additional resistive, inductive and capacitive loads to represent the "real load" curve with enough accuracy.

4. Use Case #4: Testing of the techno-economical interest of batteries

This included the Identification of flexibility products provided by batteries under two configurations: centralized and de-centralized, thus at sub-station level and at customer premises. The objective of the associated use cases was to identify the technical performance of the equipment in all previously detailed UC (UC #1, #2,#3) and provide amelioration specifications to the battery provider part of the consortium, while identifying their techno-economical characteristics for flexibility actions.

7.1.1.1 Pre-Pilot Area and Geographical Overview

For enabling the achievement of the aforementioned Use Cases, the overall architecture of the area has been organized into 3 hierarchical zones, following the electricity grid topology on site:

1. **Peak-shaving area:** The highest level area, which contains the other two, covers the whole Carros district and corresponds to the area served by the primary substation (HV/MV). The zone contains customers equipped with smart-meters (Linky) and some with more advanced control devices which participate to the flexibility experimentations either by automatic activation (connected to the management platform) or on voluntary basis (for example activation via sms). The substation is further equipped with a 1 MW battery.
2. **Solar districts area:** This corresponds to seven (7) distinct zones, each one of which in an area served by a secondary substation (MV/LV). These areas differentiate themselves by having the customers' premises equipped with PV systems and a certain number among them, also with small scale batteries (4.6 kW) combined with controllable water heaters without electric heating systems. In addition, 2 secondary substations have been equipped with a 33 kW battery.
3. **Islanding area:** This is a specific grid section, where the secondary substation has been equipped with the 250 kW sized battery. The area is further characterized by having a cumulative PV capacity of 430 kWp.

PV installation - residential

Figure 7-8: Left – battery and inverter containers user for the experimentation / right – PV system within building premises (PV panels on the roof)

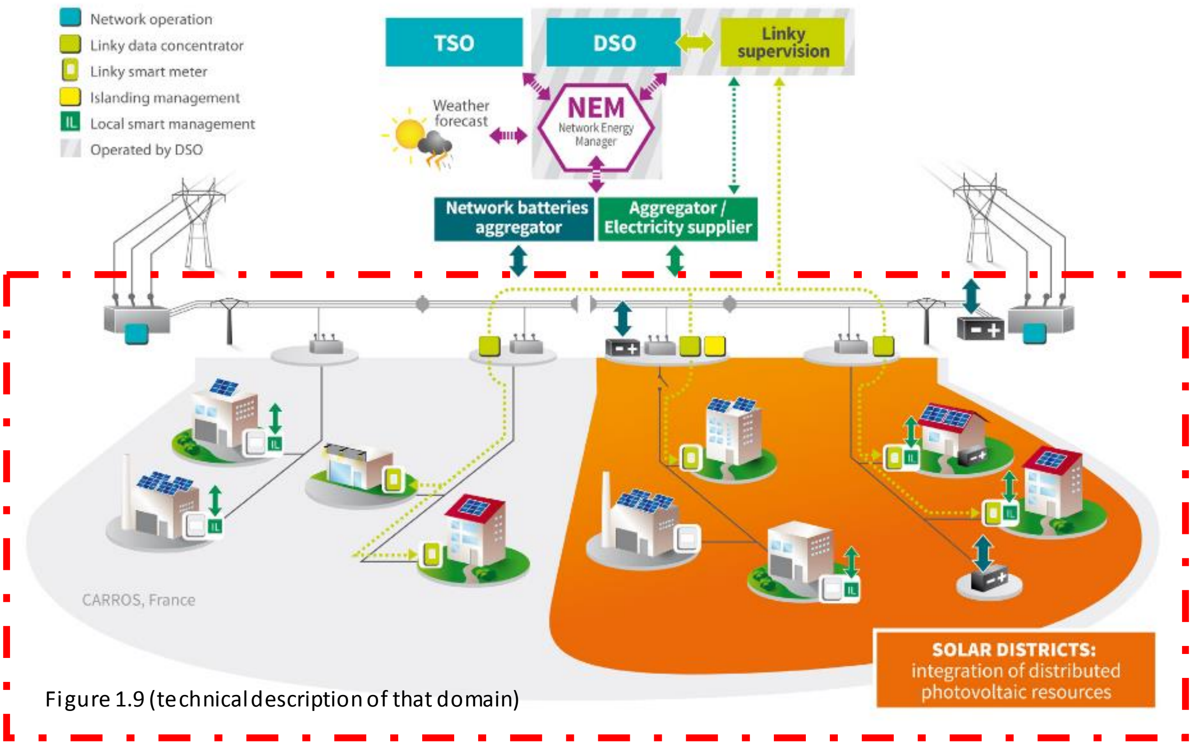


Figure 7-9: Overall schema of the Nice Grid project (production, grid and demand side components, ICT architecture and the overall energy management software)

Figure 7-10: Identification of the 3 hierarchical zones based on the grid topology

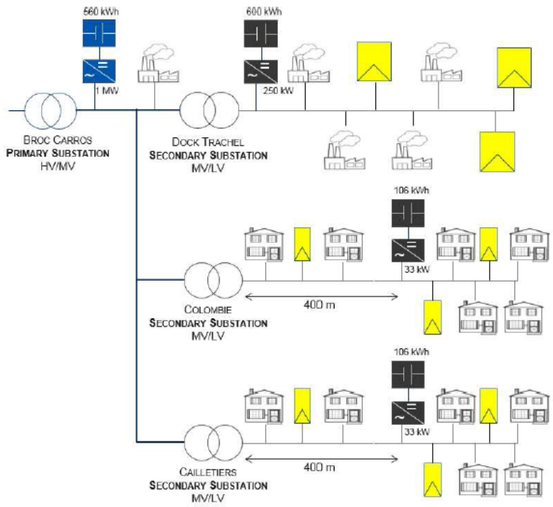


Figure 7-11: Technical depiction of the MV/LV Grid displayed in Figure 1.7 of the Carros district and localisation of the batteries (at a lower level than that of DSO)

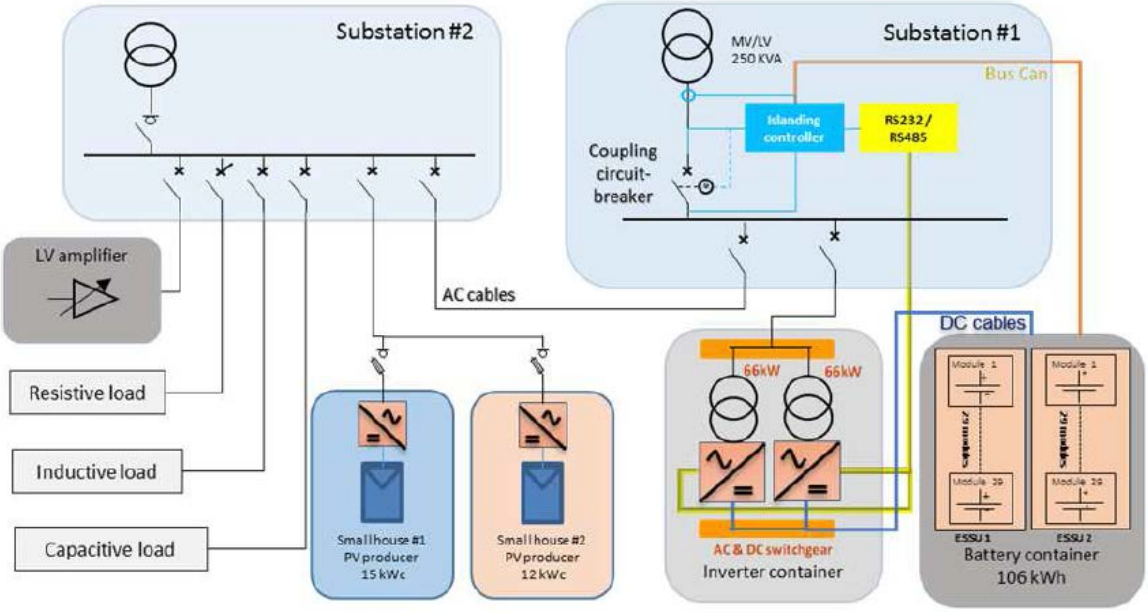


Figure 7-12: Scheme of the Concept Grid islanding experimentation

Figure 7-13: Bird eye view of the Concept Grid facility

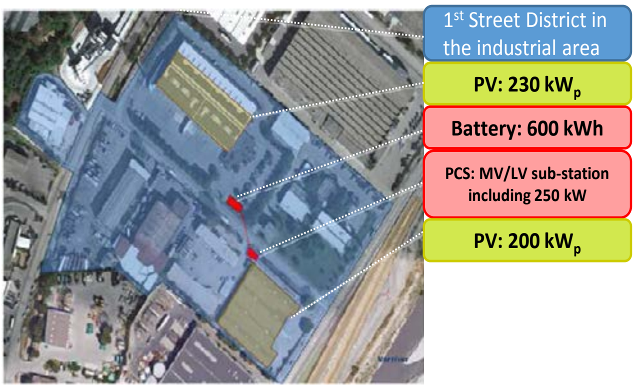


Figure 7-14: Islanding area - characterized by an almost daily flow inversion at the secondary substation level due to the PV production

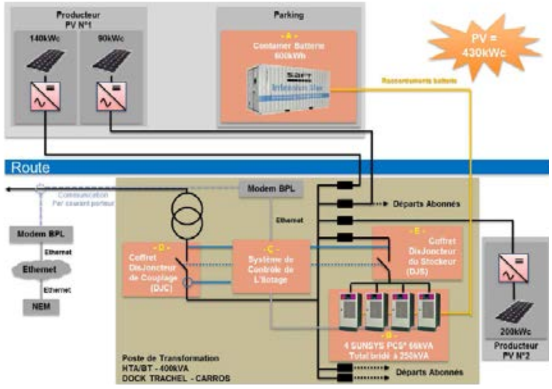


Figure 7-15: Scheme of the overall islanding experimentation

The following Table elaborates the currently available thorough information for each of the considered key innovative elements of the IRIS pre-piloted solutions. Whenever available, additional information along with more technical specification of the basic configured elements are as well provided, in order to allow a better understanding of the basic elements of the solutions:

Hardware

Main Component	Technical Specifications	Area of the pre-Pilot
Pre-Piot Area: Peak-shaving area		
Battery	Provider: SAFT, Li-Ion technology, 1 MWe 560 kWh (discharge in 30')	Positioned at the primary substation level
Pre-Piot Area: Islanding area – Concept Grid experimentation		
Battery	Provider: SAFT , Li-Ion technology, 106 kW	Concept Grid facility
AC/DC converter	Provider: SOCOMEC 2x 4 parallel 66 kVA "SUNSYS PCS²" Injection capacity of 250 kW – constrained to 50 kVA	Concept Grid facility
Charge banks	1x resistive load bank - 600kW 1x inductive load bank – 250 kVA 1x capacitive load bank – 250 kVA	Concept Grid facility
Solar inverters	1x FRONIUS IG PLUS 150V - 3 12kVA 1x SMA STP 15000TL - 15kVA	Concept Grid facility
Low voltage amplifier		Concept Grid facility
Pre-Piot Area: Islanding area		
Battery	Provider: SAFT, Li-Ion technology, 250 kW 620 kWh	Battery connected to a 250 kVA secondary substation
AC/DC converter	Provider: SOCOMEC 2x 4 parallel 66 kVA "SUNSYS PCS²" Injection capacity of 250 kW on the busbars	Positioned between the battery and the dedicated circuit breaker box at the busbar of the substation
Remote control	1) PLC medium voltage communication system	Communication system enabling the metering of the network

	2)Ethernet protocols between upstream (NEM to grid) and downstream (grid to automate) of the system (no more detailed information available)	components and the activation of the Islanding control system between the NEM platform and the substation
PV system #1	PV cells (of unknown provider), PV capacity : 200 kWc	Connected to a feeder of the substation
	Inverters, Provider: FRONIUS 9 x IG PLUS 150V-312kVA , 9 x IG PLUS 120V-310kVA	
PV System #2	PV cells (of unknown type), PV capacity: 90 kWc Inverters: Provider: SMA, 6 x Sunny Tripower 15000TL 15kVA	Connected to two distinct feeders of the substation
	PV cells (of unknown type), PV capacity : 140 kWc, Inverters of unknown provider	
Pre-Piot Area: Solar district area		
Battery	2x 33 KW / 106 kWh (No more information at hand)	Battery installed at secondary substation level
Battery system	Provider: SAF, Intensium home, 20 x 4,5 kW / 4KWh **Inverter:** Provider: SMA, Sunny Island, 20x 4,5 kW **Inverter control :** SMA Sunny Remote Control	Installed at customers' premises
DC (Nominal Voltage (VAC), Variation in output voltage, Frequency):	**EN 50160**: *Voltage variation*: High voltage, 20 kV +/- 5%, Low Voltage, 230 V +/- 10% *Frequency*: 50 Hz +/- 1% @99,5% of year, 50 Hz +4% / -6 @100% of time THD (<= H 40) < 8%	
Ancillary Equipment Type #1 (electric water heaters, followed by required specifications, e.g. Number #, Capacity (W), Max Temperature (90C)):	23 Clients Various existing water heaters by standard "controllable" through the "power line communication" (PLC) protocols (11 Mil water heaters are activated by DSO). Protocol CPL G1: 63,3kHz v(1) / 74 kHz (0) Usual temperature >60 °C	Customers already equipped with electric water heaters within the solar district area
ICT technology for active demand response (B2C)	1) EDELIA box: GRPS + MC11 + C14 2) WATTECO-NKE: SmartPlug + TIC sensor + SmartRelay	Within residential customers' premises equipped with active demand response equipment

Important Comment: For further information, mostly related to business models, the NCA ecosystem and specifically EDF, acting as partner of IRIS, are available to give more feedback, following a bilateral communication.

7.1.1.2 Lessons Learnt by the implementation of the Solution in the Pre-Pilot

1) Electricity peak consumption reduction (peak shaving)

The overall result of the experimentations that lasted for about 2 years, showed an average peak shaving potential of 400 kW (max > 1 MW). This represented about 2% of the average peak power demand of the primary substation of Carros. Considering the different aggregators separately, the average peak shaving potential was of 240 kW for the industrial/tertiary sector, 200 kW for the "grid batteries" and 25 kW for the residential sector. Results were clearly bounded to the pool of clients recruited for the project and the different grid topologies.

2) Management of PV injection into the grid

The project showed that, except for very limited and special cases, the PV power injection of the different "solar districts" did not result in relevant grid constrains, as the demand was yet about 7x higher than the peak PV production.

Customers equipped with batteries and hot water storage showed a summer average peak shaving potential of 13 kW, varying between 5 and 23 kW. Important to notice, was the need of more advanced algorithms for controlling water heaters' activation. These had to be piloted in asynchronous sub-groups in order to have a better performance between the maximal peak shaving potential and the corresponding rebound effect.

In the framework of the project, ENEDIS developed a "solar substation", by combining in a secondary substation (MV/LV) (islanding area) the tension control system with a solar irradiance measuring system. The principle was simple: the LV tension was gradually regulated downwards until the bottom of 404 V while the solar radiation neared its azimuth and then regulated gradually backwards until 420 V. This showed that a tension increase of up to 7% was achievable by the LV grid, which was more than twice than the current regulatory limitation of 3%.

3) Grid-islanding

The islanding experiment was very successful, primarily because it demonstrated that grid islanding was possible just by storage means (batteries) without the need of rotating machines to ensure grid stability in terms of supply-demand balance, frequency and harmonics. This has been validated first in the Concept Grid facility and then in the "real life" experimentation on the islanding area. For the latter, the experiment enabled the islanding on the network for 5 hours and the indicators were well below the EN 50160 thresholds in both the programmed and non-programmed (black-out) scenarios.

Table 7-2: Synthesis of main indicators from the two islanding experiments and the EN 50160 thresholds

KPI	EN 50160 criteria	Results from programmed islanding	Results from non-programmed islanding
Relative tension	< 10 %	0,63 %	0,26 %
Relative frequency	< 1 %	0,1 %	0,03%
THD-V	< 8 %	1,8 %	1 %

4) Performance of forecasting software

The solar forecast (done by ARMINES) gave very useful results as the used probabilistic method, achieved at the single installation level a normalized mean absolute error (NMAE) of less than 8%. The demand forecast (done by EDF R&D) has not achieved such positive results, having a normalised root mean square error (nRMSE) at the individual level of more than 10%. This makes it an unreliable method for practical applications. Nevertheless, at higher level of aggregation, the reliability increased falling well below the 10% mark for both day-ahead and intra-day forecasts.

5) Participant feedback

Residential consumers:

86% of surveyed consumers who participated in the summer use-cases were satisfied, considering their participation interesting, forward looking and with few constraints, while even 94% considered their participation useful and easy to adapt.

Generally speaking, negative flexibilities (demand reduction) in winter were much easier to implement than the positive ones (demand increase) in summer. Customers found it difficult to react and increase their self-consumption, while they found it much more convenient to reduce their overall consumption through limiting the use of the most consuming electric, postpone the use of the latter and/or by a more aware usage of their heating.

Companies:

For the involved businesses, an immediate interest to be part of the demonstration actions was a result of the increased knowledge about their consumption patterns and increased awareness concerning their production processes, which they could directly capitalize in commercial and marketing activities with their clients and partners.

A further result was that the implementation of intra-day peak shaving actions was more difficult than day-ahead or longer term planned actions. The cause behind this was the relatively inflexible process scheduling of their production cycles, which made intra-day actions very difficult to implement and H-1 actions almost impossible. The companies were not ready to take risks which could impact the quality or volume of their final product.

A mitigation of this type of problem was the definition of upfront well-tailored contractual arrangements. On one side, an adaptation of the production and HR processes of a company had to be ensured and on the other, a reasonable benefit and risk sharing arrangements among both parties.

6) Techno-Economic viability

Batteries proved through the different use cases, that they can represent the most reliable technical means to provide grid flexibility. Nevertheless, improvements should be achieved. In order to increase the efficiency of batteries, it had been decided to measure the consumption of their auxiliary equipment (for example fans, cooling). The study has shown that for the 1 MW and the 33 kW sized batteries, such consumption corresponds to about 10-15% of the battery capacity. This led the technology provider to rethink and optimize the design and regulation of the battery equipment. For the residential batteries, measured losses went up to 30% of the batteries capacity.

In winter, the most efficient assets to provide flexibility were (in decreasing order), a) grid scale batteries, b) tertiary sector, c) residential scale batteries, d) voluntary-based demand reduction of residential customers and e) control of electric heaters.

On the other hand, in summer, the order was as follows, a) grid scale batteries, b) residential scale batteries, c) control of water heaters (which are able to vary the target water temperature), d) control of standard water heaters and e) increase self-consumption during PV production time.

Technically speaking, at the MV and LV level, it was shown that the need for flexibility or the arising of grid constrains, was a very locally bounded problem. The main factor was the grid topology on site, which on the LV level could be very diverse and thus difficult to achieve results or solution which could be widely generalized. Most probably, constrains in the LV grid caused by “massive” decentralized PV systems’ adoption will arise at first in more vulnerable grid topologies characterised by long cables and small sections (typically in detached housing districts).

In all cases, the CBA (Cost Benefit Analysis) showed a negative NPV (Net Present Value) for the considered Use Cases. The main reason was related to the limited utilization time of the equipment compared to its investment costs. The main objective of the project was to demonstrate the technical and economic feasibility of increasing PV penetration through a more dynamic and flexible distribution network operation.

Furthermore, **the actual existing regulatory framework based on a TSO centred market design, did not allow the generation of a viable retribution from the proposed flexibility services at the distribution grid level**. This made it difficult, if not impossible, for a DSO to introduce a market for flexibility services at the MV and LV level. In addition, for more than 30% of the technical solutions proposed in the project where both grid constrains and viable flexibility solutions could be juxtaposed, it was shown that the DSO can't defer or reduce its infrastructure investment costs due to technical reasons. Thus, such Use Cases can neither be valorised through the overall long term infrastructure investment strategy of a DSO.

However, two main configurations could be seen as the most promising ones: 1) LV grid scale batteries located at a feeder departure from the secondary substation, which enabled the mitigation of the grid constrains on the main affected LV grid section; 2) flexibility solutions implemented as near as possible at the origin of the potential source of grid constrains thus, at best directly within the premises of a producer/consumer client. These two cases would need a deeper CBA to identify their economic feasibility and the elaboration of more detailed business models to identify under which market design they would be valued at best.

A further amelioration point of the project would be the integration of a wider set of energy technologies and energy infrastructures. The experimentations focused on active demand response, PV and battery systems, but further flexibility and storage potential were available. A multi energy and more district scale optimization approach could add more valuable results to the subject.

Linked Projects: Nice-Grid [17]

7.2 Demonstration in the Lighthouse Cities

7.2.1 Utrecht Demonstration

7.2.1.1 Use Case and Brief technical description

In the demonstration area, a SEMS and renewable energy storage will be integrated. The district energy system will interconnect energy consumers, energy producers and energy storage providers including the following components:

- PV panels on the roofs of the apartment buildings and the schools (see description of IS1.2);
- Households in the apartment buildings (see description of IS1.2);
- Solar V2G charged e-cars (see description of IS3.1);
- Solar V2G charged e-buses (see description of IS3.1);
- Second life batteries in apartment buildings (see description of IS2.3) and
- Public street lighting (see description of IS1.2).

A district energy management system will interconnect the EMSs at home, building and district level.

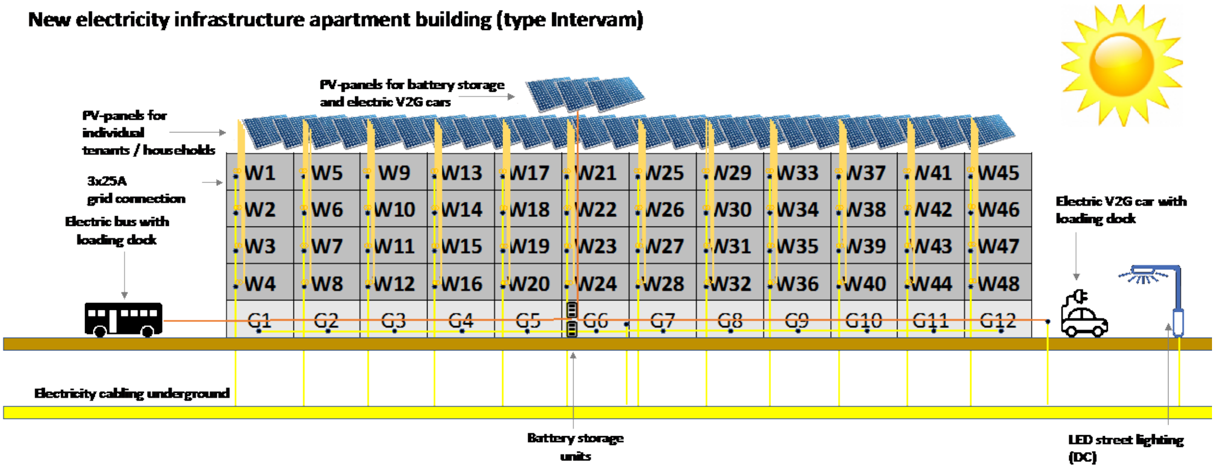


Figure 7-16: Overview of the envisioned energy system for an apartment building

The transformation of the district energy system into a smart district energy system will have serious impact on the energy flows.

A group of apartment buildings is planned to be fed by five (5) medium voltage to low voltage distribution stations. The district energy management system will have a double function:

1. While retrofitting the apartment buildings, solar panels and charging points for electrical vehicles will be installed. The EMS will measure the changes in energy flows during the process. This will enable to analyse and assess the impact on the electricity system when, due to replication, the solutions in the demonstration area are duplicated on a large scale.
2. The real time measurements of the electricity flows will be an essential input for the relevant Dutch aggregators to beneficiate from flexibility, in order to support Stedin (Dutch DSO) keep the maximum flow within acceptable values.

In order to be able to control the load in the electricity distribution grid, accurate data on the status of this grid is essential. Therefore, all homes will be equipped with a smart meter, while secondary substations will be equipped with telemetrics systems.

In the demonstration area the **Universal Smart Energy Framework (USEF)** [18] will be applied to deliver a market model for the trading and commoditisation of energy flexibility, and the architecture, tools and rules to make it work effectively. In principle USEF comprises of a set of rules and standards for cost-effectively unlocking flexibility in the energy system. USEF positions the Aggregator centrally within the USEF flexibility value chain. The Aggregator is responsible for acquiring flexibility from Prosumers, aggregating it into a portfolio, creating services that draw on the accumulated flexibility, and offering these flexibility services to different markets, serving different market players. Flexibility provided by prosumers comprises of a variety of sources, ranging from households with heat pumps and PV panels, to cooling systems at large offices. In return, the aggregator receives the value it creates with the flexibility on these markets and shares it with the Prosumer as an incentive to shift its load. Through the Aggregator, Prosumers gain access to the energy markets. USEF distinguishes 3 parties with demand for flexibility services:

1. The Balance Responsible Party (BRP)
2. the Distribution System Operator (DSO) and
3. The Transmission System Operator (TSO), who is indirectly served by the Aggregator through a BRP.

Detailed specification on the framework can be found in *USEF (2015): The Framework specification 2015*

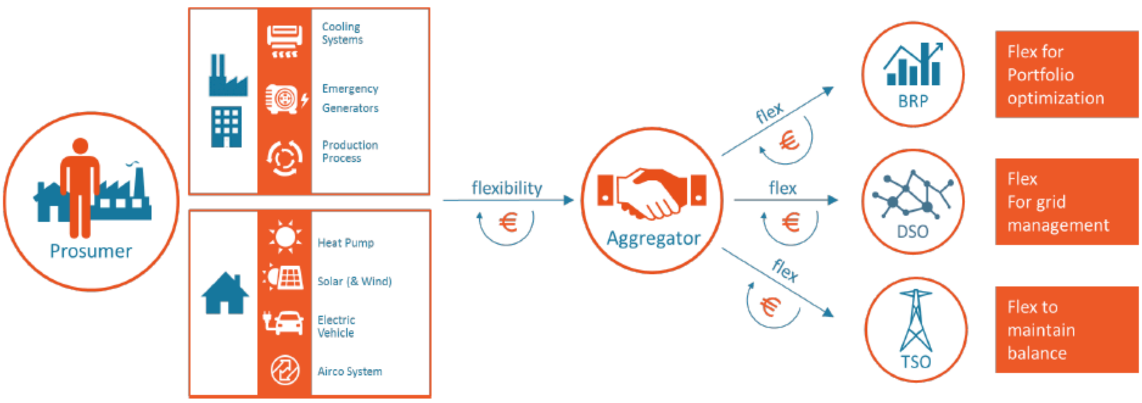


Figure 7-17: Overview of the USEF model with potential sources of flexibility (left hand side), the role of the aggregator and the demand for flexibility by various stakeholders (right). Source: USEF (2015) USEF: The Framework explained

7.2.1.2 Demonstration Area and Geographical Overview

The smart district energy system will be demonstrated in the Kanaleneiland Zuid area around the apartment building that will be renovated by Bo-Ex (see for more detailed description at IS1.2).

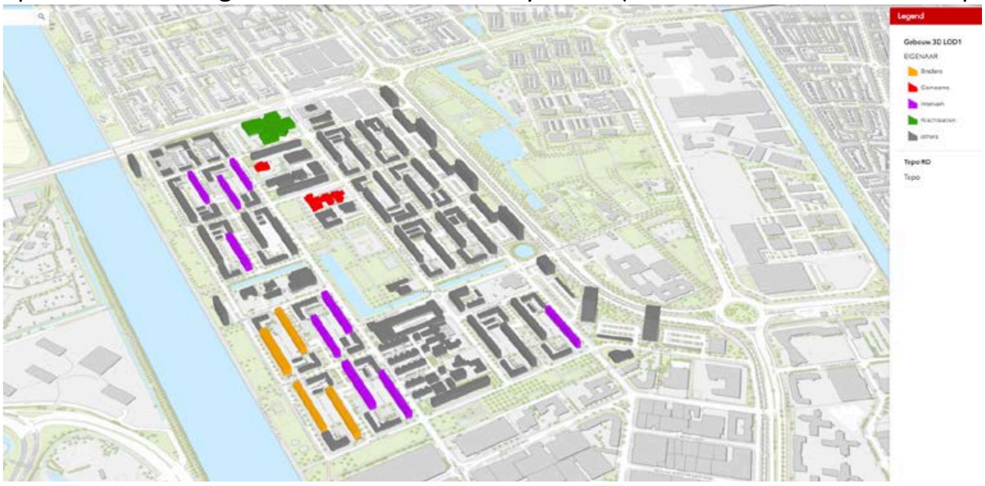


Figure 7-18: Map of the demonstration district Kanaleneiland Zuid with overview of apartment buildings that will be renovated, involved schools and the local innovations hub Krachtstation

7.2.1.3 *Objectives, Needs and Opportunities to be served by the implementation of the Solution in the Demonstration*

Opportunities	Needs
Maximize profits of renewable power production	Hardware and software equipment for monitoring and control of RES resources. Software platform able to dynamically estimate the flexibility of RES based micro grids (**Microgrid** represents a clearly delimited branch of a grid connected to a defined group of energy (electricity, heat, cooling) sources and loads). Deployment of a district management system connecting production, consumption and storage.
Maximize self-consumption reducing grid stress	

7.2.1.4 Key technical components

Hardware:

Main Component	Technical Specifications	Demonstration	IRIS partner
Smart meters	 One of the standard smart meter that is distributed by Stedin among its households [19] • Two-way monitoring: electricity consumption and injection • Storage of measurements every 15 minutes	Kanaleneiland Zuid	Stedin
Telemetrics systems for the trafo stations	Technical specification are not yet available and will be further elaborated in the coming months.	Kanaleneiland Zuid	Stedin

Software:

The data concerning the software to be used, is not yet available. Further information will be provided in D5.4.

7.2.2 Nice Cote D' Azur Demonstration

7.2.2.1 Use Case and Brief technical description

The demonstration of the LEMS (Local Energy Management System) will lean on the two demonstration area in Nice, notably the Nice Meridia and/or Grand Arenas districts.

Within this perimeter, different case studies are potentially available for allowing the implementation of an LEMS. Leaning on the IRIS partner's infrastructures and assets, which represent the pool of potential case studies to be considered, specific use cases will be identified, representing an economical and technical interest.

The LEMS to be deployed is considered as a transversal platform, which integrates different IS solutions and TTs. It will leverage the works done in TT#1 by integrating the technologies and energy conversion assets deployed into a higher level operation strategy (optimisation of operation towards the energy market), that of TT#3 concerning the electric charging infrastructure by identifying potential additional revenue streams from a smart and flexible vehicle charging management, integrate IS 2.2 and 2.3, as well as additional potential assets on site.

Globally, the objective is to deploy an operation optimisation strategy enabling to increase the revenue streams of each individual asset, by offering flexibility services or products to different markets: the DSO for reducing grid congestion on the medium and low voltage level, the TSO and national energy market to bid on different flexibility services for ensuring day ahead and intraday supply-demand balance or just by optimizing the operation of certain assets and thus, adopting an “ESCo” (Energy Service Company) type of approach.

The challenge here relies mainly on the global-local economical optimization. It has to be understood that the LEMS works on three different levels, which might potentially have redundant or diverging optimization objectives, mostly due to the de-correlation of the local level (first two levels) with the global one (energy markets):

1) **B/EMS – first level of optimization**: a system which searches to optimize costs of energy provision and a certain service quality level (building’s HVAC system and other electric usages, a substation equipped with HP and SHW boilers, a system for managing self-consumption of PV, battery storage and electric usage, a management system of the charging infrastructure of a private parking or car sharing pool)
2) **Distribution networks – second level of optimization**: for the medium/low voltage grid as well as heating/cooling network ensure supply balance performance and service quality and provision security.
3) **Energy/TSO markets - third level of optimization**: answer to “global”/national market needs which do not have a correlation with the previous levels. This can be seen a completely exogenous impact to the local system despite providing, a-priori, the economically most interesting applications for flexibility management.

The LEMS will have to identify the optimum management behaviour for each asset/system to be able to identify the most economically reasonable flexibility product or service to prioritise, this from a weekly perspective down to near to real time (in the latter the most remunerating bids are found).

The LEMS will be composed of four (4) main components or functionalities:

1. *Monitoring*: monitoring of the local assets as well as the energy markets;
2. *Forecasting*: weather forecast; load and production forecast among the different levels; forecast of product and service availabilities; potentially price forecast on different markets;
3. *Optimization*: optimize the assets operations based on market needs on the different time scales (day-ahead, intra-day) and among the potential set of products and services to be provided to customers or markets and
4. *Valorisation*: Valorise the accepted products by managing their timely and proper activation and clearing of the market transactions.

Within the project, the first step will be to identify the case studies to be integrated into the demonstration. This will be followed by the identification of the potential products, the case studies systems can provide, which have in turn to be matched with corresponding energy markets or services (securing a revenue stream). In a third step, use cases will have to be defined, which will enable a step wise approach towards increased complexity in the needed management algorithm development and testing. This will define the technical and functional specifications of the LEMS to be considered in the development of the platform. This does not mean that the system should be developed from scratch but will lean on different sub components with a TRL ranging from 4 to 8.

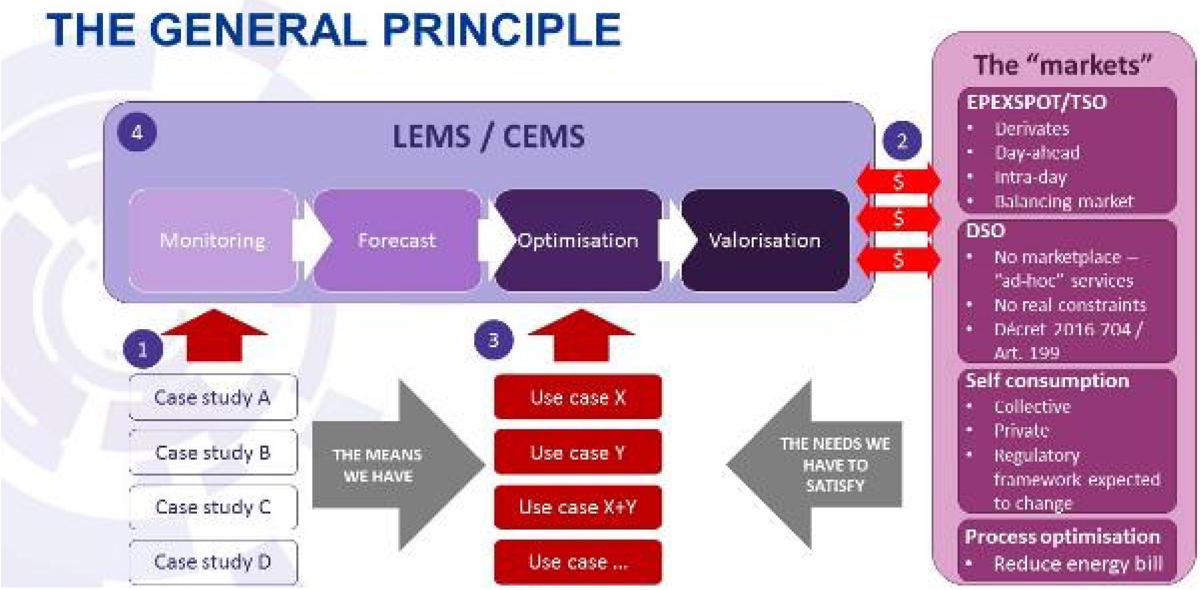


Figure 7-19: Schema of the general approach to be followed within the demonstration activity: 1) identification of available case studies and related manageable energy conversion and storage assets – a contractual relation is needed with the EMS operator; 2) Identification of relevant markets which could ensure a revenue stream from managing the different case studies' assets; 3) definition of relevant use cases to be deployed in the demonstration based on the convergence of points 1) and 2) – such use cases will focus on the generation of a revenue stream for the involved parties; 4) translation of the use cases into technical and functional specifications for the development and operation of the energy management system.

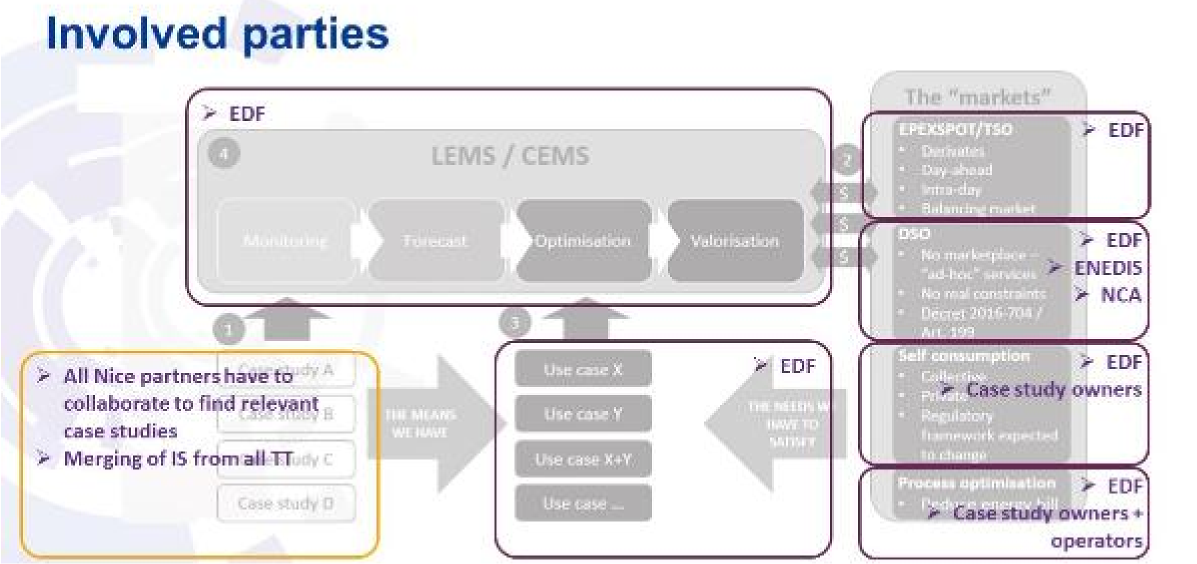


Figure 7-20 : schema to identify the main involved parties among the different "bricks"

7.2.2.2 Demonstration Area and Geographical Overview

Within the West territory of the Metropolitan area of Nice, a big urban undertaking is on the way. The state and the local authorities, after a shared diagnosis on the status and potential of the western territory of Nice, decided to design together a new territorial project. At the initiative of the mayor of Nice, Christian Estrosi, the state has put a lot of resources at stake: it has made the area one of the "Operations of National Interest" (OIN) of France, with sustainable development as a guideline. The perimeter of this undertaking is the so called "Nice Eco Valley". He entrusted the "Public Establishment for Development (EPA) of the Plaine du Var" with the implementation of this ambitious project. Ambitious because global: while proposing a new model of planning and urban planning, economics and ecology have to be combined. It also aims, for the 30 years to come, to modify in depth the economic structure of the metropolis, the modes of displacement and habitat.

Figure 7-21: Contextualisation of the demonstration area (bottom image) compared to iconic historic centre of Nice and its port (top image) – (Google Maps and © EPA / Mateoarquitectura)

Figure 7-22 : Localisation of the development district and the two demonstration sites of IRIS, Nice Meridia and Grand Arenas. On the bottom right the Nice Airport – (EPA plaine du Var)

<u>Nice Grand Arenas</u>

The new international business district of the Côte d'Azur will be that of the "Grand Arénas". The Grand Arénas represents a highly strategic sector, at the gateway to the city of Nice and in the immediate vicinity of Nice Côte d'Azur international airport. Its articulation with the international airport and the future multimodal exchange hub of Nice-Airport gives it exceptional accessibility and rapid connections with the whole of the Eco-Valley and the metropolitan area.

To the existing tertiary site of 10 hectares, a complementary area of 49 hectares will be added, corresponding to potentially 700 000 m² of new floors-pace. Within the Eco-Valley, the goal of the Grand Arénas is to create a lively, innovative and eco-friendly neighbourhood, as the two driving principles of the new international business centers are urban diversity and eco-exemplarity. In addition to the offices and other facilities, a diversified housing offer is ensured (social mix), accompanied by services, shops, hotels or public facilities. The first development phase will be realized by 2021, achieving up to 140.000 m² of new mixed developments.

To achieve this large-scale project, several actors come into play alongside the C Energy Service Company. These are the City of Nice, the Nice Côte d'Azur Metropolis, the airports of the Côte d'Azur, the French State, the Alpes-Maritimes General Council, the Provence-Alpes-Côte d'Azur region, RFF and the SNCF among others. Private investors will then intervene on projects they will carry.

Figure 7-23: Plan of the Nice Grand Arenas project (EPA plaine du Var)

Figure 7-24 : North to south bird eye view of the project (EPA plaine du Var)

Nice Meridia

High priority operation of the eco-valley, the technological pole of Nice Meridia will have a first development area of 24 ha or 537 000 m^2 of new mixed use floor-area, with the objective to achieve 200 ha in the long term.

Its location and its mixed used program will make it an outstanding eco-district, aiming at providing high quality living and working conditions. Its vocation is to be a catalyzer of Innovation, thanks to its dedicated R&D and educational spaces with a vocation to attract businesses and institutions dedicated to technology and services from the sustainability and health care branches. This target should be achieved by first attracting public and private R&D and innovative organizations which should self-reinforce themselves by speeding up the developments of incubators, start-ups, co-working spaces and business centers among other.

Aiming at functioning as an «eco campus», the development program wants to enable short circuits between knowledge and innovation. With such aim, the IMREDD and the CEEI (European center for businesses and innovation) have been opened on the site, promoting innovation and the creation of businesses related to the sustainable development and "green" technologies.

The leitmotif of the land use and transport organization is "accessibility": this should enable to provide an integration of offices, commerce and housing areas among the districts, as well as access to services connected to the sport center situated in the same perimeter.

The first development phase will not only be center among a mixed use and accessibility oriented development, but also aim at being a precursor in terms of renewable energy. Therefore, a public call for tenders has been put in place to develop a geothermal low temperature DHCN (LT DHCN). The call for tender further integrated the notion of smart grid services which the foreseen SPV will have to consider in their development targets.

Figure 7-25 : Land use plan of the Destination Meridia project - (D&A - Devillers et Associés)

Figure 7-26: East to west bird eye view of the Nice Meridia area (EPA plaine du Var)

Figure 7-27: Méridia tower by Sou Fujimoto Architects (Worldarchitecture.org)

7.2.2.3 Objectives, Needs and Opportunities to be served by the implementation of the Solution in the Demonstration

The two districts are undergoing a deep transformation of their infrastructure and overall urban concept. Any quantitative statement would be misleading at this stage, as the urbanization process in underway and no securities are given about the energy related infrastructures that will be developed or the choices that private actors and external to the IRIS project will take. The following statements are indicative and bounded to the currently most promising opportunities related to the project, nevertheless, changes will apply.

Opportunities	Needs
Promotion of self-consumption coupled with storage	Promote the self-consumption business model in the frame of B2B activities, to favour the penetration of decentralized renewable energy (PV in IRIS case) coupled with storage technology. The development of a mixed approach (production with battery storage) towards a self-consumption undertaking will demonstrate that in the long term, the installation will enable a win-win situation for both operator and client. The integration of the notion of battery storage, should enable to develop a bankable business model and contribute to the demonstration that local renewable energies with low impact on the distribution grid are viable. Moreover, that the storage facility can have an upper value in the overall flexibility of the grid.
Flexibility by smart charging management of EV charging infrastructure	Promote the use of environmental friendly mobility solutions and contribute to the flexibility of the electricity grid, by enhancing the existing business models, or innovative ones, by introducing the notion of smart charging. The smart management from the coupling of the vehicle fleet management and the recharging infrastructure operation, new means to provide flexibility to the grid can be identified, addressing or a DSO or directly a TSO market. As the TSO market is more mature, with well-defined needs in terms of product and services, it is more likely that “traditional” product might be developed. A DSO market could also be addressed, which could potentially lead to additional revenue streams by reducing the congestion of the MV/LV grid.
Local Energy Management System	The demonstration will enable to further develop and identify the viability of a LEMS, enabling to balance the iteration between local grids and assets with the overall energy markets. The current market design, being by definition technology agnostic, does not give any market incentive, nor is it blocking it, to develop local based approaches as an aggregation of locally bounded flexibilities. The LEMS will provide a first pilot on how to combine local available products to provide services in a TSO led market design. The algorithms that will be integrated in the LEMS platform will be a key determinant of the feasibility of such higher level EMS. The integration of the local portfolio toward a national global portfolio will be analysed and thus, identify the opportunities that are given by a wider adoption of LMES among districts and cities.

7.2.2.4 Key technical components

Almost all infrastructure mentioned here below is in the design, procurement or construction process and no system has been delivered yet. Therefore, only rough information can be given and should be considered as such, temporary information and no guarantee can be applied.

Hardware:

Main Component	Technical Specifications	Area of the pre-Pilot	IRIS partner
Rooftop PV	No actual specification about the cumulative capacities on the districts are given. This will vary depending on the owners' choice between a classic feed-in tariff model or a self-consumption model. Foreseen to be in the range of a couple of hundred kWp by project (small to medium sized installations). 3 project connected to the LEMS seems reasonable.	• Nice Meridia • Grand Arenas	EDF NCA CSTB IMREDD NEXITY
Battery	Li-On batteries seems the most probable solution nevertheless, the providers of the systems are not known yet. In the range of a couple of hundreds of kWh, depending of the sizing of the self-consumption schemes chosen by the project owners. The operation by the LEMS of up to 2 clusters (PV+Battery) might be achieved.	• Nice Meridia • Grand Arenas	EDF NCA CSTB IMREDD NEXITY
Electric vehicle charging infrastructure	Two options are given at present date: 1) *Private infrastructure:* IMREDD and NEXITY will provide a couple of dozens of charging points which are potentially be connected to the LEMS. In a base scenario those will be conventional technology, so not providing a bi-directional approach. A Boolean (On-Off) management seems the most probable solution. 2) *Public infrastructure:* the existing charging infrastructure of the Autobleau and Izzie car sharing fleet might be available to the project. This provides a pool of about a hundred charging points to be managed. A Boolean (On-Off) management seems the most probable solution.	• Nice Meridia • Grand Arenas • Potentially the whole perimeter of the NCA metropolitan area	EDF NCA VULOG CSTB IMREDD NEXITY
DHCN substation equipment: reversible heat pumps and SHW storage	While the two networks have different energy sources, both will have the same overall scheme: LT network (average of 15-30°C) providing heating, cooling and SHW to mixed use buildings. The LEMS might leverage in the Grand arenas network from the building substations, producing both heating and cooling energy and SHW. For more technical details, please refer to the pilot of IS 1.3. In the case of the geothermal sourced LT network of Nice Meridia, the system design is not given. Public tendering process is still underway.	• Nice Meridia (public call for tenders) • Grand Arenas (private endeavour)	EDF NCA DHCN operator

Software:

The technical specifications of the LEMS and related software needs and algorithm development are underway and not finalized yet. The information below is a potential set of specifications and solution that could be provided and no guarantee can be given on their implementation or correctness or completeness. For this reason, software (proprietary or not), has not been specifically named. More information will be provided in D6.4.

Main Component	Technical Specifications	Demonstration Area	IRIS partner
Overall EMS	The software solution has to be built around an energy optimization software and production real-time control of renewable energy, energy storage and, load shedding. The Energy Management System (EMS) potentially to be implemented is based on a redundant architecture of three industrial boxes (1 main, 1 emergency, 1 spare). These boxes communicate via Modbus TCP with the battery converters, PV inverters, control gateway for demand response and genset control and command. A local database records all the data operations at a 1 to 5-second pace. The proposed solution will incorporate also data base, Human Machine Interface and the necessary tools for its local or remote supervision and administration.	• Nice Meridia • Grand Arenas	EDF
Remote control gateway	A load shedding platform needs to control PLCs boxes capable of collecting state process and send stop/start requests or modulation. If required, PLCs boxes could be provided, which will connect to the automation of the load to erase. These boxes interact with the overall EMS to send information of the state of charge and receive instructions for load shedding, stop/start or modulation. Many process could be controlled, such as: • Cold storage • Heat storage • Chillers • Motors • E-vehicles charging infrastructure	• Nice Meridia • Grand Arenas	
PV Production forecast	The PV production forecast module, combines different data sources in order to minimize the forecast errors on different time horizons: • local measurements: on site system with <10 min steps • satellite images: delivered by the French centre for meteorology (15 to 30 min time steps) • weather data: data retrieved by a third party organisation which provides daily weather forecasts, updated at least every 12h. These data are combined and integrated into different methods and algorithms: • Forecast by persistence by using on site measured time series, corrected by daily forecast profiles (less than 1h forecast) • Forecast by imagery: forecast by meteorological scenarios for 1 to 6h time frame • Climate and weather forecast for the 6 to 24h timeframe • Combination of all forecasts to minimize errors for both day-ahead and intraday forecasts.	• Nice Meridia • Grand Arenas	EDF

	If needed, other methods can be used for the 1 to 15 min forecast of production.		
Demand forecast	Generation of day-ahead and intra-day consumption forecasts by combining local weather variables that influence consumption with real-time consumption measurements and industrial process signatures. Depending on the processes and energies to be considered, mixed platforms will have to be adopted.	• Nice Meridia • Grand Arenas	EDF

7.2.3 Gothenburg Demonstration

7.2.3.1 Use Case and Brief technical description

Use case #1: AWL

At Chalmers campus Akademiska hus (AH) there are an office building called AWL (Earlier JSP2). AWL building will be the AH centre of innovation project. One of the project goals is to demonstrate a 350 V DC building microgrid utilizing 140 kW rooftop PV installation and 200 kWh battery storage. The demonstration will include the PV and battery in AWL as well as in the separate FED (Fossil Free Energy Districts, https://www.johannebergsciencepark.com/en/projects/fed-fossil-free-energy-districts) project. The DC system will feed ventilation fans, LED lightning, pumps and hot water tanks. The PV will charge the battery system when the DC load is low in the AWL building.

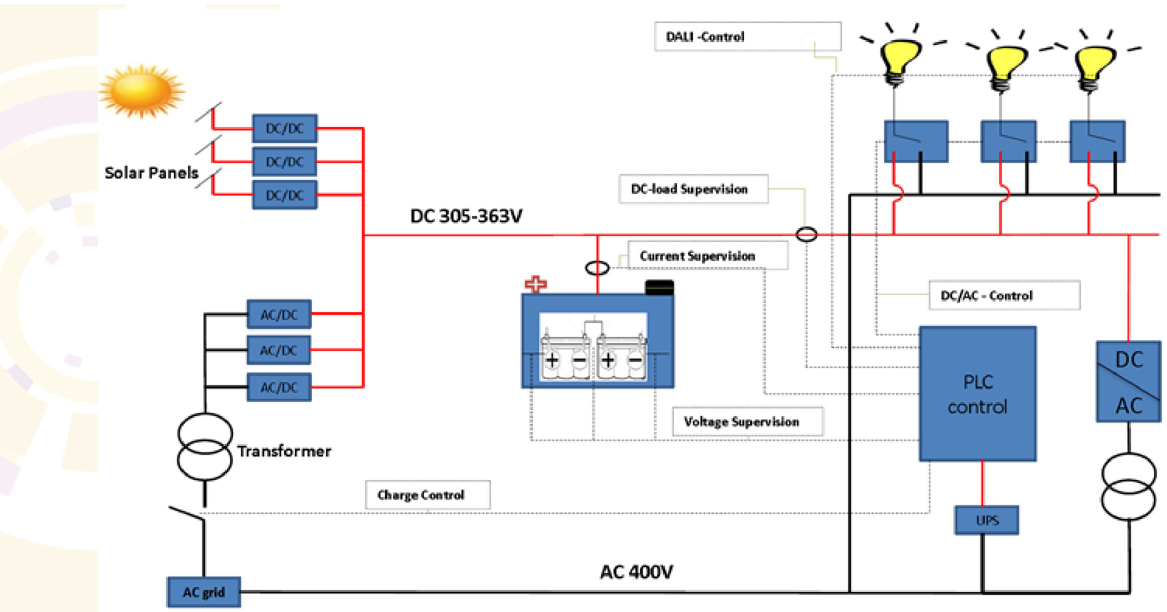


Figure 7-28 : Descriptive scheme of the GOT demo

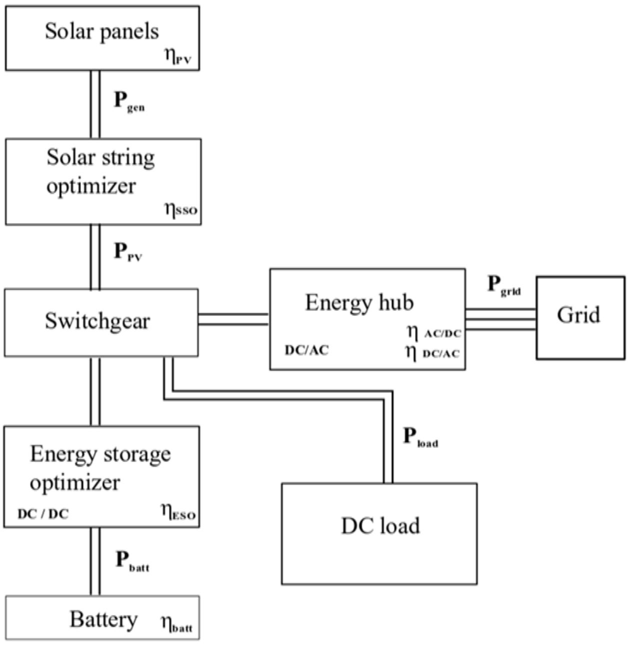


Figure 7-29 : Another descriptive scheme of the GOT demo

Use case #2: Viva (this is the name of Housing project) energy management

The flexible energy system in Riksbyggen's sub-district Viva Housing Association has been developed in a joint project with the local utility company Göteborg Energi (GE). Aided by advances in digitalization, it has become apparent that new ways of reaching efficiency and manageability in methods and systems are possible, enabling small-scale solutions to become complementary to today's large-scale production of heat and power. By utilizing several energy sources, a flexible energy system has been created. Energy is brought into the system as electricity from 140 kWp rooftop PVs, and heating from the boreholes (the case of the geothermal field). This is supported by a bilateral energy trading system with a neighbouring office building, as well as from the city-wide distribution grids for electricity and DH.

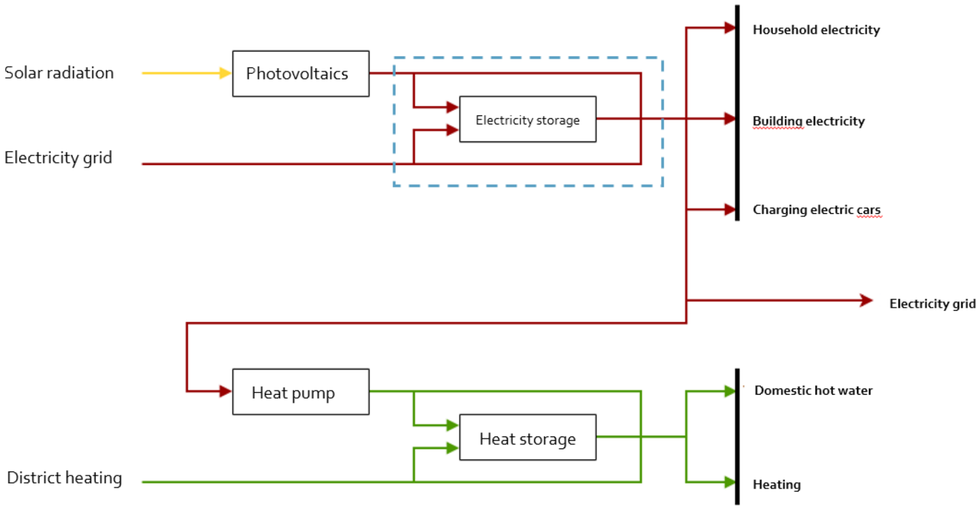


Figure 7-30. Schematic overview of the flexible energy system in Riksbyggen's housing association Viva

Energy is stored within the system as heat through the thermal inertia in the building structure itself, in accumulator tanks, and in the boreholes. Additionally, electricity is stored in 200 kWh 2nd life electric bus batteries, as a stationary application that is dedicated to Viva.

Energy leaves the system through the ordinary usages that occur in housing buildings, although measures have been taken to reduce these as well as to make the residents aware of their consumption on a household basis and encouraged to reduce it. Additionally, the charging of a pool of electric vehicles situated at Viva buildings. Finally, excess electricity can be sold back to the grid.

7.2.3.2 Demonstration Area and Geographical Overview

Use case #1: AWL

The demonstration will be at Chalmers Campus in the new office/innovation building AWL.

Figure 7-31 : 3D model of the office/innovation building AWL

The planned 200 kWh battery installation in the Riksbyggen sub-district will be connected with the 140 kW PV roof top installations with DC. This will allow an uninterrupted supply of 350V DC. In the Riksbyggen project, DC for LED-lighting and charging of cars have been evaluated but so far no installations have been planned. Similar systems with DC, solar PV and batteries are also planned in the JSP2 office building and in HSB Living Lab.

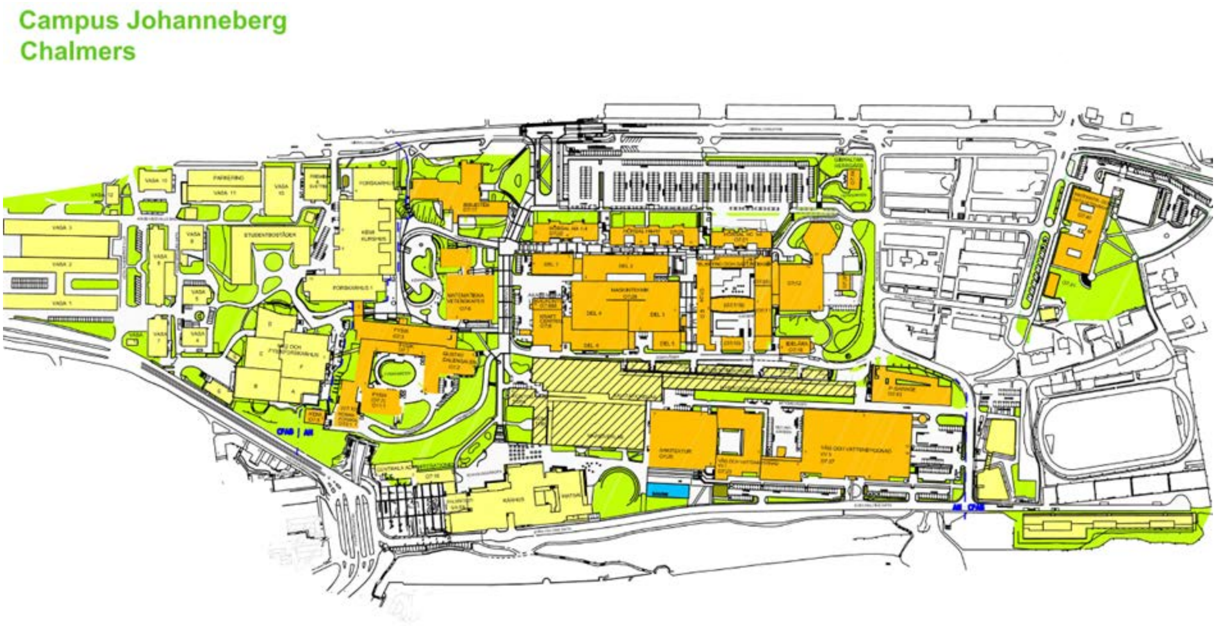


Figure 7-32 : A map depiction of the Chalmers Campus Johanneberg

Use case #2: Viva energy management

Riksbyggen's brf Viva is situated next to Chalmers campus Johanneberg. It is a housing association consisting of 132 apartments in 6 residential buildings, with 2 additional buildings for technical functions and common areas such as a bike garage or an orangery. Viva is built in a steep wooded slope, which puts special demands on the groundwork and foundational work. Over the span of seven years, ideas and concepts have been collected and elaborated to develop Viva into Sweden's most innovative and sustainable housing project. Thereby, a large number of issues have been dealt with, aiming at making Viva inductive to social cohesion, causing minimal negative environmental impact, and challenging the predominant view of a housing in today's Sweden.

Picture 7-33. A bird view of the housing association Viva

Picture 7-34. One of Viva's pairs of buildings as seen from the upper servicing road. N.B. the lack of parked cars.

7.2.3.3 Objectives, Needs and Opportunities to be served by the implementation of the Solution in the Demonstration

Use case #1: AWL

When the DC system with PV and battery storage was installed, the aim was to minimise the losses in transforming AC to DC using many small AC/DC transformers. Another objective was to minimise the DC/AC losses from the PV to the consumers. The battery system will give the opportunity to store energy from PV system and also store AC to DC in times when the grid provides cheaper energy.

Today's faced challenges are:

- To find appropriate DC fans for the ventilation;
- To match the PV system with battery size;
- To find an appropriate battery system and
- To regulate the input and output from the battery system to AWL building and to the FED (Fossil Free Energy) District (Campus Chalmers).

Opportunities	Needs
RES (PV) availability in the demo houses	Further penetration of PVs on a district level on the roof-tops of local buildings. Hardware and Software equipment for monitoring and control of PV resources. Software platform able to dynamically estimate the flexibility of a PV based DC microgrid.
Battery	Recharge with PV power but also through electricity from the grid during low cost time.
DC electricity network	Minimization of energy losses in the AC/DC system
Software Equipment	Smartening the microgrid through the Local Energy Management (LEM) to allow the monitoring and control of available RES, when connected on a DC operating grid, instead that of an AC system. Also to allow FED (Fossil Free Energy) Districts to work

	together with the LEM system

Use case #2: Viva energy management

This project is expected to bring valuable insights into how to manage and coordinate multiple energy sources in a housing project at sub-district scale (132 apartments in 6 buildings). Particularly how to manage downhole (denoting any piece of equipment that is used in the well itself) heat pumps and DH together, in ways that are financially beneficial for the housing association but at the same time contribute to quality and balance of the distribution grid.

On a yearly basis, Viva is expected to produce enough solar PV electricity and provide enough cooling to the nearby offices to exceed the energy used for the building itself, such as heating, fans, heat pumps or lighting in common rooms.

Opportunities	Needs
Renewable energy availability in the demo locate houses	Increase further the penetration of renewable energy on a district level on the roof-tops of 4 local buildings. Hardware and Software equipment for monitoring and control of RES resources. Software platform able to dynamically estimate the flexibility of RES.
Battery	Store available electricity excess, probably 200 kWh for the Viva residential building
Software Equipment	Smartening the grid through the Local Energy Management (LEM) to allow the monitoring and control of available resources.

7.2.3.4 Key technical components

Use case #1: AWL

Hardware:

Main Component	Technical Specifications	Demonstration Area	IRIS partner
PV	140 kW roof-top solar PVs, PV mounted in parallel lines angled 15 degrees. Shadow angle may not exceed 32 degrees.	Office building AWL	Akademiskahus JSP Rise
Battery	200 kWh battery system Preliminary data: Delivery is a fully functional battery system including BMS with BMS protocol System is plus/minus polarity from battery system and canbus-connection. ESO from Ferroamp is delivered by entrepreneur. Battery will be delivered with one BMS per battery string. Each BMS will communicate with cambus and least get information about: BMS shall also contain main contactors and precharge BMS will be supplied from battery or from 760 VDC bus. DC-bussed, not from 230 V AC -Max battery voltage charge 720 V -Min battery voltage discharge 450V	Office building AWL	Akademiskahus JSP Rise

Lighting	The DC system will feed about 200 led luminaries	Office building AWL	Akademiskahus JSP Rise
DC system	The main part of the DC system will operate at 400V. It will be supervised by internal control system which also comes to communicate with FED systems	Office building AWL	Akademiskahus JSP Rise

Smart metering:

Main Component	Technical Specifications	Demonstration Area	IRIS partner
Smart Meters	We have not yet determined the extent of the measurements.	Office building AWL	Akademiskahus JSP Rise
Communication Platform	Will communicate with AWL platform for the building and with Metry system.	Office building AWL	Akademiskhus JSP Rise Metry

Use case #2: Viva energy management

Main Component	Technical Specifications	Demonstration Area	IRIS partner
PV	140 kWp roof-top solar PVs	Viva Housing Association	Riksbyggen, Göteborg Energi,
Battery	10-14 2nd life Li-Ion batteries from electrical buses, aiming for 200 kWh.	Viva Housing Association	Riksbyggen, Göteborg Energi,
Auxiliary Equipment Type #1	Heat pumps for the boreholes in a joint energy generation center, as well as for SHW (Sanitary Hot Water) in each pair of buildings.	Viva Housing Association	Riksbyggen, Göteborg Energi,
Auxiliary Equipment Type #2	Auxiliary equipment, which is used for the connection of the Viva sub-district with the main municipal grid for electricity and DH provision (left hand side of Figure 7-30. Maximum effect from solar cells and batteries towards the grid are 168 kW.	Viva Housing Association	Riksbyggen, Göteborg Energi,

Software:

Main Component	Technical Specifications	Demonstration Area	IRIS partner
Management and control software	Software to coordinate the energy flows for several plausible service cases.		Riksbyggen, Göteborg Energi,

7.3 Replication Planning in the Lighthouse and Follower Cities

7.3.1 Utrecht Replication

7.3.1.1 Use Case and Brief technical description

In the Netherlands 14.000 apartments of the Intervam type were built in 1960's, of which 6.500 in Utrecht alone. In 1948-1973 13.000 apartments of the Bredero type were built as well. The social housing associations Bo-Ex, Portaal and Mitros who own the apartment blocks have recently started refurbishing buildings, resulting in energy labels A/B. All the apartments need to be renovated in the coming years, providing opportunities to replicate demonstrated solutions especially:

- PV panels on the rooftops of the apartment buildings;
- Home Energy Management Systems (HEMS) Eneco TOON;
- Energy savings resulting from refurbishment towards near zero energy building;
- Smart (hybrid) electric heat pumps for the production of heating and hot water / LT DHN for heating and hot water;

7.3.1.2 Replication Area and Geographical Overview

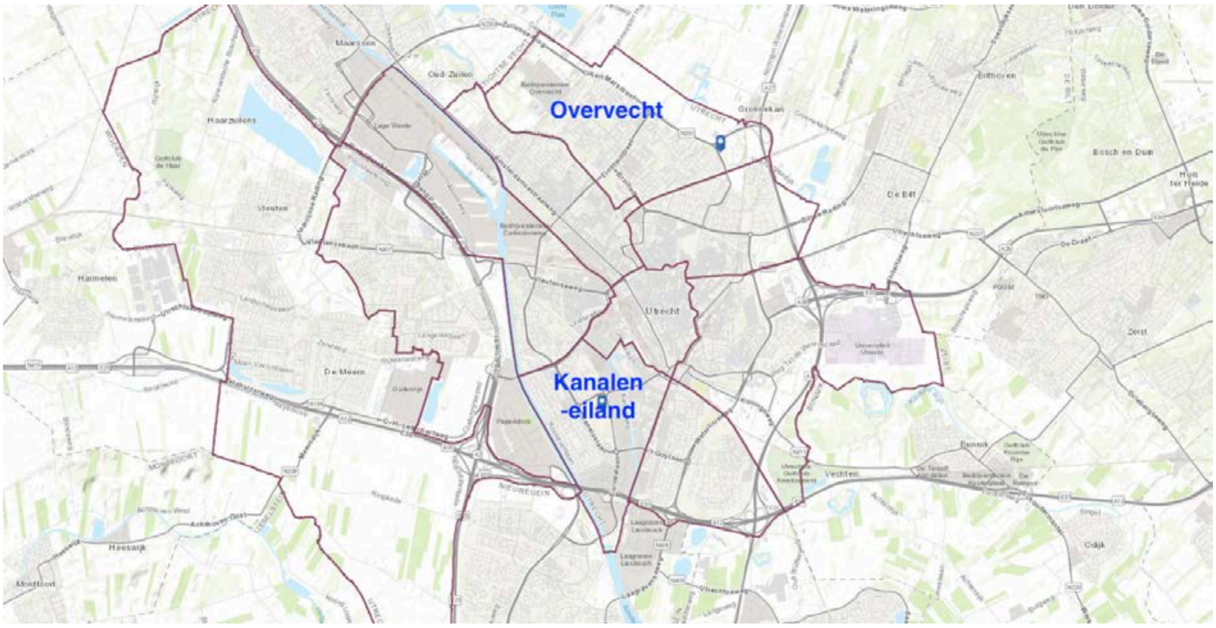


Figure 7-35 : Overview of two replication areas in Utrecht : Kanaleneiland and Overvecht

7.3.1.3 Objectives, Needs and Opportunities to be served by the implementation of the Solution in the Replication

Opportunities	Needs
Maximize profits of renewable power production	Hardware and software equipment for monitoring and control of RES resources. Software platform able to dynamically estimate the flexibility of RES based micro grids. Deployment of a district management system connecting production, consumption and storage.
Maximize self-consumption reducing grid stress	

7.3.2 Nice Cote D' Azur Replication

7.3.2.1 Use Case and Brief technical description

- Aggregation of local flexibilities for grid services (DSO, TSO or Energy Market - Aggregator) through a LEMS;
- Smart charging of electric vehicles for flexibility provision to the grid and
- Operation and maintenance of a coupled PV and Battery storage system in tertiary buildings.

7.3.2.2 Replication Area and Geographical Overview

In case the LEMS implementation will result as a viable product, it could be foreseen to extend its implementation to the second phased developments of the Nice Méridia urbanization project or within the wider territory of Nice Eco Valley. At present date, the Nice Méridia urbanization project covers about 26ha, representing a first phase among the wider 200 ha project, for which a high level master plan has already been developed. The latter does not yet provide a fine grain land use planning or phasing, nor identifies major energy infrastructure or energy related actions. The area will be a prolongation of the current development project, however, a higher housing share is expected to for the long term overall program. If the current regulation on parking's' equipment level for electric vehicle charging is maintained as well as the current obligation in local renewable energy production and on-site consumption, a high potential is given to enlarge the LEMS to this further urbanization phase. The LEMS developed in IRIS could potentially be connected to more users and thus, provide a bigger pool (size and volume) of potential flexibility products. Nevertheless, a growing flexibility potential accompanied by an increasing share of intermittent renewable energy sources and new electric usages as e-vehicles, would probably need an impact study, in order to avoid any impact on the energy provision quality or security. The role of storage should be better identified as a mean to mitigate possible disturbances on the grid level.

Figure 7-36 : Contextualization of the existing urbanization project within the long term plan.

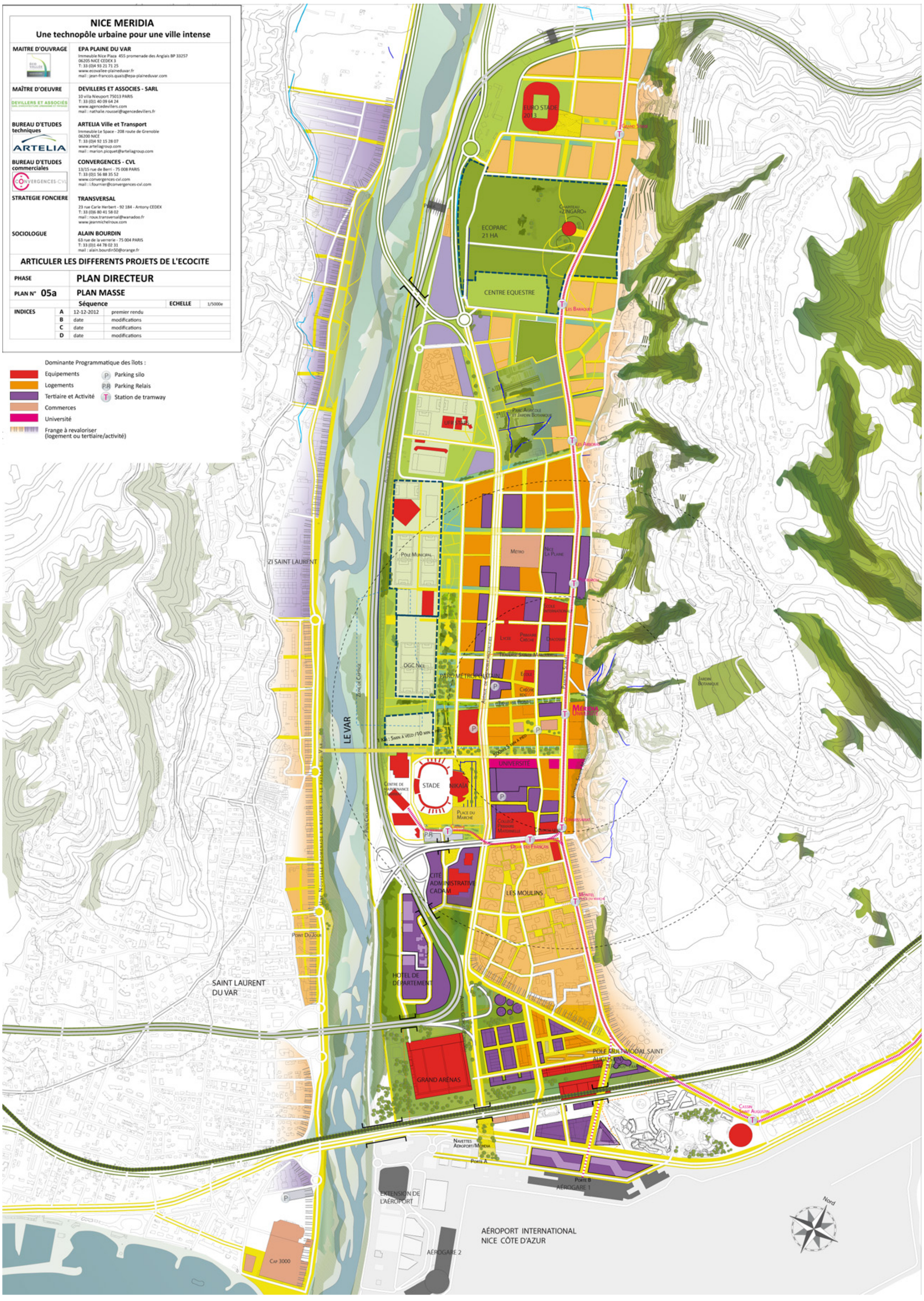


Figure 7-37 : Master plan of the 200 ha area (source : D&A – Agence Devillers).

As a further replication area, the greater Eco Valley area can be targeted. The project has to be seen in a long term perspective, aiming at a strong territorial mutation and revitalization. Its developments will be divided into further urbanization phases and related construction programs. Yet, the projects to come are not defined, but the whole area will be developed under the same objective of sustainable development, driven by innovation and green technologies. This whole area, represents a potential pool of 3 000 000 m² of new constructions and developments. A Spill Over effect could be expected, fostering an adoption of the solutions which have proven their upper value in the first demonstration projects.

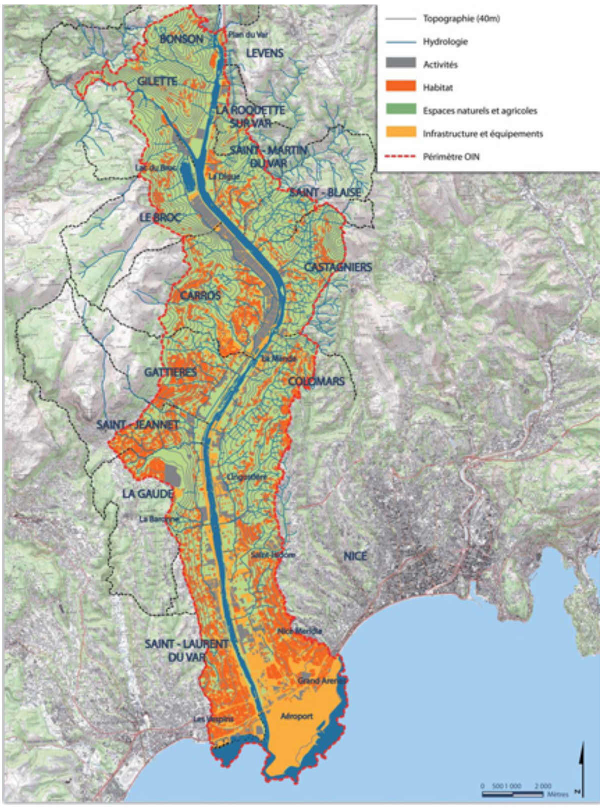


Figure 7-38 : Perimeter of the Nice Eco Valley project : a territory with potentially up to 3 000 000 m² of new constructions

7.3.2.3 Objectives, Needs and Opportunities to be served by the implementation of the Solution in the Replication

Opportunities	Needs
LEMS - Renewable energies and self-consumption	The uptake and extension of the LEMS gives the opportunity to integrate more widely renewable energy and this, while providing more flexibilities to the grid. It will ensure the capability to increase the share of low carbon distributed and decentralised energy generation means and their onsite consumption. This at a reasonable cost and without diminishing the energy provision quality or security.
Battery	Integrate more storage capacity among the area to better manage Self-consumption endeavours and complementary production means. Reduce overall exploitation costs for business (for example connection charges, peak shaving). Create over time enough reserve capacities for answering to ancillary service market or ensuring the local grid stability.

Smart charging	Enable a wider increase of charging infrastructure and electric vehicle adoption and decrease the proportional impact on the distribution grid. Through smart charging, grid congestions might be avoided as well as a certain degree of grid reinforcement, without impacting the overall charging service.

7.3.3 Gothenburg Replication

7.3.3.1 Use Case and Brief technical description

Akademiska Hus is considering replicating the PV/DC infrastructure solution in a planned addition to the School of Business, Economics and Law at the University of Gothenburg.

7.3.3.2 Replication Area and Geographical Overview

Due to the planned construction of an underground railway station, the School of Business, Economics and Law at the University of Gothenburg will need to be partly rebuilt. Planning will start in 2019 and works are expected to take place between 2020-2022.

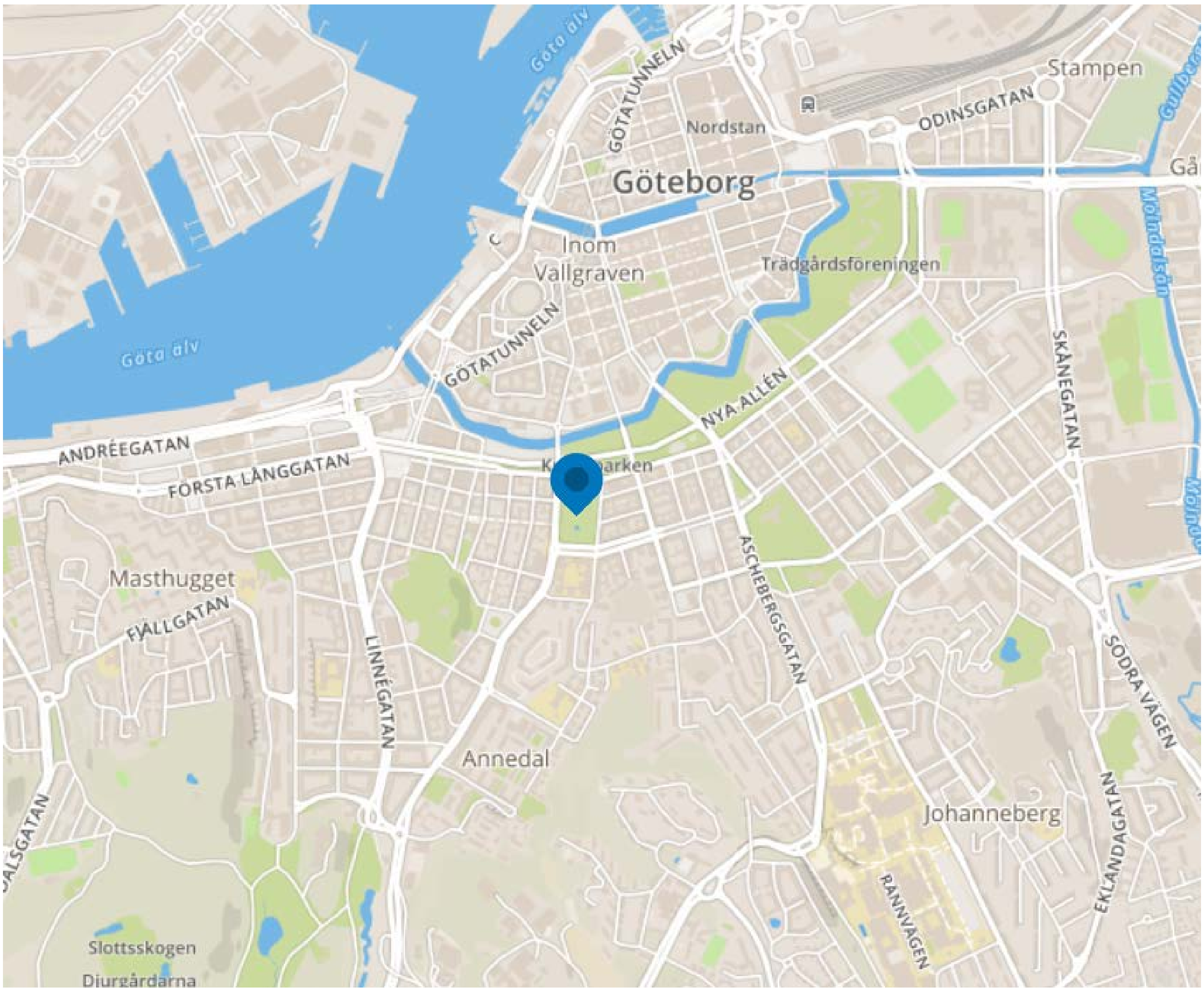


Figure 7-39 : Location of the School of Business, Economics and Law at the University of Gothenburg

Figure 7-40 : The School of Business, Economics and Law at the University of Gothenburg

7.3.3.3 Objectives, Needs and Opportunities to be served by the implementation of the Solution in the Replication

Opportunities	Needs
RES (PV) availability in the demo locate houses	Rooftop PV panels are included as a standard component on all new constructions by Akademiska Hus (excluding shaded roofs). In the planned Business School rebuild, about 100 kW/90 MWh capacity is planned. An efficient way of utilising the electricity generated by the solar panel is needed.
DC electricity network	A DC electricity network for lighting and building operation (for example fans, pumps) can increase the efficiency of the electricity usage (DC from PV's is used directly without conversion to AC) in the building, as well as lowering installation costs (fewer components such as inverters needed, as well as less cabling)
Batteries	Batteries will allow excess electricity to be stored, reducing the need for externally supplied electricity.
Software Equipment	Smartening the microgrid through the Local Energy Management (LEM) to allow the monitoring and control of available RES microgrid resources, when connected on a DC operating grid, instead that of an AC.

7.3.4 Vaasa Replication

7.3.4.1 Use Case and Brief technical description

The LEM will introduce the following innovative elements:

- enhanced management as well as flexible and optimized operation of a distributed smart grid. This is especially required when share of renewable energy (wind and solar) is increasing, (TRL7). In Sundom Smart Grid pilot some preliminary information and knowledge is already developed,
- integration of innovative concepts (e.g. Virtual Power Plants, microgrids) together with off-the-shelf components and technologies (e.g. smart meters, EVs, storage components) (TRL9) and

- algorithms, and open data/information dealing with demand-response optimized schemes, consumer empowerment (including active participation) and autonomous management / self-consumption, and combination and interoperability between distributed (local) energy resources and storage equipment and systems (TRL8).

7.3.4.2 Replication Area and Geographical Overview.

Sundom Smart Grid project (2014 – 2016) already demonstrated a Living Lab in Sundom village to enable crosscutting R&D and demonstration activities between the local University, enterprises and the local community. In Sundom, due to the transformation of the rural area to urban district, the structure of the power network is also changing. ABB was testing the latest automatic fault management technology in the area. Project also aimed to build solutions that promote the use of renewable energy production, such as wind and solar power. The existing optical fiber network in Sundom makes it possible to transfer digital measurement data in real time. The data was collected at the data center. Replication can provide continuation of the living lab in Sundom area, which is also under rapid development. Some solutions could be also replicated in University Campus, in connection to the Smart Grid laboratory/building to be constructed within the University Campus area.

Figure 7-41 : Location of Sundom demonstration area

Figure 7-42 : Location of University Campus demonstration area

7.3.4.3 Objectives, Needs and Opportunities to be served by the implementation of the Solution in the Replication

Opportunities	Needs
RES (PV) availability in the Replication area houses	Increase further the penetration of RES on a district level on the roof-tops of local buildings. Hardware and Software equipment for monitoring and control of RES resources. Software platform able to dynamically estimate the flexibility of the RES based microgrid. Deployment of a MV/LV substation for the interconnection of the microgrid with the distribution network.
Software Equipment	Smartening the microgrid through the Local Energy Management (LEM) to allow the

	monitoring and control of available RES microgrid resources, when connected on a DC operating grid, instead that of an AC.

7.4 Data Collection and Management

7.4.1 Utrecht

The following list of data will be collected within the demonstration area:

- Real time energy consumption on the household level. Data collection through the Home Energy Management System "Toon". Because of Privacy legislation, permission of the tenants to obtain this data is required;
- Real time energy consumption and production at the apartment building level. Data collection through the district energy monitoring system;
- Real time electricity production of the PV panels. Data collection through electricity (sub)meters and
- Real time consumption of locally produced electricity with the PV panels. Data collection through smart meters (with the permission of the tenants).

7.4.2 Nice Cote D' Azur

Neither technical nor functional specifications are done yet for the LEMS. What is clear is that the LEMS needs the fine monitoring of the connected loads and energy conversion/storage means. The standards of the data management are relative to the implemented solutions and might vary among the technical equipment that will be installed by the different owners. No precise standards or protocol are imposed in the sector up-to date, so concerning SCADA, BEMS or HEMS nor vehicle charging stations. Most probably both open and proprietary protocols will be encountered. It is foreseen that ad-hoc interfaces will have to be defined. Data will be collected in the range of the seconds to minutes, in order to ensure a proper management of the different equipment. The generated data will be stored locally at the EMS installed on site and/or in the data servers of a third party B/EMS provider and/or the LEMS server itself. By any mean, for ensuring a correct functioning of the EMS and a quality service provision, all logs will have to be transmitted to the central management station of the LEMS.

Interfaces and connectors will have to be built, to interface with data sources external to the LEMS. More precisely, the forecast algorithms will need most probably external data sources to ameliorate the prediction quality. For permission of flexibilities, their activation, tracking and settling with the aggregator and retailer, the standard imposed by the French grid code will apply (regulation section). The LEMS could provide in relation with the CIP (potentially, as yet this is not clearly technically feasible) and its open data chart, aggregated data about the performance of the LEMS however, this has yet not been defined.

7.4.3 Gothenburg

Data to be collected are expected to include:

- Overall system efficiency
- PV current and voltage
- Charging current to batteries and
- Electricity supplied

7.5 Regulatory Framework per LH/FC

7.5.1 Utrecht

- Current regulation in the Netherlands does not provide incentives to consume or store locally produced electricity (behind the meter). Households that produce electricity with PV panels are given the opportunity to balance their consumption and own production (The so-called *balancing regulation*). This means that the energy supplier deducts the produced electricity from the consumption of the customer. As a result, the customer receives the same price (including taxes and transport costs) for the returned energy as he pays for the energy he purchases from the energy supplier at a different time. Due to the relatively high level of energy taxes in the Netherlands this provides an attractive financial incentive for household resulting in average pay back times for PV panels of 7 years.
- The government started a process to revise the electricity regulations with the aim to incentivise stakeholder to provide flexibility resulting in a lowering of the grid stress in periods of high demand or high production with renewable energy sources. Currently a "Regulation experiments under the electricity law" is in place under which stakeholders can apply to be exempted from the rules under the electricity law to e.g. experiment with maximizing electricity consumption behind the meter.

7.5.2 Nice Cote D' Azur

In NCA, the current legislation framework is long and sometimes complex to understand. Specific and limited guidelines cannot be provided, since the information should be presented extensively. However, one can have at the following regulations, based on his/her requirements. These address most of the important aspects.

- Regulations on the TSO level flexibility market in France (products, services, market rules, roles and duties, e.t.c.)
  - https://clients.rte-france.com/lang/fr/clients_producteurs/services_clients/regles.jsp

- Regulation on data interchange among flexibility actors and the DSO in the French context.
  - http://www.enedis.fr/sites/default/files/NEBEF_SI-_Echanges_de_donnees_entre_GRD_et_OE_-_v2.0.pdf
  - http://www.enedis.fr/sites/default/files/MA_SI-guide_dimplementation_des_echanges_entre_GRD_et_AA.pdf

- Self-consumption regulation
  - https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000032938257&categorieLien=id
  - https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000032966823&categorieLien=id
  - https://www.legifrance.gouv.fr/eli/loi/2017/2/24/2017-227/jo/texte

- Submetering chapter of the actual building thermal regulation (RT 2012)
  - https://media.xpair.com/pdf/reglementation/Consommations-RT2012.pdf

7.5.3 Gothenburg

There is currently a lack of specific regulations governing the use of DC machinery in buildings concerning electrical safety. These regulations are issued by the Swedish National Electrical Safety Board. Akademiska Hus will investigate how available regulations can be used, or alternatively, new regulations may be needed.

7.5.4 Vaasa

Current regulation in Finland does not provide incentives to consume or store locally produced electricity (behind the meter). Households that produce electricity can balance their consumption and own production but they can only sell extra electricity to grid operator (direct transaction to a neighbouring property are not allowed). Customers receive a Feed In Tariff which is actually lower than the electricity retail price. Also the transfer taxes are paid in both directions, lowering the attractiveness for investing. PV, in general, is used only when a household is able to consume all produced energy.

7.6 Bounds and Drivers per LH/FC

7.6.1 Utrecht

- Technical Bounds & Drivers: Equipment to monitoring performance of the electricity grid and the various components of the smart district energy system are well known and broadly available in the market.
- Legal/financial: Current legislation provides insufficient incentives to optimise balancing of supply and demand on the local level with the aim to minimize grid stress. The government started a process to revise the electricity regulations with the aim to incentivise stakeholder to provide flexibility. It is, yet, uncertain when this new regulation will actually be in place.
- Social: It is yet uncertain which role households can and are willing to play in offering flexibility to lower grid stress.

7.6.2 Nice Cote D' Azur

Some of main aspects that need to be considered, including the following regulations, which are as well in line with European based ones. Since no specific and short information can be provided, at this point, one can have a detailed view of the following Directives/regulations to get an idea of the facing Bounds and Drivers for the case of NCA.

- EU COMMISSION:
    - EU regulations and Evaluation Report covering the Evaluation of the EU's regulatory framework for electricity market design and consumer protection in the fields of electricity and gas Evaluation of the EU rules on measures to safeguard security of electricity supply and infrastructure investment (Directive 2005/89), Nov 2016, EUROPEAN COMMISSION
    - 7 COM (2016) 860 – "Clean Energy For All Europeans", European Commission, Brussels Nov 2016

- Investment aids from ADEME in renewables
    - http://www.ademe.fr/expertises/energies-renouvelables-enr-production-reseaux-stockage/passer-a-laction/produire-chaleur/fonds-chaleur-bref

- Tax reduction on energy bill for district heating cooling networks, providing at least 50% of energy from renewable sources.
    - http://bofip.impots.gouv.fr/bofip/1201-PGP.html

- Nice's Charta on ready to grid buildings
    - http://le-be.fr/wp-content/uploads/2017/01/Recommandations-pour-des-b%C3%A2timents-Smart-Grids-Ready.pdf

- Nice's environmental Charta on constructions

- http://www.ecovallee-plaineduvar.fr/sites/default/files/fichiers/demarche_ecovallee_qualite_v2018_270218_light_0.pdf

7.6.3 Gothenburg

The same stands for the Gothenburg city

1) Technical:
   a. Drivers – Technological development is moving fast in this field and this rapid development is a driver in itself. There is also a good opportunity for publicity when new technologies are implemented and tested in real life.
   b. Bounds – As always with new technology, there is a level of uncertainty. Some solutions may prove more difficult to implement than planned and results may not be as expected
2) Legal:
   a. Drivers – There are public commitments to reduce fossil dependence, resulting in subsidies to flexible energy solutions.
   b. Bounds – Subsidies can be complex and subject to political decisions, can be difficult to build sustainable business models
3) Social:
   a. Drivers - Champions and influencers in this field can create a positive social context driving the progress in the right direction
   b. Bounds - Personal drive may change or disappear
4) Financial:
   a. Drivers - A flexible energy system will provide financial benefits by enabling storage of energy and shaving peak consumption.
   b. Bounds – It is still largely impossible to quantify life cycle costs of systems and how large the savings are in reality
5) Environmental:
   a. Drivers - Flexible energy systems are crucial for the development and market penetration of renewable energy sources, which in turn provides environmental benefits
   b. Bounds – There is still insufficient information on life cycle environmental benefits/costs for these systems

7.6.4 Vaasa

Based on the Sundom Smart Grid project there are good basis to continue with replication. Local companies involved have good knowledge and co-operation with the University. Also the basic infrastructure with optical fibre network and data centre is in place and already tested. Project has also received good feedback on citizen's involved.

7.7 Business Models

Concerning any current BMs underpinning the development and promotion of the different IRIS solutions, concrete information is yet lacking. However, a generic idea of what is envisioned to be developed and studies in the framework of IRIS project, within the next short-time period can be derived by the following attached information.

7.7.1 Utrecht

The Universal Smart Energy Framework (USEF) will be used to develop a new business model unlocking the value of flexibility in the energy grid.

7.7.2 Nice Cote D' Azur

Smart charging – A new BM enabling to create additional revenue streams for an electric vehicles charging infrastructure operator or owner, by selling flexibility services to the grid. The challenge relies in identifying and matching the grid flexibility needs and the availability of the charging infrastructure.

Yet no clear business model defined: in the followings are listed first elements which could be considered (EMS provider's point of view > not overall operator).

- **Key partners**
  - City administration and agencies
  - Aggregator
  - Charging infrastructure operator
  - Main car sharing fleet or service operator
  - Customers
- **Key activities**
  - Monitoring and forecast of charging behaviour
  - Send signal or directly perform activation/deactivation/modulation of charging depending on EMS signal or Aggregator signal
  - In case a public pool of charging infrastructure is operated, define aggregation area for dispatching of charging
  - Ensure quality of forecasts and validity of provided information and services
- **Key resources**
  - Data scientists
  - Mobility experts
  - Energy engineers
  - Software developers
  - Developers/commercials
- **Value proposition**
  - Increased revenue stream from the smart charging with no impact on service provision
  - Economies in reduction of subscribed capacities
  - Reduction of peak loads (expenses) through dispatching of charging points
- **Customer relationships**
  - Periodic exchange on service provision quality and satisfaction
- **Channels**
  - Web sites (company's or clients web sites, city)
  - Public spaces as parking lots, public transport, bus stops, e.t.c (QR codes, posters)
  - Commercial activity in the sector
  - Association with charging infrastructure operators
- **Customer segment**
  - B2B
  - B2G2B
- **Cost structure**
  - To be defined – No available information
- **Revenue Stream**
  - Design and delivery of system
  - Licensing of EMS
  - Energy market revenues

Local Energy Manager – An innovative business model, leveraging on the LEMS concept, with new interfaces between energy transport, distribution, aggregation, management, consumption stakeholders as well as new contractual approaches between the LEM manager, the B2B clients as well as the district/city and regional authorities will be explored.

Yet no clear business model defined: in the following first elements which could be considered

- **Key partners**
  - City administration and agencies
  - Aggregator
  - Charging infrastructure operator
  - Main car sharing fleet or service operator
  - Building/asset owners
  - Businesses in the building (clients)
  - Building operators / BEMS operator
  - Any EMS operator
  - ESCO
- **Key activities**
  - Monitoring and forecast load and production
  - Send signal to BEMS or directly perform activation/deactivation/modulation of connected assets from EMS signal or Aggregator signal
  - Ensure service provision quality within contractual constrains
  - Validation of flexibility activations with DSO, aggregator or other market player and eventual building operators
  - Operation and maintenance of related assets and key components (depending on contractual arrangement)
- **Key resources**
  - Data scientists
  - Energy engineers
  - Software developers
  - Developers/commercials
  - Service and equipment providers
- **Value proposition**
  - Decrease energy billing and/or provide complementary revenue stream for building owner with no impact on service provision
  - Valorisation of assets through a smart building/smart city approach
  - Optimize the dimensioning of the overall system, thus generate economies for investor/owner
  - Enable a district energy system operation where local/distributed renewable energy systems are locally valorised
  - Put into practice the smart city and smart grid vision
  - High automation and low intrusiveness in operation phase > possibility of customization for specific needs
- **Customer relationships**
  - Periodic exchange on service provision quality and satisfaction
- **Channels**
  - Participation in Smart City/Smart Grid dedicated fora/event/associations
  - Web sites (company's or clients web sites, city)
  - Commercial activity on the ground
  - Public spaces and transport, bus stops, e.t.c (QR codes, posters)
  - Association with charging infrastructure operators
- **Customer segment**
  - B2B
  - B2G2B
- **Cost structure**

  - To be defined – No available information
- **Revenue Stream**
  - Design and delivery of system
  - Licensing of EMS
  - Energy market revenues
  - ESCO model
  - O&M contract
  - Provision of equipment
  - EPCM of whole system

Self-consumption– The self-consumption model coupled with storage facilities has seen demonstrators in the industrial sector nevertheless, the tertiary buildings seem a next frontier to be addressed. The viability of such BM and its legal, financial and contractual arrangements still have to be better identified within the French energy market and regulatory context.

7.7.3 Gothenburg

There is currently no business model associated with this solution. More information will be provided in D3.2.

7.7.4 Vaasa

Prosumer oriented mechanisms – A new BM enabling to exchange energy between consumers outside trade and market for example by sharing properties and investments in production/storage units and short range grids, will be defined and built. To plan and devise such business model and value chain all along urban project according to each country policies and regulations, is another central challenge.

Local Energy Manager – An innovative BM, leveraging on the LEM concept, with new interfaces between energy transport, distribution, management and consumption stakeholders as well as new contractual approaches between the LEM manager and the district/city and regional authorities will be developed.

8. ANNEX for IRIS Solution IS-2.2: Smart multi-sourced low temperature district heating with innovative storage solutions

8.1 Pre-pilot Areas description and Available Infrastructure

Disclaimer

In the Pre-Pilot description section, data is provided about the scope, structure, results and conclusions of the past related activities. The herein stated information represents the state-of-the-art on which IRIS is going to proceed as a one step further. For the case of more information needed, the interested stakeholder should contact the responsible entity of the pre-pilot site.

8.1.1 Utrecht Pre-Pilot

Medium temperature DH is demonstrated by IRIS partner Eneco in the Harnasch polder, in the municipality of Delft in the province of Zuid-Holland, instead of Utrecht, since it was identified during the IRIS evolution that Utrecht local ecosystem could not identify any pre-pilot already being in operation in the area of Utrecht. Given this condition and after discussion within the IRIS consortium, it was decided to find an alternative.

The pre-pilot in Harnaschpolder in Delft encompasses a greenfield project with 1.440 homes and 12.000 m^2 of office and business buildings, which are supplied with medium temperature heat used for space heating and SHW production. Heat is supplied to the building through a district-heating network that is supplied by different sources, which together supply connected buildings with heat year round. The DH is fed by:

a) a natural gas fired cogeneration plant of 1800 MW_e (delivering ~60% of the heat on an annual basis);
b) an industrial sized heat pump (delivering ~25% of the heat on an annual basis);
c) three (3) natural gas fired back up boilers with a total capacity of 4800 kW_{th} (delivering ~15% of the heat on an annual basis) and
d) three (3) buffer tanks of a total capacity of 360 m^3.

To project is aimed at promoting the idea of LT DHN and its benefits lie on expected lower losses compared to those by high temperature operating ones. For this purpose, LT heat is extracted from purified water produced by the nearby waste water treatment plant (WWTP), and a large industrial high temperature heat pump (with a capacity 1.200 kW_{th}) located at the WWTP. This WWTP utilizes this heat source to produce heat of 70 ^{0}C. This is an innovative solution, which is not yet implemented on a large scale. The project received financial support from the national government for this innovative concept.

The advantage of using LT heat from the WWTP, is that the temperature of the effluent feeding the heat pump is almost constant on a yearly basis (varying from 21 ^oC to 16 ^oC); thus allowing to have an almost constant overall Coefficient of Performance (COP) of the Heat Pump around to three (3). The electric consumption of the heat pump corresponds to a power of 370 kW_e. The working medium of the heat pump is Ammonia (NH_3) and the outlet stream of water after being heated up, by the Heat Pump, is delivered to a heat transfer station, which is part of the DHN, which delivers heat to the homes and utility buildings. The figure below roughly sketches the operation of the system.

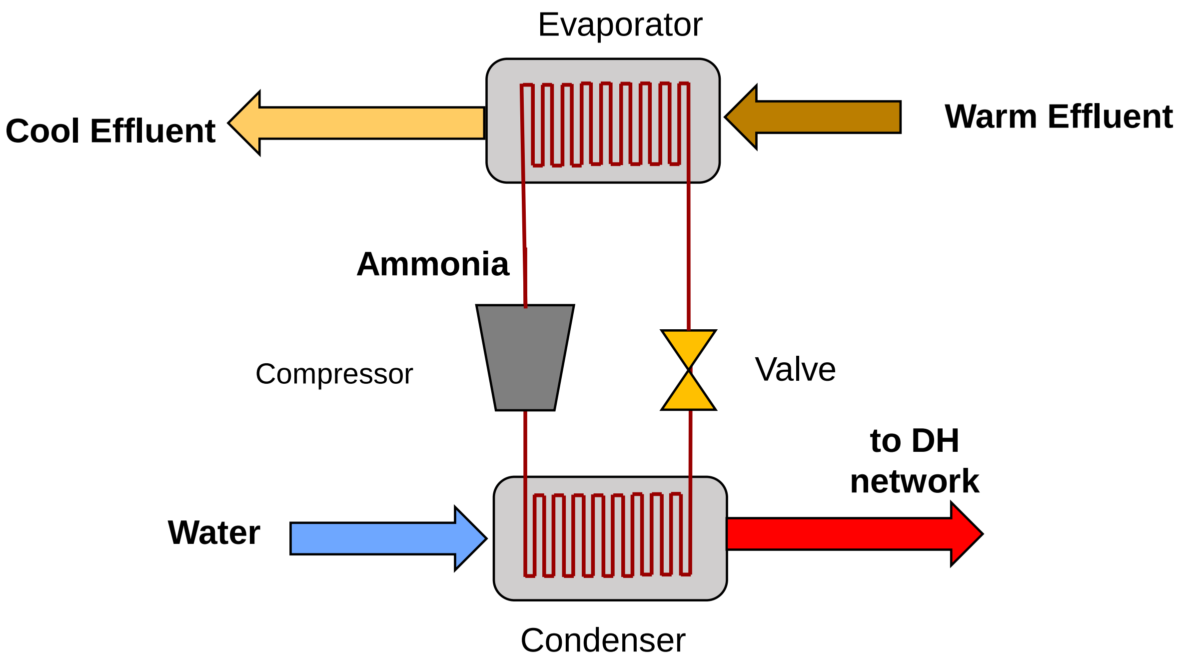


Figure 8-1 : A representative operation scheme of the heat pump

8.1.1.1 Pre-Pilot Area and Geographical Overview

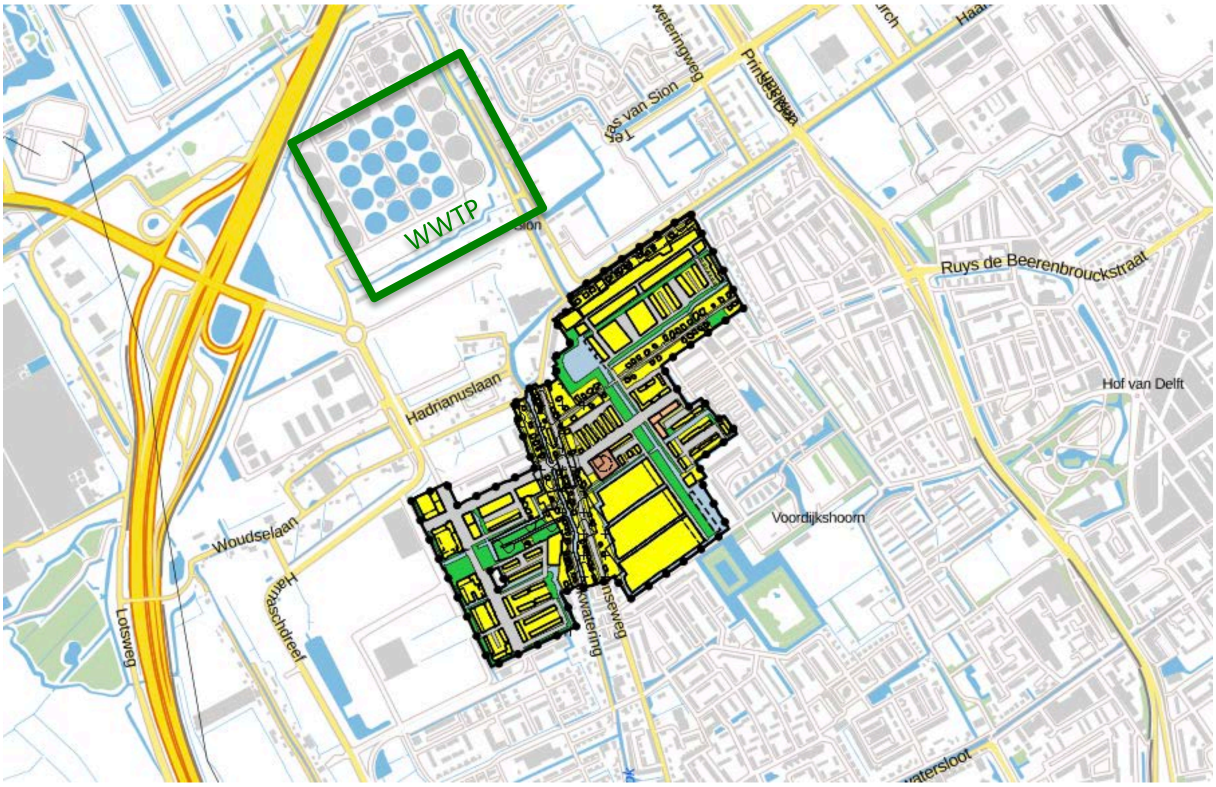
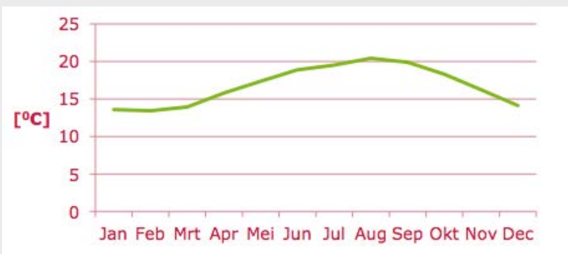
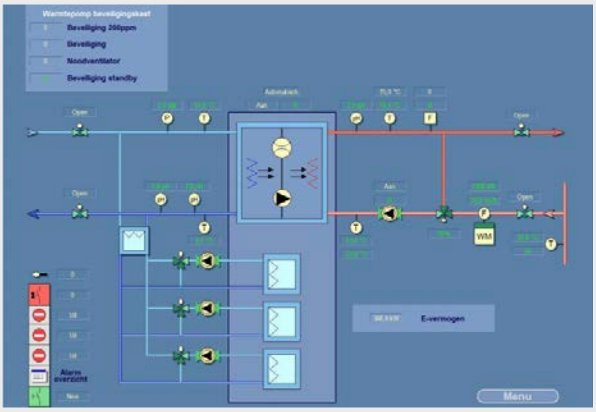
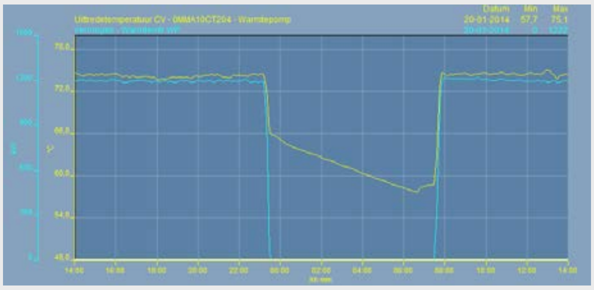


Figure 8-2 : Location of the building location Harnaschpolder and the WWTP which is supplying the buidlings with heat

Figure 8-3 : Location of the heat transfer station at the borders of the WWTP

Figure 8-4 : The industrial heat pump used to produce heat of 70 0C

Main Component	Technical Specifications	Area of the pre-Pilot
Heat Source	• Effluent from a Waste Water Treatment Plant • Available volume of effluent: 10.000 m^3 per year  Average monthly temperature profile of the effluent	Harnasch polder

Heat pump	• Coefficient Of Performance (COP) > 3 • Thermal capacity: 1.200 kW_{th} • Effluent mass flow rate: 160 m^3/h • Electrical capacity demand: 370 kWe • Number of compressors: 3 • Maximum pressure: 45 bar • Liquid to Liquid Heat Pump: effluent-water • Operating medium of the Heat Pump: NH_3 (ammonia) • Delta T effluent: 5 ^{0}C  Typical controlling layout of the heat pump  Representative ramp-up/down times of the heat pump. Within 10-15 minutes the heat pump can heat up water in a temperature range of 70 ^{0}C.	Harnasch polder
Heating grid operating temperatures	• return heat temperature 40 ^{0}C • input heat temperature : 70 ^{0}C	Harnasch polder

8.1.1.2 Lessons Learnt by the implementation of the Solution in the Pre-Pilot

The main lesson learned from this project is that the choice of material for the heat pump is crucial. The heat pump had to be taken out of operation because the bacteria in the effluent corroded the stainless steel leading to small holes in it. The WWTP operators, were forced to search for a new material, which is not corroded by the bacteria. The current system is not yet cost-effective, i.e. that Eneco can make a business case under current tariff regulations for households. Eneco is currently exploring further opportunities to replicate this concept in Utrecht or elsewhere.

8.1.2 Nice Cote D' Azur Pre-Pilot

Côte d'Azur Habitat together with Métropole Nice Côte d'Azur began in 2010 an ambitious multi-phase renovation program for the buildings of the Les Moulins neighbourhood. On the original 2969 dwellings (around 12 000 inhabitants), 547 dwellings have been destroyed and 568 dwellings have been retrofitted. The Les Moulins DH was implemented at the neighbourhood creation in the 1970's. The boiling station was modified several times, and is now composed of 3 natural gas boilers for a total power capacity of 21 MW_{th}. It supplies heat mainly to the collective housing buildings owned by Côte d'Azur Habitat (initially 31 buildings), through 28 substations (typical sub-station organization below), and also to several municipal buildings (one school and a swimming-pool).

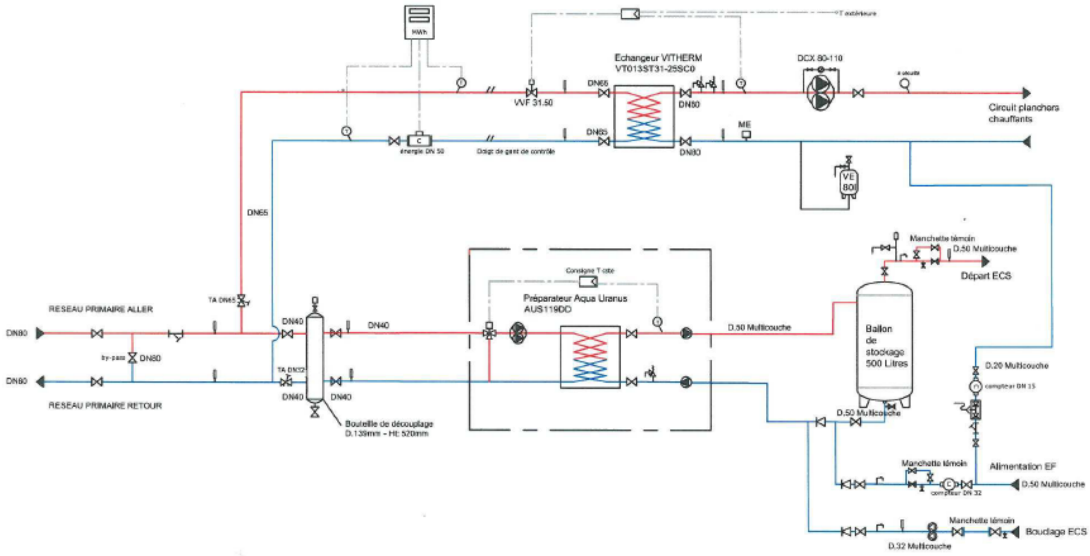


Figure 8-5 : The DH structure of Nice pre-pilot in Côte d'Azur

During the summer, the total needs for the hot water production is only 1500 kWth.

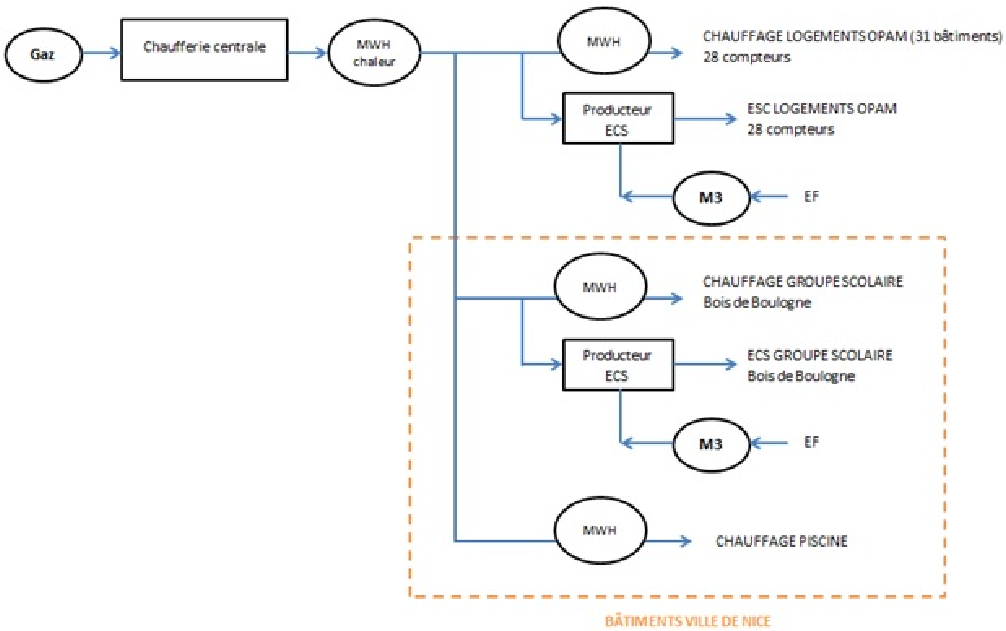


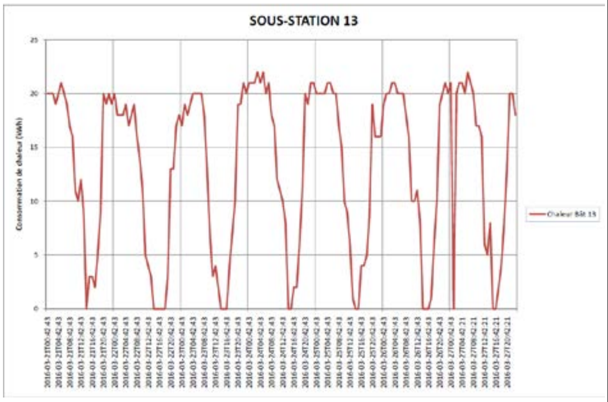
Figure 8-6 : Sketch of the DH structure of Nice pre-pilot in Côte d'Azur

Through the monitoring of the hourly energy and water consumptions of the boilers plant and the buildings sub-stations, the purpose of the pre-pilot was to identify optimization actions at DH and buildings scale. The pre-pilot was implemented during Q4 2014 and Q1 2015 and terminated in December 2017.

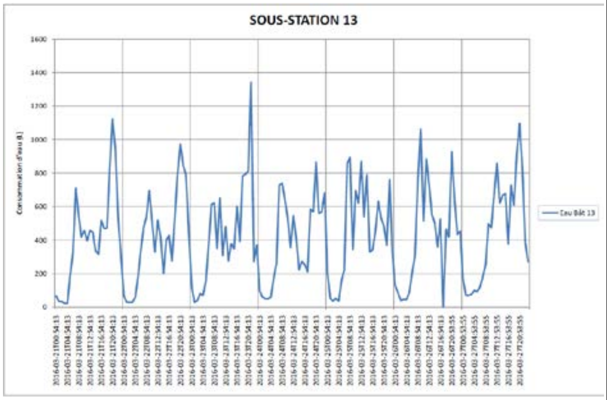
The data collected during the monitoring, which began in April 2015, were used:

- to simulate the thermal dynamic behaviour of the Les Moulins district buildings;
- to improve the efficiency of the DH and reduce the heat losses;
- to assess the impact of the retrofitting actions on these buildings and
- to assess the feasibility of heating distribution load curve optimization.

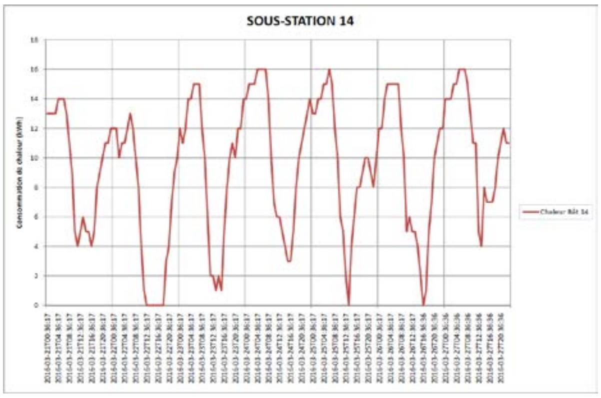
All the data collected since the beginning of the pre-pilot have not been analysed yet, as it is an on-going process.



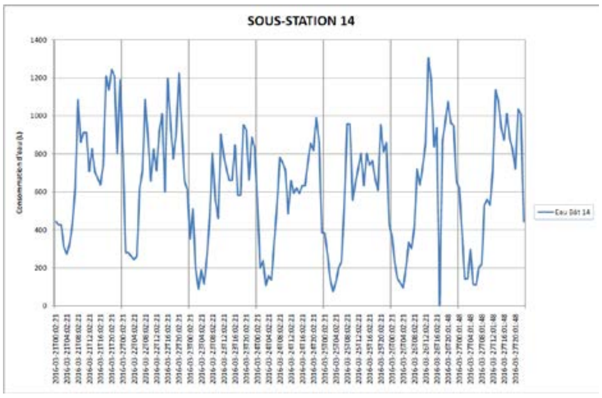
Tower 13 - Hourly heat (space heating and hot water production) consumptions from 21 to 27 March 2016



Tower 13 - Hourly hot water consumptions from 21 to 27 March 2016



Tower 14 - Hourly heat (space heating and hot water production) consumptions from 21 to 27 March 2016



Tower 14 - Hourly hot water consumptions from 21 to 27 March 2016

Figure 8-7 : Indicative space heating and hot water consumptions for Nice

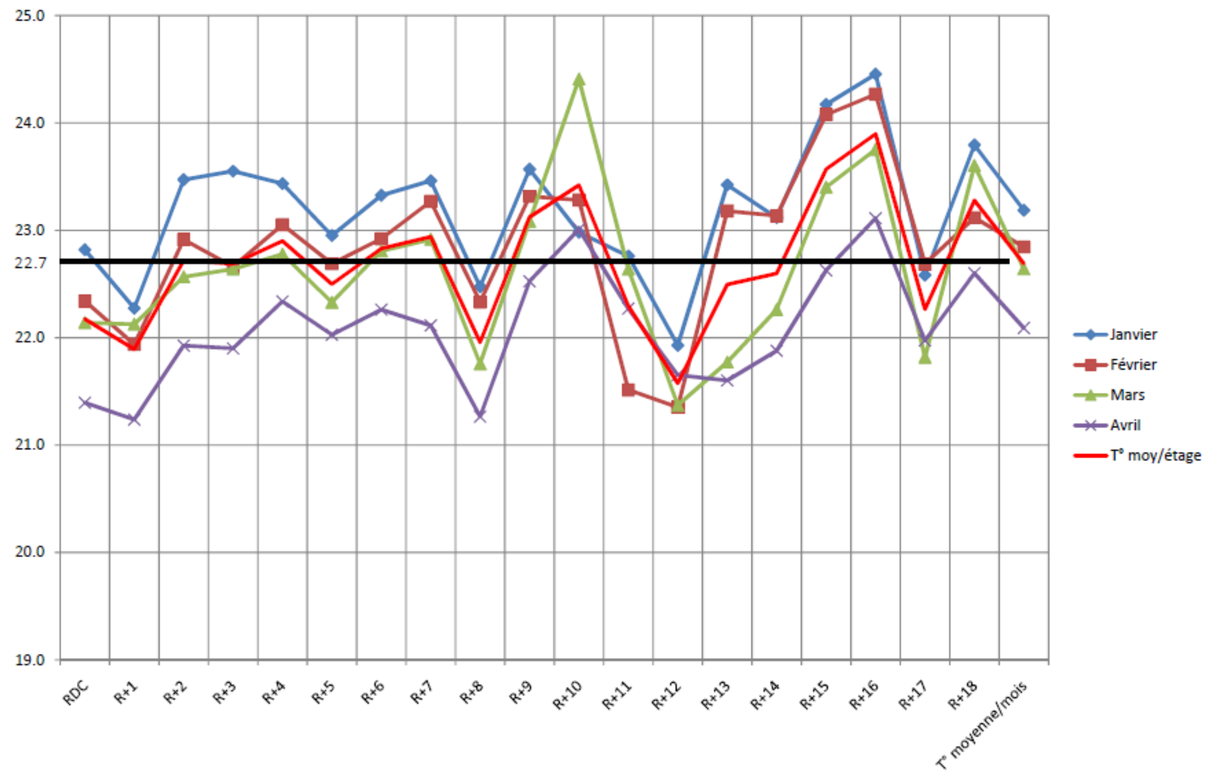


Figure 8-8 : Tower 31 – Average temperature per level and per month (January to April 2016)

8.1.2.1 Pre-Pilot Area and Geographical Overview

The pre-pilot DH is located in the Les Moulins neighbourhood, which is mainly composed of collective social housing buildings owned by Côte d'Azur Habitat.

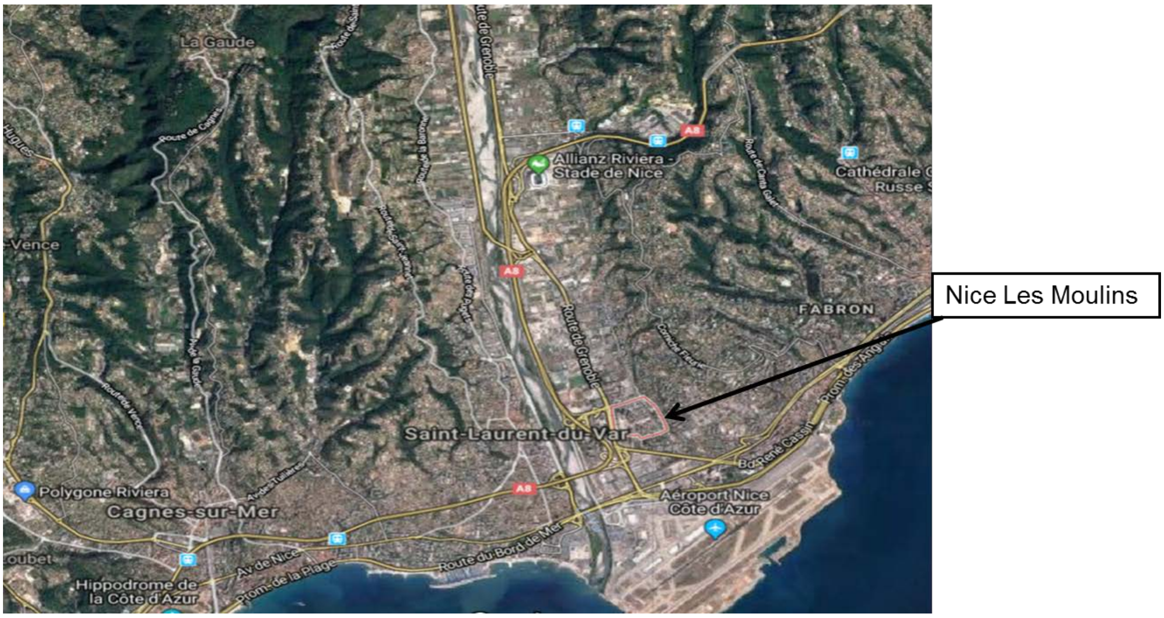


Figure 8-9 : The location of Moulins district in Nice

Figure 8-10 : The Moulins district

The following Table presents a detailed description of the different Components having been integrated in the past to form the specific Solution, along with their main technical specifications:

Main Component	Technical Specifications	Area of the pre-Pilot
Monitoring devices (followed by required specification and number of devices): 	The monitoring devices consist of Homerider 468 MHz radio heads implemented on existing energy and water meters: • 2 energy meter radio heads in the hot water boiler plant • 30 energy meter radio heads in the DH substations • 28 water meter radio heads in the DH substations	Les Moulins

Existing energy meters 	No available data yet.	Les Moulins
Several radio wave Homerider repeaters were installed in order to improve the quality of the radio signal 	No available data yet.	Les Moulins

8.1.2.2 Lessons Learnt by the implementation of the Solution in the Pre-Pilot

The project is still on-going, so there are no solid conclusions and lessons learnt yet. The data that is being collected throughout the undertaking of the demonstrations is awaited and require post-processing before being in position to deliver conclusions concerning not only the technical and economic performance of the DH solutions tested, but also the ability to make thorough retrofitting to a neighbourhood so as to accommodate such solutions.

Linked Projects: E2DISTRICT [20]

8.1.3 Gothenburg Pre-Pilots

In Sweden, heating demand is very high throughout the whole year. Gothenburg, has a climate of an average temperature just below 0°C in the winter and just above 20°C in the summer. This high heating demand made technology solutions like DH ideal. Moreover, geo-storage provides an opportunity to balance heating demand (in winter) with cooling demand (in summer). This is why the city council agreed to participate in research projects for the improvement and economic feasibility of such technology solutions. The two Use Cases tried in Gothenburg are listed below and are described thoroughly:

1. Smart management of heating and cooling on the campus area. Responsible organization is Akademiska Hus
2. Geo storage in LT DHN at Medical Campus. Responsible organisation is Akademiska Hus

Use *Case* #1: Smart management of heating and cooling systems at Campus Johanneberg – Topology description

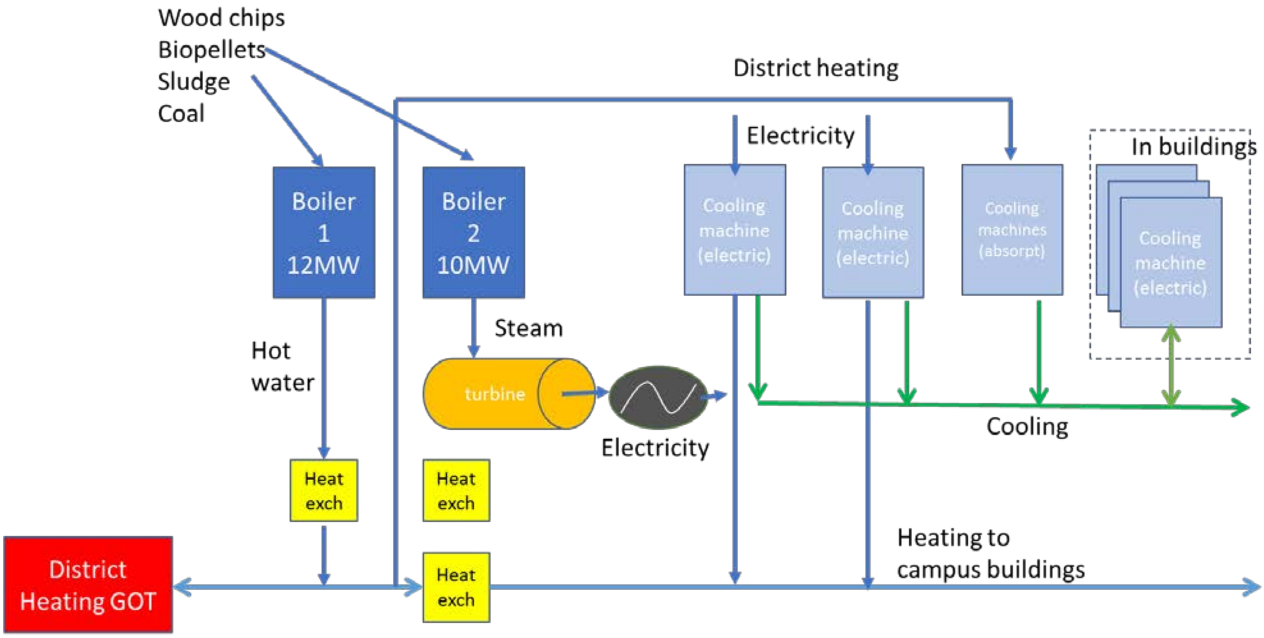


Figure 8-11 Schematic of Chalmers Power Central and the heating and cooling system

Chalmers Power Central is a combined research and production facility for heat, cooling and power generation on the Chalmers University of Technology Johanneberg Campus. The plant supplies the Chalmers campus area with heat, cooling, electricity, and compressed air. The campus area consists of some 50 buildings (for example lecture halls, laboratories, offices) with a total area of about 180 000 m^2 and is frequented by some 10 000 students and 3 000 employees.

The energy production is largely based on 2 boilers fired with wood chips, biopellets and HVO (Hydrogenated Vegetable Oils). The power station is primarily used for research purposes, and its waste heat is used to heat the buildings on the campus area. The campus area is also connected to Gothenburg's DHN in order to accommodate peak loads when the capacity of the Chalmers power central is insufficient. When research is not carried out, the boilers run according to supply the heat requirement of the campus.

Normally the heating season is between 1 Oct and 1 May. In research operations, the load is regulated by purchasing or supplying DH to Gothenburg city. For the cooling needs there are 3 heat pumps powered by electricity, supplying a local district cooling network DCN on the campus. When cooling, the heat pumps produce heat. Normally, all waste heat from the cooling heat pumps is recovered and fed into the campus heating system using heat exchangers in order to cover hot water demand. In summertime, the two absorption cooling machines provide cooling when the demand is high and reflux to the heating system is low. The absorption coolers are powered with excess heat supplied by the Gothenburg DHN. In summer, when heating demand is low, heat is still produced from waste incinerators. In the followings, some useful results are given:

- The energy performance of the building has been estimated at 62 kWh / m^2 year (Energy includes energy for; heating, hot water preparation, cooling via remote cooling, operational electricity and electricity for comfort cooling);
- The reference value for the corresponding building according to the new building requirement is 132 kWh / m^2 year;
- Statistical range of similar buildings according to the Boverket calculation is 76 - 110 kWh / m^2 year;

- Of the building's energy performance, electricity is 61 kWh / m² year;
- Share of energy in energy performance includes electricity for heating, hot water preparation, operation and electricity for comfort cooling) and
- Operations and household applications have been estimated at 35 kWh / m² year.

Figure 8-12 : Chalmers Power Central

The innovative aspects of the system include:

- Combination of commercial operation of power generation unit with research projects carried out on the plant itself;
- Combination of different energy sources to provide near energy autonomy of the campus area;
- Combination of heating and cooling, recovery of waste heat from cooling heat pumps that can be utilized as additional heat energy source;
- Use of “excess heat” from DHN to power absorption coolers in the summer

Figure 8-13 Chalmers Power Central on the Chalmers Campus

Use Case #2: Geo storage in low temperature heating system at Medical campus – Topology description

The heating and cooling demands of the Academicum building on the Medical Campus were supplied with the help of geothermal energy. The building was heated and cooled by heat pumps connected to a geo storage. The geo storage is a seasonal storage where heat is being extracted in winter and cold in summer. In winter the rock is cooled down and can be used as free cold in the summer. There are 11 boreholes, approximately 200 m deep and dispersed in an area of about 3000 m^2.

The building heating system, which consists of radiators and heating air-conditioners, was designed for a 55^{o}C supply temperature. Air conditioners have rotating heat exchangers with 80% efficiency. In the winter months when the average temperature is around 0^{o}C or below, the building is supplied with peak heating from the DHN return of an adjacent building.

The building's cooling system is supplied with free cold from the geo storage. At peak demand, cold can be supplied by the cooling heat pumps powered by electricity.

Figure 8-14 Academicum building on Medical campus connected to geo storage

The innovative aspect of the solution deals with using a LT heat flow return from the DH in an adjacent building to cover peak heating demand. LTDH can contribute significantly to a more efficient use of energy resources as well as better integration of renewable energy (e.g. geothermal or solar heat), and surplus heat (e.g. industrial waste heat) into the heating sector. LTDH offers prospects for both the demand side (community building structure) and the supply side (network properties or energy sources), especially in connection with buildings that demand only LT for space heating. The utilisation of lower temperatures reduces losses in pipelines and can increase the overall efficiency of the total energy chains used in DH. Additionally, the use of geo storage in boreholes provides a seasonal balancing of temperatures, whereby heat stored from the cooling in the summer can be extracted for heating the building in the winter season (Figs. 4.15, 4.16).

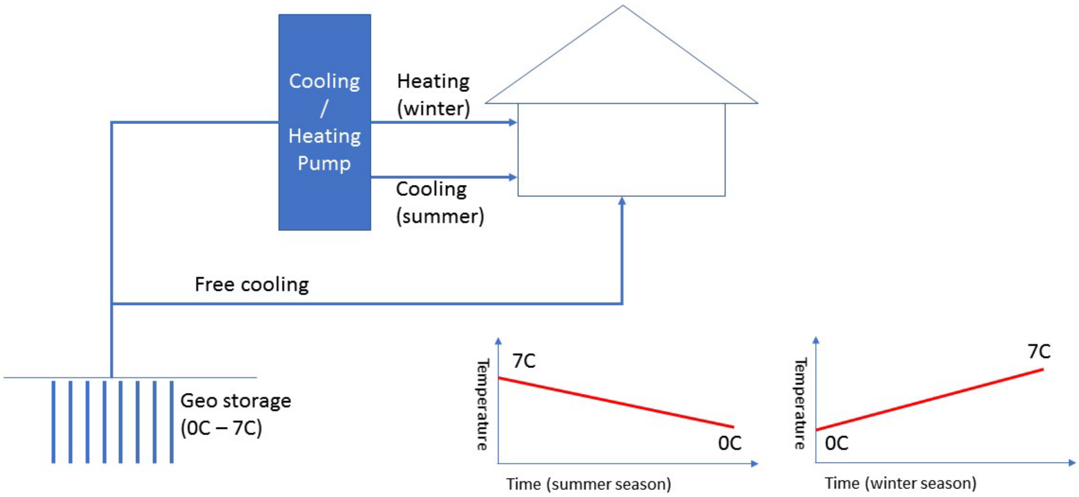


Figure 8-15. Simplified Schematic of Heating/Cooling System with seasonal storage

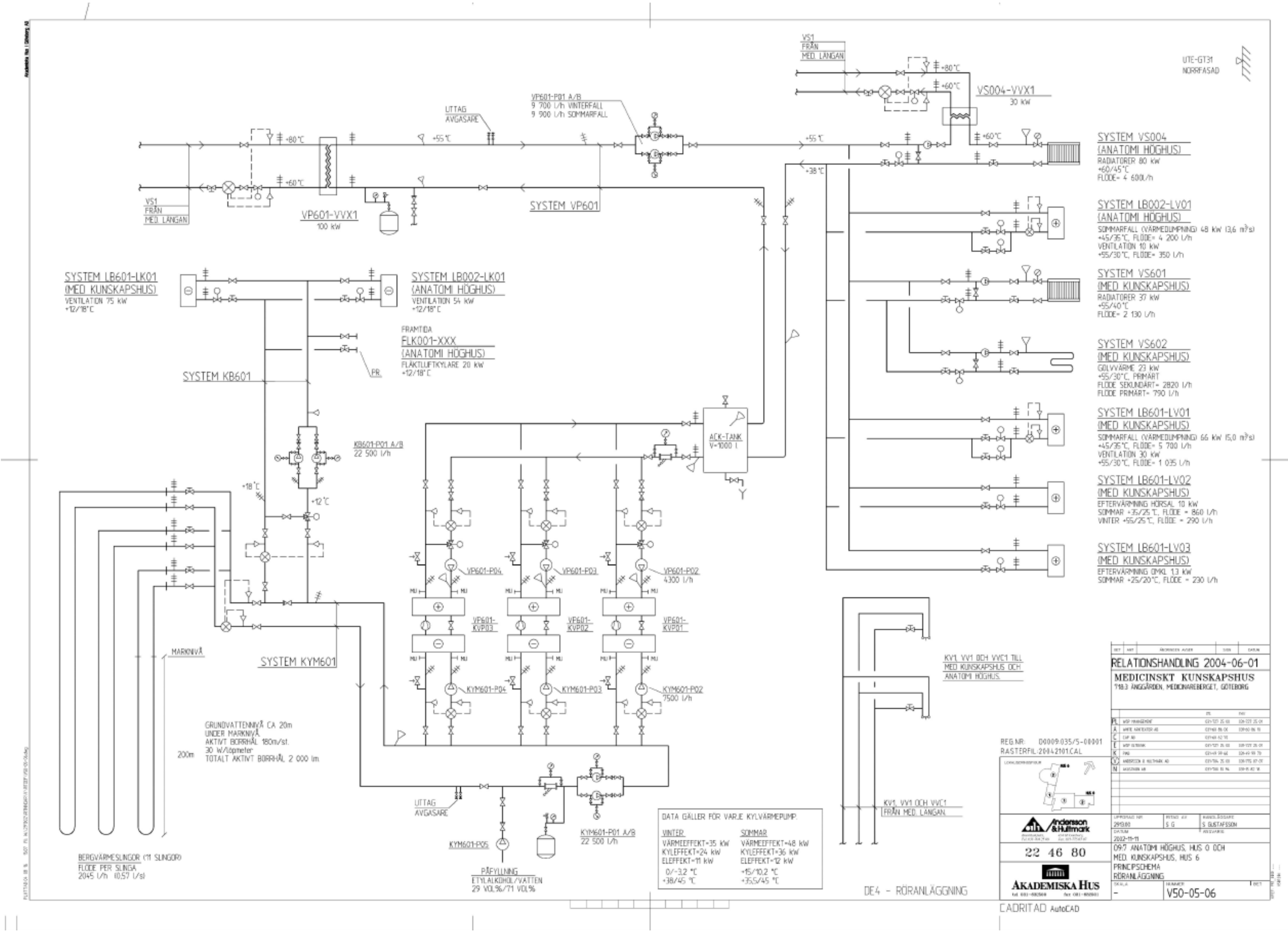


Figure 8-16 Schematic of Academicum heating/cooling/storage system

8.1.3.1Pre-Pilot Area and Geographical Overview

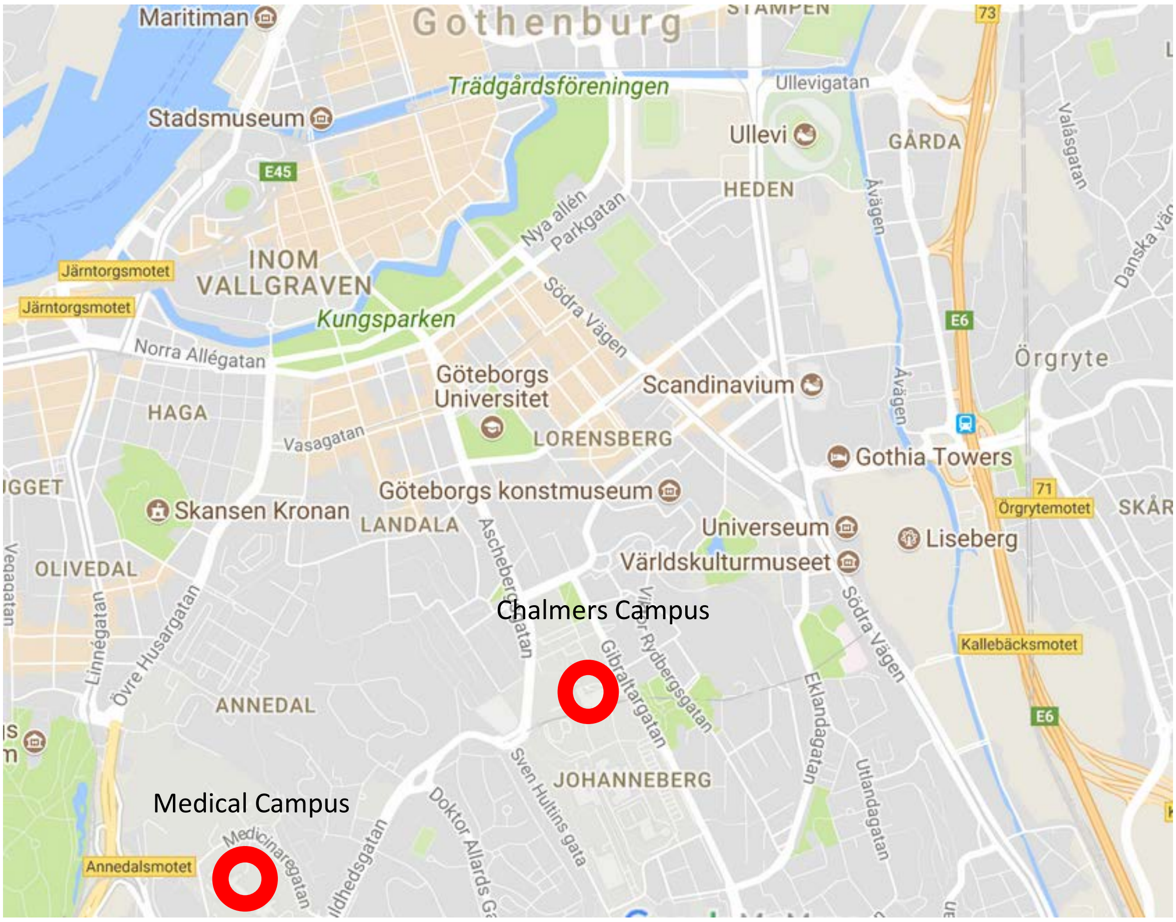


Figure 8-17 Location of the pre-pilots in the South Central parts of Gothenburg

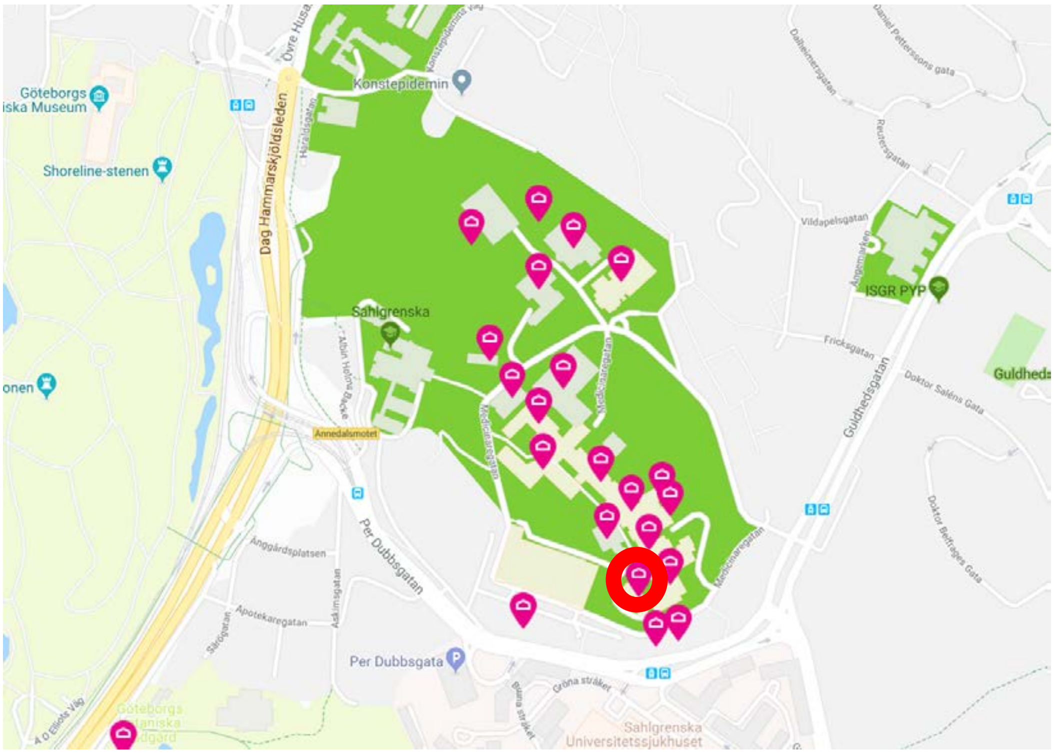


Figure 8-18 Location of the Academicum building on the Medical campus

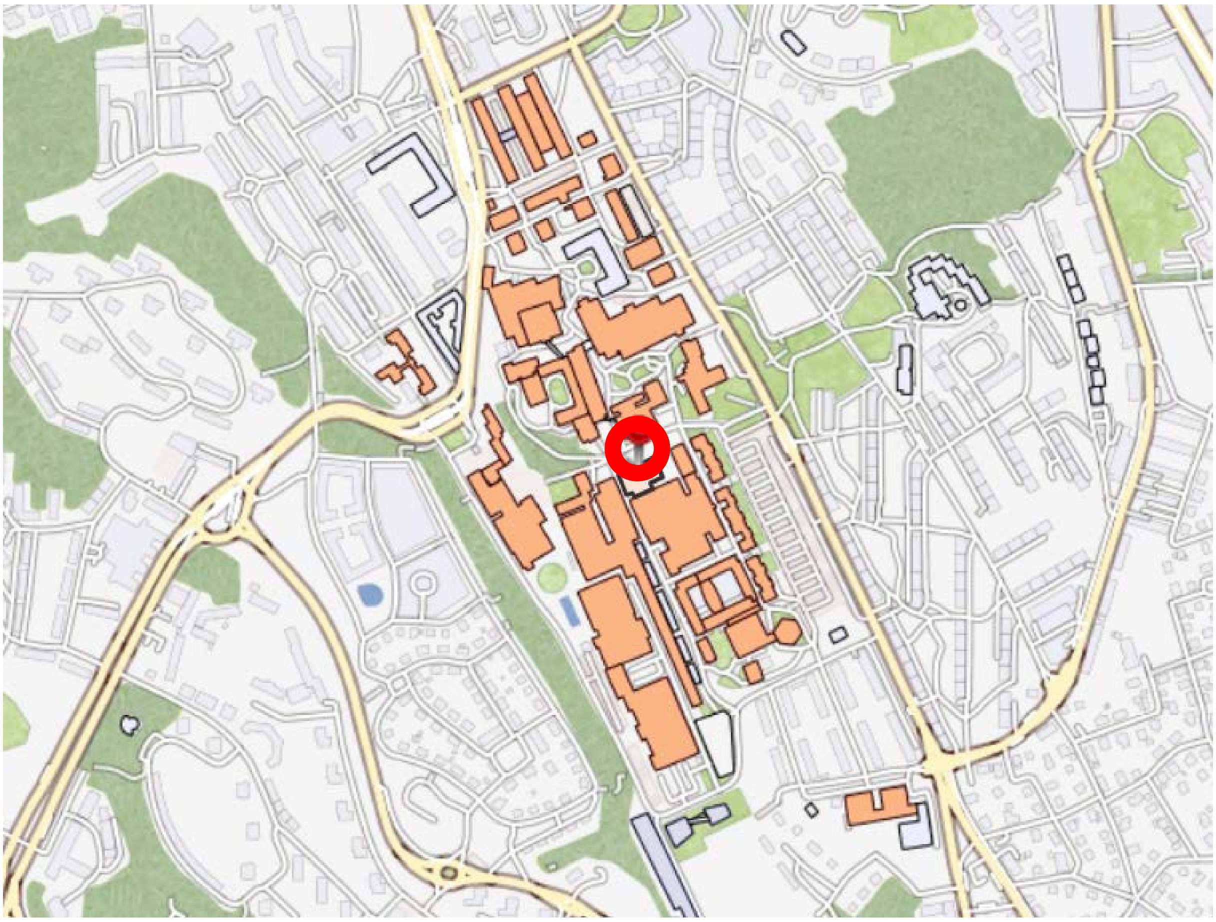


Figure 8-19 Location of Chalmers Power Central on the Johanneberg Campus

The following Table elaborates the currently available thorough information for each of the considered key innovative elements of the IRIS pre-piloted solutions. Whenever available, additional information along with more technical specification of the basic configured elements are as well provided, in order to allow a better understanding of the basic elements of the solutions:

Main Component	Technical Specifications	Area of the pre-Pilot
Pre-Piot Area #1: Chalmers Power Central on the Chalmers Campus (Johanneberg)		
Water boiler P1 (wood chips and biopellets**)**	Power: 8 MW 200/105°C Energy: approx. 19000 MWh/year	Chalmers campus area.
Adjoining flue gas condensor	Power: 1 MW 55°C Energy ca 3000 MWh/year	Chalmers campus area.
Steam boiler P2 (wood pellets and HVO**)**	Power: 6 MW 400°C 40 bar **Heat** Energy ca 6000 MWh/year heat **Electricity**	Chalmers campus area.

	1000 MWh/year electricity	
Cooling machine / heat pump 8-VKA 3	**Cooling machine** 800 kW heat, 1600 MWh/year **Heat pump** 500 kW cold, 1000 MWh/year	Chalmers campus area.
Cooling machine / heat pump 8-VKA 2	**Cooling machine** 800 kW heat, 800 MWh/year **Heat pump** 500 kW cold, 500 MWh/year	Chalmers campus area.
Cooling machine / heat pump 28-VKA-1	**Cooling machine** 800 kW heat, 1600 MWh/year **Heat pump** 500 kW cold, 1000 MWh/year	Chalmers campus area.
Heat pump 8-VKA 1	**Absorption cooling** 1100 kW, 1000 MWh/year	Chalmers campus area.
Heat pump 8-VKA 3	**Absorption cooling** 1100 kW, 1000 MWh/year	Chalmers campus area.
Peak heat, back-up heat by local utility (purchased by Göteborg Energi**)**	Power: 4 MW Energy: 3000-5000 MWh/year	Chalmers campus area.
Surplus energy supplied to the local utility (Göteborg Energi**)**	Power: 4 MW Energy: 3000-5000 MWh/year	Chalmers campus area.
PV	Approx. 16 kW, 13 MWh/year	facade
Geothermal Energy	Within the campus area there are two geothermal energy installations. The Chalmers Power Central is served by the ”Herrgården” geo storage installation	Chalmers campus area 1. JSP1 building 2. ”Herrgården Gibraltarvallen”
District cooling KB0	3000 kW, 5000 MWh/year Supply temperature 8-12^{o}C Return temperature 10-15^{o}C	Within the campus
District heating VP01:	13 000kW, 30000MWh/y Supply temperature 65-75^{o}C Return temperature 45-55^{o}C	Within the campus

Other ancillary equipment	**Pressurised air compressor** 8+10 m3/min 7 bar **Clean water production** 10 m^3/24h **Purchased electricity to campus excluding Vasa/JSP2 Teknikparken** 6000 kW, 32000 MWh	Chalmers campus area.
Pre-Piot Area #2: Building on Medical campus		
Building	Gross floor area:2287 m^2 Main usable area: 1765 m^2 Building constructed in 2004 **Total energy consumption 2017** 79,8 kWh/m^2 el. No peak heating **Operational energy consumption** 37 kWh/m^2 el.	Campus Medicinarberget Göteborg.
Geothermal site	**Number of bore holes** 11 approx. 180 m depth. **Winter case** Heating capacity: 144 kW, 45/38^{o}C Cooling capacity: 72 kW 0/-3,2^{o}C Electrical capacity: 11 kW **Summer case** Heating capacity: 144 kW 45/35^{o}C Cooling capacity: 108 kW 10/15^{o}C Electrical capacity: 12 kW	Campus Medicinarberget Göteborg.
Radiators and heating air-conditioners	Efficiency: 80%	Campus Medicinarberget Göteborg.

8.1.3.2 *Lessons Learnt by the implementation of the Solution in the Pre-Pilot*

<u>Use Case #1: Chalmers Campus</u>

- It is estimated that the property owner saves at least 2000-2500 MWh annually just by recovering the heat from the cooling heat pump;
- The cooling system has resulted in a saving of about 100 000 m^3 of water previously used for cooling purposes and

- The centralized layout of the heating/cooling system has proven to be economically profitable, resulting in both lower investment costs and less maintenance (fewer installations to maintain). Additionally, there is a greater degree of flexibility since additional capacity can easily be retrofitted in the existing installations.

Use Case #2: Medical Campus

It can be concluded that the building's energy performance is significantly better than most similar existing buildings and twice as good as the level prescribed by regulations. Some particular lessons have been learned concerning the use of bore holes and geo storage. These are:

- The ground should be analysed where the geo storage is to be established. A thermal response test (TRT) should be carried out to determine the ability of the rock to store thermal energy over time;
- It should be noted that a geo storage installation would make the area inaccessible for future construction works.

Linked Projects: HSB Living Lab [21], FED (Fossil Free Energy Districts) [22]

8.2 Demonstration in the Lighthouse Cities

8.2.1 Nice Demonstration

8.2.1.1 Use Case and Brief technical description

In Nice Meridia an energy master plan has been produced identifying geothermal energy (being a renewable energy source) the main source for heating and cooling for the district's buildings. A low-temperature fourth generation heating and cooling network should be deployed and connected to a geothermal plant. This district network will provide heat to buildings at a typical supply temperature of 50°C and the buildings will deliver heat to the DHCN, through a double-way substation, at a lower or same range temperature. The network should also refresh the building by a centralised cooling system. Electricity will be partly supplied by PV panels (20%) and will be used to partially cover electricity consumption of circulation pumps and decentralized heat pumps.

In 2013, the Public Planning Institution of the Eco Valley of the Plaine du Var, together with BRGM, launched a potential assessment study for the geothermal resources of the Nice Meridia sector. Aim was to cross compare the geothermal resources and the forecasted thermal demand of the area and identify the feasibility to launch a public call for tenders for a district/heating cooling network. The result was the following: the exploitation could attend a flow rate of up to 300 m^3/h, with an annual temperature range of 13-17°C, which are sufficient to cover 100% of the estimated heating, cooling and sanitary hot water demand of the area. What has not been defined, is the optimal arrangement between the sourcing and injection boreholes and the network topology to be deployed. Those are variable and depending on the source location and phasing of the network, what has been ensured are the techno-economic feasibility of the undertaking.

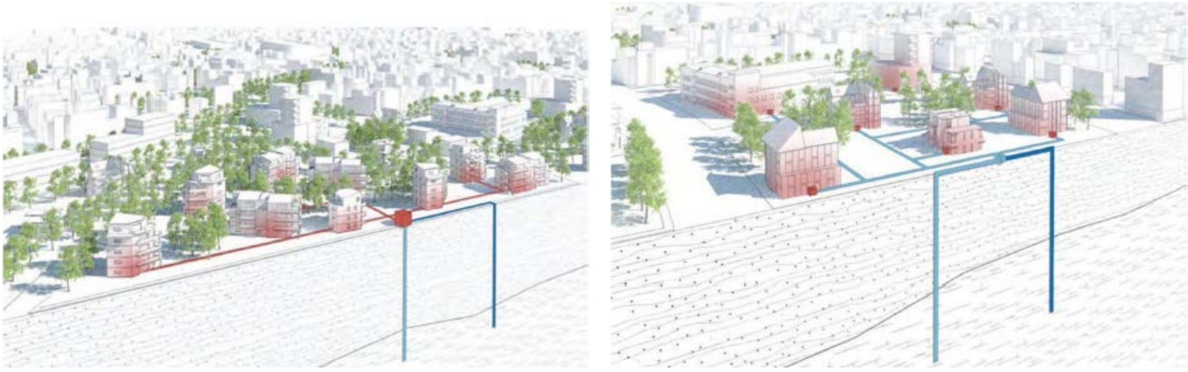


Figure 8-20 : Two possible solutions presented to the EPA : 1) Four pipe scheme of mid temperature district heating cooling network with centralized energy production (HP) ; 2) double pipe scheme of low temperature district heating/cooling network with decentralized energy production (building substation with HP) (source : BRGM/RP – 62578-FR)

For the realization of this network, the Metropolis of Nice Cote d'Azur has launched a call for tenders as defined within the French legal system (Art. L.2224-38 du Code Général des Collectivités Territoriales; art. 33, 57, 58 and 59 of the Rules of the Public Market – "Code des Marchés Publics"), opting for a "Delegation of Public Service" model, a specific type of public contract. This model can be resumed as a BOT (Build, Operate, Transfer) model, where the public authority remains infrastructure owner and exploitation and works are delegated to a private company under a certain concession duration (typically about 15-20 years). The main advantage of this model, besides ensuring the district energy system can be "classified" by local authorities, so identifying a perimeter where the connection to the system is mandatory, the public authority can define the technical, functional and financial boundaries of the endeavour.

The particularity of the Nice Meridia case, is the introduction of "smart grid" services. This means, among the specifications of the call, that the participants were asked to integrate in their overall business plan, the development of smart grid services for the district. Main aim was hereby assuring a global optimization of the district (both thermal energy and electricity). Moreover, services should be provided which would ensure a correct integration of renewables, a maximization of on-site consumption, services for energy efficiency and an overall grid flexibility approach.

As by French law, the heating sector is well regulated so, providing for both operator and users, a framework for the connection obligation and associated heating/cooling provision pricing and taxing mechanisms. However, this is not the case for the "smart grid" services and related specifications as integrated in the call for tenders. The electricity retail and other related services, are not included in such regulatory framework and have to agree to the wider national law and regulatory system. It has to be understood that future customers will be obliged to connect to the DHCN but, will not be obliged to subscribe or engage in any of the smart grid related services. This remains a commercial and private endeavour of the DHCS operator and open to competition. Nevertheless, by defining such functional and technical specifications within the call, it should be ensured that the operator will be able to have a global approach concerning the local energy mix and provide added value services to the wider community, in line with the expectation of the public authority.

The public call for tenders has been initiated in 2016 (closing 2nd semester 2017) and it is expected that the result will be made public by mid-2018. Therefore, no detailed information about its content can be disclosed at this time being.

8.2.1.2 *Demonstration Area and Geographical Overview*

Within the West territory of the Metropolitan area of Nice, a big urban undertaking is on the way. The state and the local authorities, after a shared diagnosis on the status and potential of the western territory of Nice, decided to design together a new territorial project. At the initiative of the Mayor of Nice, Christian Estrosi, the state has put a lot of resources at stake: it has made the area one of the “Operations of National Interest” (OIN) of France, with sustainable development as a guideline. The perimeter of this undertaking is the so called “Nice Eco Valley”. He entrusted the “Public Establishment for Development (EPA) of the Plaine du Var” with the implementation of this ambitious project. Ambitious because global: while proposing a new model of planning and urban planning, economics and ecology have to be combined. It also aims, for the 30 years to come, to modify in depth the economic structure of the metropolis, the modes of displacement and habitat.

Figure 8-21: Contextualisation of the demonstration area (bottom image) compared to iconic historic centre of Nice and its port (top image) – source Google Maps and © EPA / Mateoarquitectura

Figure 8-22 : Localisation of the development district and the two demonstration sites of IRIS, Nice Meridia and Grand Arenas. On the bottom right the Nice Airport. (Source: EPA plaine du Var)

Nice Meridia

High priority operation of the eco-valley, the technological pole of Nice Meridia will have a first development area of 24 ha or 360 000 m^2 of new mixed use floor-area, with the objective to achieve 200 ha in the long term.

Its location and its mixed used program will make it an outstanding eco-district, aiming at providing high quality living and working conditions. Its vocation is to be a catalyzer of innovation, thanks to its dedicated R&D and educational spaces with a vocation to attract businesses and institutions dedicated to technology and services from the sustainability and health care branches. This target should be achieved by first attracting public and private R&D and innovative organizations which should self-reinforce themselves by speeding up the developments of incubators, start-ups, co-working spaces and business centres among other.

Aiming at functioning as an "eco campus", the development program wants to enable short circuits between knowledge and innovation. With such aim, the IMREDD and the CEEI (European centre for businesses and innovation) have been opened on the site, promoting innovation and the creation of businesses related to the sustainable development and "green" technologies.

The leitmotif of the land use and transport organization is "accessibility": this should enable to provide an integration of offices, commerce and housing areas among the districts, as well as access to services connected to the sport centre situated in the same perimeter.

The first development phase will not only be centre among a mixed use and accessibility oriented development, but also aim at being a precursor in terms of renewable energy. Therefore, a public call for tenders has been put in place to develop a geothermal LT DHCN. The call for tender further integrated the notion of smart grid services which the foreseen SPV will have to consider in their development targets.

Figure 8-23 : Land use plan of the Destination Meridia project (Source: D&A - Devillers et Associés)

Figure 8-24 : East to west bird eye view of the Nice Meridia area (Source: EPA plaine du Var)

Figure 8-25 : Méridia tower by Sou Fujimoto Architects (Source: worldarchitecture.org)

8.2.1.3 *Objectives, Needs and Opportunities to be served by the implementation of the Solution in the Demonstration*

As being the undertaking still under tendering process, no specification can be given is specific manner and it might change depending on the outcome of the process.

Opportunities	Needs
Increase the penetration of RES in the district through a global approach	Optimize the energy mix of the district, by integrating the notion of RES (geothermal, PV and others) and associated services, coupling a DHCN and smart grid services. This should ensure that the district will have a high share of renewable energy (+65%) and at the same time, a long term visibility on energy pricing for the end users.
Renewable energy sourced district energy network	Achieve 70-80% share of the final delivered thermal energy from the shallow geothermal source. By this mean, the end consumer could ensure a long term visibility on the energy pricing and hedge against fluctuating or increasing electricity pricing, as representing only 20 to 30% of the final bill.
Software Equipment	The call for tenders asked for a “centralized operation system”, which should combine both the optimal operation of the geothermal DHCN and the provided services. The upper value for the public authority, is that after the BOT contract or Service delegation termination, the community will see a transposition of an operating system which is tailored and optimized to the existing district.

8.2.1.4 *Key technical components*

Hardware:

Main Component	Technical Specifications	Area of the pre-Pilot	IRIS partner
Heating/cooling production and distribution	Shallow geothermal energy source, coupled with semi- or de-centralized substations equipped with reversible HP (cooling + heating) and SHW production. Temperatures will have to be ensured to be +60°C for the SHW, whereas the heating and cooling production depending on the technical choice of the operator to be assigned. Source temperature is at an annual range of 13-17°C.	Nice Meridia	NCA > operator resulting from the Call for Tenders
Storage	Depending on the technical choice made by the operator to be assigned (water tanks and/or ice storage). Short term storage systems seem to be appropriate (daily management load).	Nice Meridia	NCA > operator resulting from the Call for Tenders
Other renewables	The current construction projects have a target of a share of about 20% of the electricity production on site to be produced by renewable energy.	Nice Meridia	No engagement for any IRIS partner

Hardware:

Main Component	Technical Specifications	Demonstration Area	IRIS partner

Smart Meters	In France, all new buildings should be equipped with the Linky Smart Meters	1 per client	ENEDIS
Smart Energy Management System (SEMS)	The specification will depend on the technical choice made by the operator to be assigned.	Nice Meridia	NCA > operator resulting from the Call for Tenders

8.2.2 Gothenburg Demonstration

8.2.2.1 Use Case and Brief technical description

Use case #1: Chalmers campus

At Chalmers campus Akademiska hus (AH), there is an office building called AWL (Earlier JSP2). AWL building will be the AH centre of innovation project.

Akademiska hus will build a phase change material (PCM) for cooling storage in AWL. Project will be conducted in two subsequent phases:

Phase 1: Demonstration with a PCM storage of 375 kWh.

Phase 2: According to the results of **Phase 1**, the plan is to continue with a demonstration of a PCM storage of 1700 kWh.

The PCM that will be used is salt (Rubitherm SP21EK or similar). The discharging output Temperature is 16°C, providing 75kW for 5 hours with a flow rate of 4.5 litres/sec. The charging input Temperature is 8.5°C absorbing 45kW for 9 hours with a flow rate 4.2 l/sec. The PCM storage will be connected in one of the two alternatives presented in Figure 8-26, Figure 8-27.

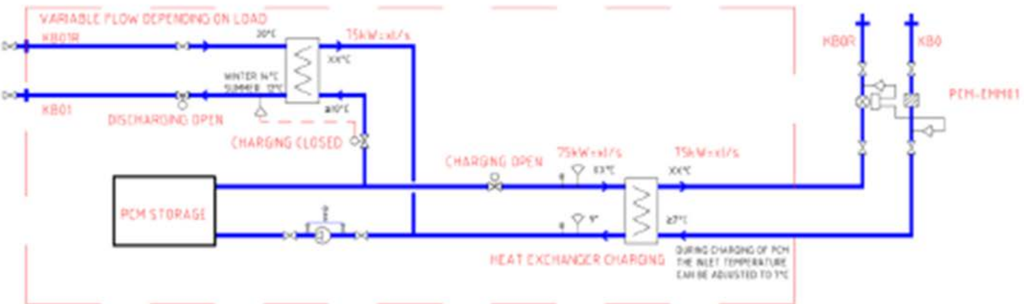


Figure 8-26 : The TES serves the KB01 system directly and delivers temperatures suitable for the KB01 cooling system (Alternative 1)

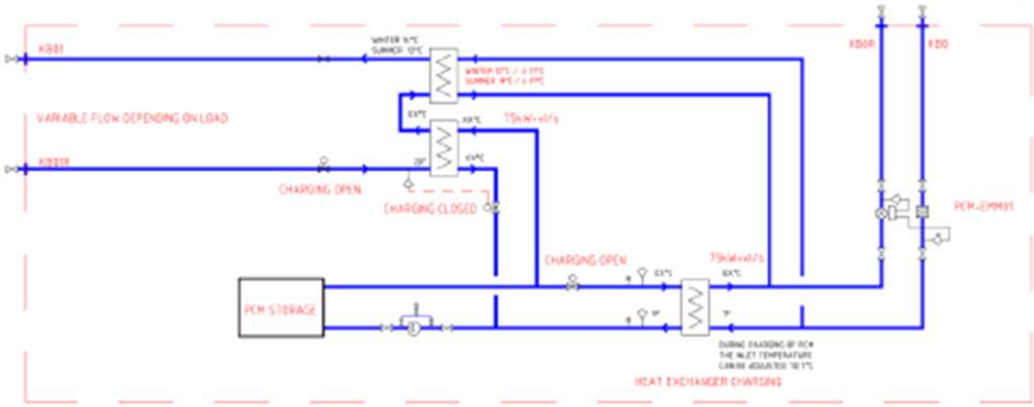


Figure 8-27 : The TES serves as a pre-cooling system for the KB01, and the KB0 system will cool to the remaining temperature difference (Alternative 2)

Use case #2: Riksbyggen Viva (Viva Housing Association group of buildings)

Gothenburg has a 45/30°C DHCN planned for the six buildings in Riksbyggen's sub-district. This will be supported by a shallow geo energy solution with 19 boreholes at around 230 m depth where the boreholes also are used as long term thermal storage and to cool nearby office buildings in summertime. The reasoning behind choosing a LT system is primarily twofold. Since the main part of the heating demand of the apartments is satisfied by the borehole heat exchanger, rather than DH, which is the most common solution for similar applications in Gothenburg, most of the hot water that is moved between the buildings is heated by the heat exchangers, and using a lower supply temperature to the individual buildings relieves some of the effect demand on heat exchangers. Additionally, the topological situation on site, calls for the piping to be drawn fairly shallowly between the individual buildings in Viva, and thus, in colder surroundings than would have been in a deeper underground distribution system. At least during the heating season. A lower supply temperature means a smaller temperature difference between the medium and the surroundings, resulting in smaller heat losses during distribution.

The long-term heat storage planned for the boreholes has its origin in the observed neighbouring office building with cooling demand, which of course occurs during the warm periods of the year. In a future energy system that is robust and flexible, energy can be traded between buildings in pairs. This project demonstrates and evaluates a system which transfers heated cooling water from an office building to a borehole in a residential building. The boreholes are part of the residential buildings heating system. Cold water is then transferred from the boreholes to the office building where it is used to provide a more comfortable and cool indoor environment.

The aim of the use case is to demonstrate, evaluate and communicate the aforementioned system to the Swedish and European market. The system is built during 2018-2019, and monitoring and evaluation will be done during 2019-2021. For this type of energy exchange, it is easy to see a relatively broad range of applications. There are many places that has, or will have, residential buildings with heat pump solutions close to office buildings with comfort cooling. Therefore, the replicability potential of such a system can be considered as quite high. Additional funds to cover depreciation cost not included in IRIS, might be retrieved form the application to the Swedish Energy Agency's program for energy efficient housing and construction, named E2B2.

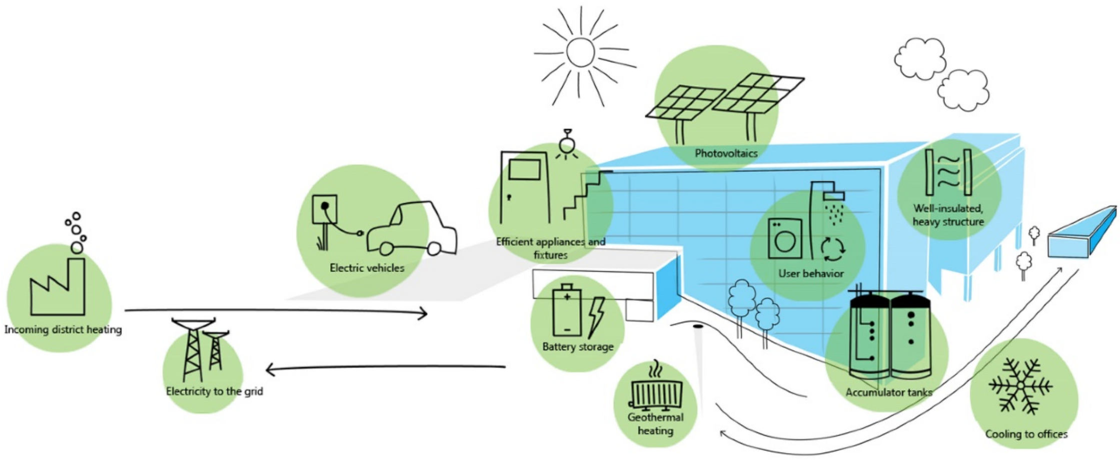


Figure 8-28. The components of the flexible energy system in Riksbyggen's housing association Viva, including how energy is being traded for cooling of the neighbouring office building.

8.2.2.2 Demonstration Area and Geographical Overview

Use Case #1: Chalmers campus

In the campus area of Johanneberg a local integrated DH/DC system will be operated, where shallow geo energy, long and short time heat storage as well as cooling storage will be integrated. Chalmers plans to build a PCM pilot facility (Phase 1) inside the JSP2-building in order to test different ways of storing energy for cooling purposes. The storage can be "centralised" in the building and energy for cooling can be redistributed.

Use case #2: Riksbyggen Viva

The demonstration area is the Riksbyggen's brf Viva, situated next to Chalmers campus Johanneberg.

Figure 8-29 : The Chalmers campus

Picture 8-30. A bird view of the housing association Viva

Picture 8-31. One of Viva's pairs of buildings as seen from the upper servicing road. N.B. the lack of parked cars.

8.2.2.3 Objectives, Needs and Opportunities to be served by the implementation of the Solution in the Demonstration

Use Case #1: Chalmers campus

A challenge is to find a good supplier for the PCM, to match the PCM with the respective temperature levels. The project will also find out which solution will work best for the PCM installation, encapsulated or bulk PCM with heat exchangers.

Opportunities	Needs
Benefits from PCM	To store cooling capacity in low cooling demand and release it when the cooling demand is large. Can also use it for storing at low price energy time, and use it during high cost energy time.
Storage	Storage available to feed the cooling system in the AWL building. Charging with the Campus cooling system and diischarge to AWL building. PCM storage material will be salt.
DHN fault detection and diagnostics	To reduce OPEX and minimize the risk for being set out of order. Increase operating hours.
Software Equipment	PCM will be connected to AWL control system and FED systems

Excess heat will not be removed from the energy system by cooling it off, but rather stored for future utilisation, resulting in overall energy savings. This, in turn, will lower the need to purchase heat from the DHN. This trading will extend the service life of the existing cooling machines in the office building, postponing the need for reinvestment. Additionally, it will provide a source of income for the association, money to be spent as collectively decided by the residents.

Use case #2: Riksbyggen Viva

Opportunities	Needs

Benefits from available geothermal energy as a RES source	Increase further the penetration of RES on a district level for covering the citizens' heating/cooling needs.
Storage	Store available excess of energy for heating purposes.
DHN fault detection and diagnostics	To reduce OPEX and minimize the risk for being set out of order. Reduce operating hours of cooling machines.
Software Equipment	Smartening the DHCN microgrid through the SEMS.

8.2.2.4 Key technical components

Hardware:

Main Component	Technical Specifications	Area of the Demonstration	IRIS partner
Heat Source	i) Downhole heat exchangers using 19 boreholes ii) energy trading, iii) DH, iv) passive heat gains.	Viva Housing Association group of buildings	Riksbyggen, Göteborg Energi,
Type of storage	Seasonal recharging in boreholes, short term storage in accumulator tanks and somewhat in the structural thermal inertia	Viva Housing Association group of buildings	Riksbyggen, Göteborg Energi,
Heating network operating temperatures	45 °C supply, 30 °C return	Viva Housing Association group of buildings	Riksbyggen, Göteborg Energi,
PV for feeding the electric load required by auxiliary equipment as heat pumps	140 kWp roof-top solar PVs	Chalmers campus	
Auxiliary Equipment	Heat pumps for the boreholes in a joint energy generation station as well as for SHW in each pair of buildings.	Viva Housing Association group of buildings	Riksbyggen, Göteborg Energi,

Smart metering:

Main Component	Technical Specifications	Demonstration Area	IRIS partner
Smart Meters	For heating, drinking water and electricity on household level.	The 132 households in Viva	Riksbyggen, Göteborg Energi,
Smart Energy Management System (SEMS)	Software to coordinate the energy flows for several plausible service cases.	Viva Housing Association group of buildings	Riksbyggen, Göteborg Energi,

8.3 Replication Planning in the Lighthouse and Follower Cities

8.3.1 Utrecht Replication

Local project partner Eneco is currently examining the feasibility to utilize the heat produced at the waste water treatment plant in the adjacent area of Overvecht in Utrecht, after first pumping its temperature up to 70°C. (See map of the location of the area in the section on replication for solution 1.2)

8.3.2 Nice Cote D' Azur Replication

8.3.2.1 Use Case and Brief technical description

Shallow geothermal DHCN for thermal energy, needs provision. Other energy sources could be used, as sea water or waste heat recuperation from industrial or public processing plants (as for e.g. Waste Water Treatment Plant). The business model of the system operator, should enlarge its scope towards a district level approach and embrace also smart grids and associated services. Yet it has to be identified, in how far this represents a viable business model. The return of experience from the operator to be assigned by the call for tenders will define if such auxiliary services concerning energy efficiency and energy services will be an added value and possible in the local scale (so not depending on the national marketplace).

8.3.2.2 Replication Area and Geographical Overview

It could be foreseen to extend this type of approach to the second phased developments of the Nice Méridia urbanization project or within the wider territory of Nice Eco Valley.

Figure 8-32 : Contextualization of the existing urbanization project within the long term plan.

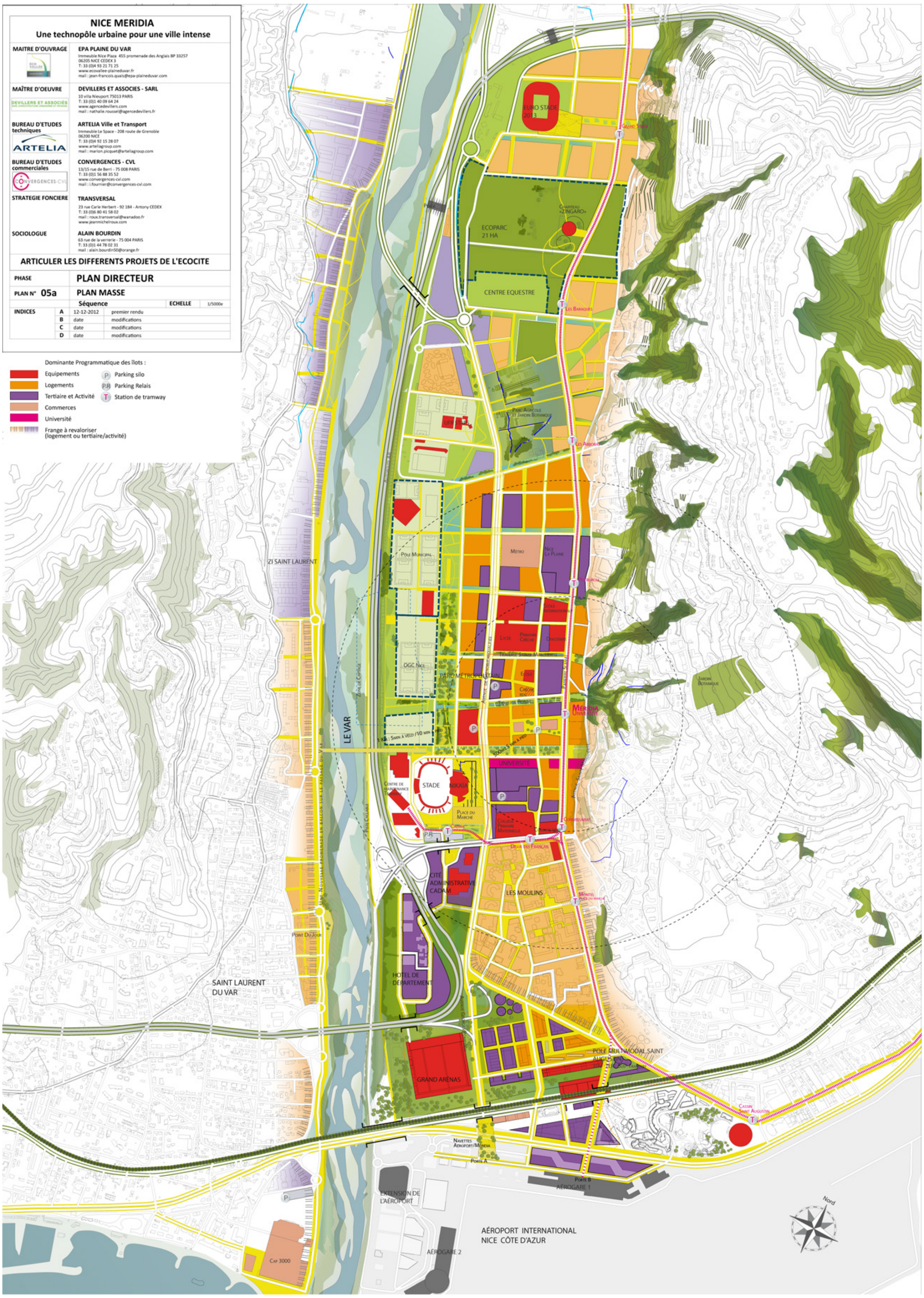


Figure 8-33 : Master plan of the 200 ha area (source : D&A – Agence Devillers).

At present date, the Nice Méridia urbanization project covers about 26ha, representing a first phase among the wider 200 ha project, for which a high level master plan has already been developed. The latter does not yet provide a fine grain land use planning or phasing, nor identifies major energy infrastructure or energy related actions. The area will be a prolongation of the current development project; however, a higher housing share is expected to for the long term overall program. Surely the call for tenders to be launched will have to consider the local characteristics of the construction site to be defined. The technical, functional and financial specifications, will depend on the construction program mix (housing, commerce and businesses, industry) and the availability and characteristics of the geothermal heat source. An overall potential assessment study of the geothermal source is available on the whole Nice Eco Valley area. The specific construction programs are not defined yet.

As a further replication area, the greater Eco Valley area can be targeted. The project has to be seen in a long term perspective, aiming at a strong territorial mutation and revitalization. Its developments will be divided into further urbanization phases and related construction programs. Yet, the projects to come are not defined, but the whole area will be developed under the same objective of sustainable development, driven by innovation and green technologies. This whole area, represents a potential pool of 3 000 000 m² of new constructions and developments. A Spill Over effect could be expected, fostering an adoption of the solutions which have proven their upper value in the first demonstration projects.

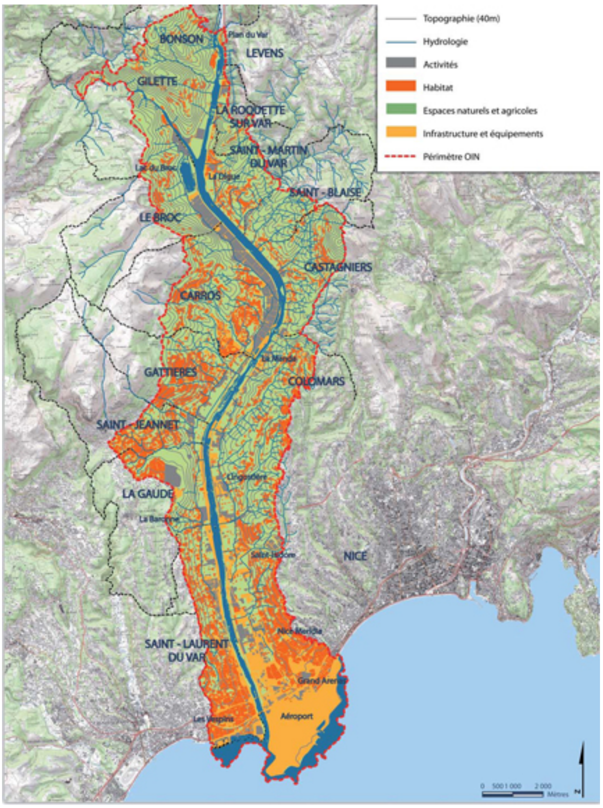


Figure 8-34 : Perimeter of the Nice Eco Valley project : a territory with potentially up to 3 000 000 m² of new constructions.

8.3.2.3 Objectives, Needs and Opportunities to be served by the implementation of the Solution in the Replication

Opportunities	Needs
Achieve environmental targets set by city administration	By the potential wider development and spread of this type of solution, a consistent contribution in achieving the environmental targets could be achieved. The public authority has set clear objectives in terms of renewable energy penetration in the energy sectors and related targets on CO_2 emission reduction as well as air pollution reduction.
Identification of viable connection and retail tariffs	Thanks to the first demo project, better understanding will be gained for the trade-off between the overall business model and the connection and energy retail tariffs to be charged to end users. Interest of the public authority is here to serve to the public good and at the same time, ensure a reasonable business model for the operator. Due to the specificity of the Mediterranean region, this model has not yet been enough applied.
Combining heating network operation and smart grid services for Smart Cities	The demonstration will provide the first endeavour where such an approach has been tested. In case the overall business model will not be depending only from the network operation, but have consistent revenue streams (about 10%?) from smart grid and energy services, a wider and durable adoption of Smart Grid technologies can be expected. It should enable thus to create a self-reinforcing mechanism which favours an adoption of renewable energies, smart grid equipment, innovative H/B/EMS and non-conventional mobility means.

8.3.3 Gothenburg Replication

8.3.3.1 Use Case and Brief technical description

Low temperature district heating (LT DH) has significant advantages over standard temperature heating in terms of reduced thermal loss and improved efficiency. LTDH can contribute significantly to a more efficient use of energy resources as well as better integration of renewable energy (e.g. geothermal or solar heat), and surplus heat (e.g. industrial waste heat) into the heating sector. LTDH offers prospects for both the demand side (community building structure) and the supply side (network properties or energy sources), especially in connection with buildings that demand only LT for space heating. The utilisation of lower temperatures reduces losses in pipelines and can increase the overall efficiency of the total energy chains used in DH. However, it also entails drawbacks, such as increased installation costs and increased use of electricity to power heat pumps. Overall, in locations where there is already a well-functioning and adequate LT DHCN is rarely seen as an attractive alternative. Situations where LTDH is a viable alternative necessitate that:

- There is a large supply of low-grade heat (e. g. from industrial processes, solar or geothermal heat) and
- There is none or insufficient DH already available.

Gothenburg has a well-developed DH network, largely powered by non-fossil fuels. This means that in most cases, LTDH is not chosen for new installations when considering the business case involved. One property owner, who is currently weighing the pros and cons of a LT network is Akademiska Hus, who is developing the Gibraltarvallen area on the Chalmers campus, currently used as a parking lot. Akademiska Hus is looking at several possible alternatives, including the recently launched Ectogrid™ system from E.ON. Ectogrid™ uses a variable LT feed to provide both cooling and heating (using heat pumps) for DHCN.

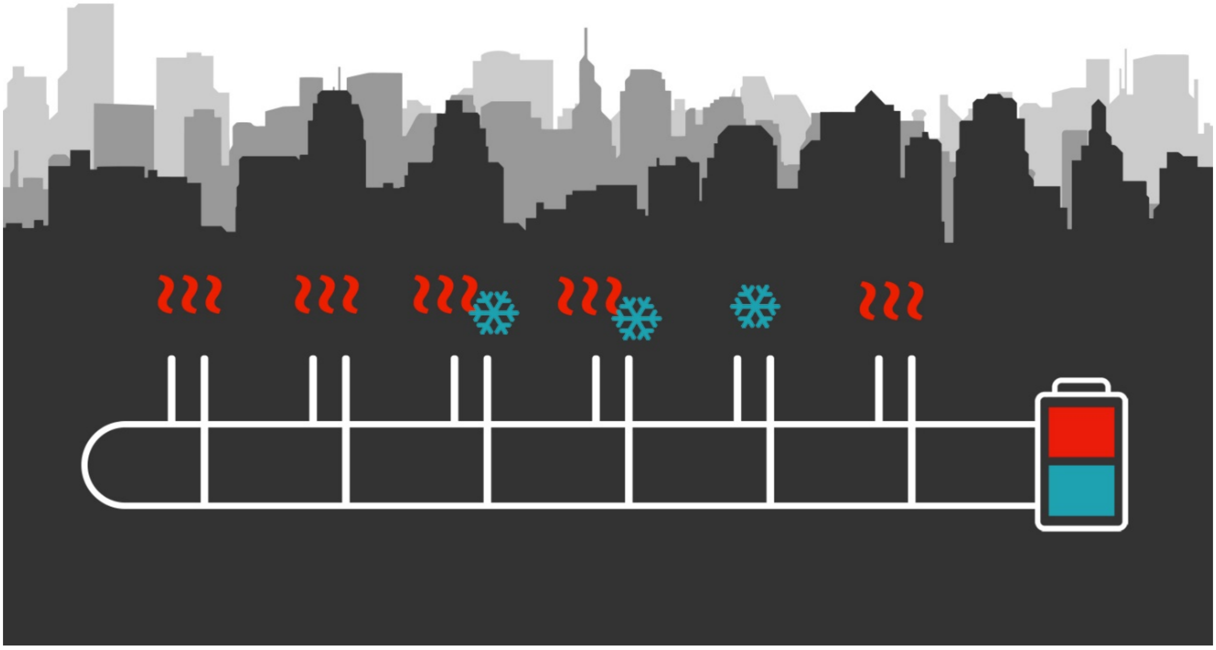


Figure 8-35. Ectogrid(TM) schematic (Picture E.ON)

8.3.3.2 Replication Area and Geographical Overview

Gothenburg is planning to replicate the district heat integrated system in the Campus area and the new districts in the city with low-energy buildings, such Lindholmen and Frihamnen.

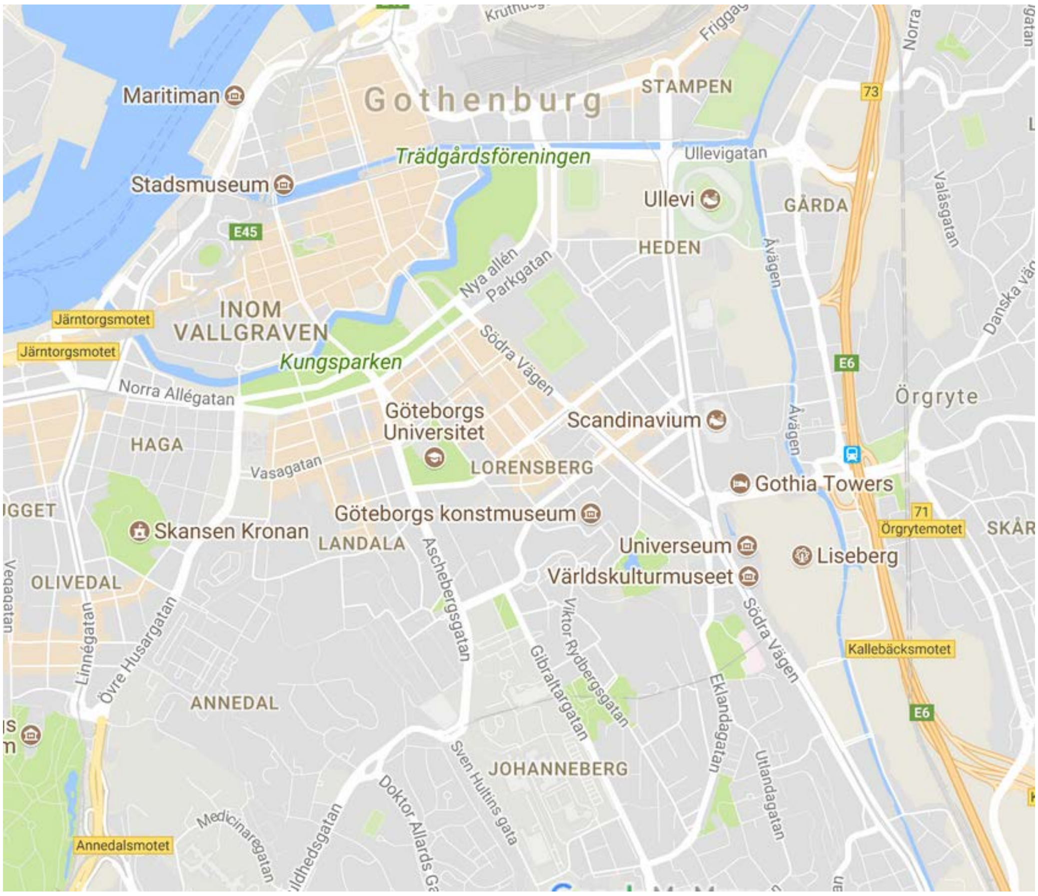


Figure 8-36. Chalmers Campus Johanneberg in Gothenburg

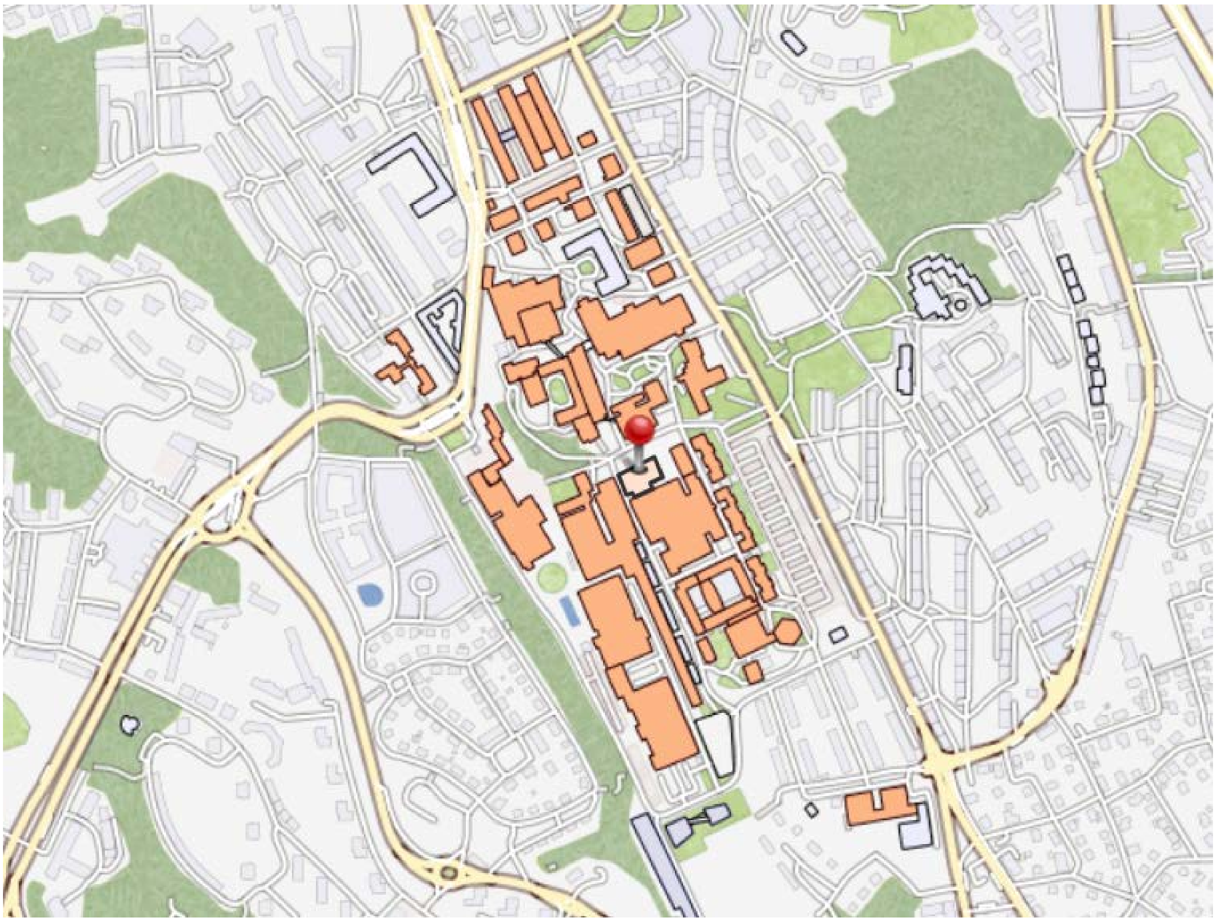


Figure 8-37. Location of Gibraltarvallen on the campus

Gibraltarvallen is a former sports ground that was incorporated with the Chalmers university campus in the late 1950s and converted to parking lots. In the planning document from 2013 the City of Gothenburg decided that Gibraltarvallen should be developed as a new district with housing, offices and student accommodations, erasing the border between the city and the campus and creating a city feel in the adjoining street Gibraltargatan. Akademiska Hus will develop about 120 000 m^2 in this new district.

8.3.3.3 Objectives, Needs and Opportunities to be served by the implementation of the Solution in the Replication

Akademiska Hus is the main property owner on the Chalmers Campus, and operates the DHCN for the area. The new Gibraltarvallen district would be connected to the existing heating and cooling system. The European company E.ON has developed a system called Ectogrid™ that is being investigated as a possible solution.

A LT network could provide the following benefits

Opportunities	Needs
Utilising low-grade waste heat and balancing between neighbouring buildings	Increasing overall efficiency and reducing environmental impact of heating and cooling.
Using a common feed for both heating and cooling	Reducing installation costs
Use ambient temperature feed	Eliminate distribution losses

Use algorithms and data about typical demands over time of users, dates, seasons, weather, local energy production and energy trading prices, in a smart cloud system to optimize the energy flow and storage.	Optimise and manage the DH system.
Combining low installation costs, efficient operation and utilization of surplus heat and cold from neighbouring buildings	Reducing overall cost of operation and thereby the energy bills for residents.

NIKOS

8.3.4 Vaasa Replication

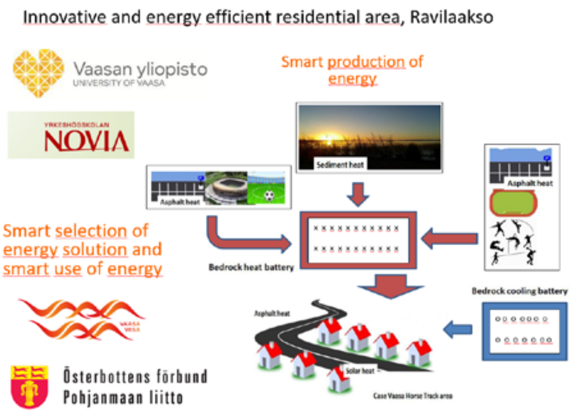
8.3.4.1 Use Case and Brief technical description

For Ravilaakso area a research project is studying: local potential of renewable energy, modelling use and management of energy with different scenarios, including zero or positive energy buildings, smart grids, 4th generation LT DHCN, geothermal and solar systems with required automation systems for buildings, blocks and district level. Vaasa is preparing a solution for Ravilaakso where preliminary solutions studied include: LT DH network with utilization of waste heat from West Energy incinerator plant, long term energy storage (boreholes 50 – 200 m), use of absorption pumps for cooling and heat storage solutions. System is planned to be open to other possible solutions including solar, asphalt and sediment heat.

The City of Vaasa is interested in a) the operation of LT networks, b) the decision and business model support, c) intelligent, self-learning and automatically optimised controls for DHN, d) DHN fault detection and diagnostics when it affects energy efficiency, and e) cloud based energy management services for DHN.

8.3.4.2 Replication Area and Geographical Overview

A new mainly residential area, Ravilaakso will be constructed starting from 2020. Area is located within 1000 m distance from the city centre. Ravilaakso is an old trolling track of about 30 ha. Ravilaakso will establish a vision for a future energy efficient and innovative neighbourhood for about 2000 – 2500 inhabitants. It includes blocks with both townhouses and apartment houses that are architecturally high level, interesting open public spaces and local business premises. Ravilaakso will create a city-like, lively, diverse and active city district next to the city centre. The aim is that the area will act as a showcase and a living lab for energy-efficient and sustainable solutions where innovative companies can test their products and services in an enabling environment. New Ravilaakso will include about 140.000 – 150.000 m^2 of new construction to be realised in about 10 years' time. The pre-construction of the area has started already in 2017. The old trolling track was built in 1950´s and it is situated on an old sea-bed which trough postglacial earth lifting was gradually transformed into a small valley. Today the bottom area lies about 1 meter above sea level.

 **Figure 8-38: Location of Ravilaakso demonstration area**	 **Figure 8-39 : Visualisation of Ravilaakso demonstration area**
 **Figure 8-40 : Preliminary concept of energy solution**	 **Figure 8-41 : Preliminary detailed urban plan**

8.3.4.3 Objectives, Needs and Opportunities to be served by the implementation of the Solution in the Replication

Opportunities	Needs
Increased use of renewable energy resources.	Increase further the penetration of RES on a district level for covering the citizens' heating/cooling needs. Political decision to promote green energy.
New smart buildings integration	New buildings will be „smart buildings" or „smart grid ready", with electricity storage systems, highly efficient insulation and geothermal network connection to reach positive energy level.
Storage	Store available excess energy for both cooling/heating purposes,
DHN fault detection and diagnostics	To reduce OPEX and minimize the risk for being set out of order. Increase operating hours.
Software Equipment	Smartening the DHCN microgrid through the SEMS.

8.3.5 Alexandroupolis Replication

8.3.5.1 Use Case and Brief technical description

Municipality of Alexandroupolis is currently implementing a new geothermal energy DHN utilising the low enthalpy geothermal field of Traianoupolis located within the administrative boarders of the Municipality. The project includes the DH of public buildings, social housing and greenhouses and constitutes the first phase of geothermal energy exploitation by the municipality. Therefore, Alexandroupolis is expected to be an owner of a DHN that however will operate with temperatures of about 90^{o}C, which is the temperature of the geothermal fluid. Nevertheless, the solutions of smart, multi sourced LT DHN are of great interest for Alexandroupolis, in order to efficiently and effectively expand the DHNto other areas and increase the number of consumers. The specific solutions for which Alexandroupolis is interested are:

- operation of LT networks;
- innovative algorithms for increasing energy-efficiency in existing DHN;
- utilization of LT waste heat such as the excess heat from buildings and
- short-term and long-term thermal storage.

8.3.5.2 Replication Area and Geographical Overview

The low enthalpy geothermal field of Traianoupolis is located approximately 10 km east from the city centre of city of Alexandroupolis. It constitutes one of the most important low enthalpy geothermal fields of Greece and has been leased by Municipality of Alexandroupolis for 35 years.

Figure 8-42 *Pumping test of geothermal drills of* **Alexandroupolis**

On 17th of May 2018, Municipality of Alexandoupolis has issued the public tender for the construction of 18 km of DHN, the thermal station and the return geothermal drills. The geothermal DHN will cover the heating demand of 40 hectares of greenhouses, of 8 municipal buildings and of the building facilities of the institution “SOS Children’s villages”, all located in “Antheia” of Alexandroupolis. The above described DHN will constitute the replication area for the feasibility studies developed, that will take advantage of the solution tested and demonstrated in LHs of the project. The area “Antheia” includes mostly detached houses and local business premises.

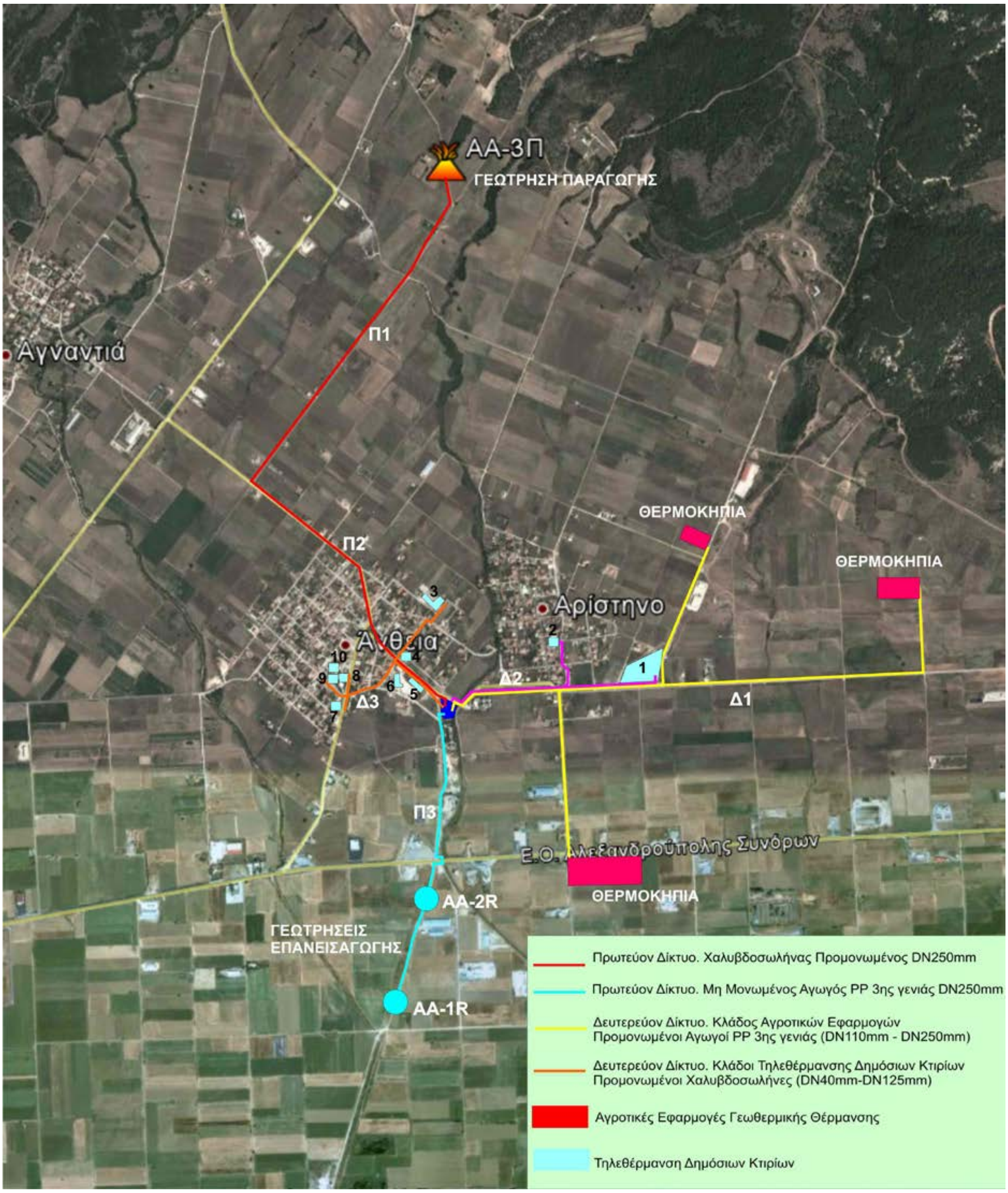


Figure 8-43 : Layout of the geothermal district heating network

8.3.5.3 Objectives, Needs and Opportunities to be served by the implementation of the Solution in the Replication

Opportunities	Needs
Benefits from available geothermal energy as a RES source	Increase further the penetration of RES on a district level for covering the citizens' heating/cooling needs.
Upgrade of the existing DHCN into a Low Temperature one	Minimize energy losses

Storage	Store available excess energy for both cooling/heating purposes
DHN fault detection and diagnostics	To reduce OPEX and minimize the risk for being set out of order. Increase operating hours
Software Equipment	Smartening the DHCN microgrid through the SEMS

8.3.6 Focsani Replication

8.3.6.1 Use Case and Brief technical description

Municipality of Focsani, through its DH company, owns and operates a centralized DHN, which includes a cogeneration plant, transportation network, thermal substations and distribution network. The replication project includes measures for increasing energy efficiency, heat storage and eventually heat utilization for cold generation. The project includes the following main objectives:

- Increasing energy efficiency of the cogeneration plant by optimization its operation, using heat storage and by using available heat for cold production during summer time;
- Rehabilitation of the transportation and distribution networks, thermal substations and the implementation of a monitoring and control system.

8.3.6.2 Replication Area and Geographical Overview

The figure bellow shows the integration of the heat storage tank into the cogeneration plant. This measure shall increase the energy efficiency of the plant operation, which shall lead to increasing the economic efficiency of the DH company.

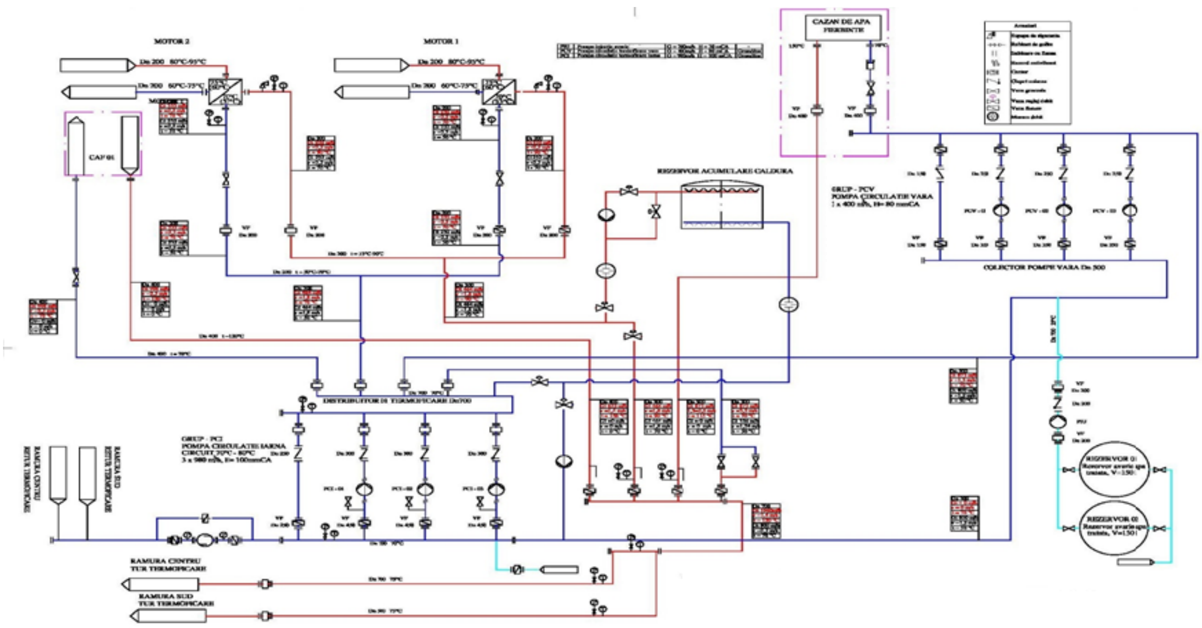


Figure 8-44 : LTDH through a cogeneration plant

For increasing energy efficiency and reducing energy losses of the DHN the Municipality of Focsani has started the overhaul of DHN and thermal substation.

In the period of 2010-2013 through the Government program "District heating 2006-2015 – Heat and comfort" and from its own financial sources, 1,29 km of transportation network, 11,7 km of distribution network have been rehabilitated, while having modernized 15 thermal substation and 3 thermal modules.

A structural fund financed project, implemented by the Municipality of Focsani, included a new cogeneration plant based on internal combustion engines leading to increasing the efficiency and at the same time reducing environmental impact. The project also included rehabilitation of 4.5 km of primary network, 10.5 km of secondary network and rehabilitation of 10 thermal substations.

Presently, there is a project that is under elaboration aiming at rehabilitation of 2.8 km of primary network, 10.9 km of secondary network and rehabilitation of 9 thermal substations.

Figure 4.45 shows the rehabilitation works for the DHN of the Municipality of Focsani. The figure bellow shows the following:

- With blue rehabilitation works through the Government program "District heating 2006-2015 – Heat and comfort";
- With green rehabilitation works through structural fund;
- With red rehabilitation works through the project in the elaboration phase.

8.3.6.3Objectives, Needs and Opportunities to be served by the implementation of the Solution in the Replication

Opportunities	Needs
Heat storage	Increasing energy efficiency of the DHN by implementation of a heat storage tank
Heat utilization for cold production	Utilization of available heat during summer time for cold production
Rehabilitation of transportation & distribution networks and thermal substations	Reducing heat and water losses
Monitoring and control system	Increasing efficiency of DHN, better fault detection, increasing service quality

SITUATIA
LUCRARILOR DE REABILITARE A SISTEMULUI CENTRALIZAT DE ALIMENTARE CU ENERGIE TERMICA

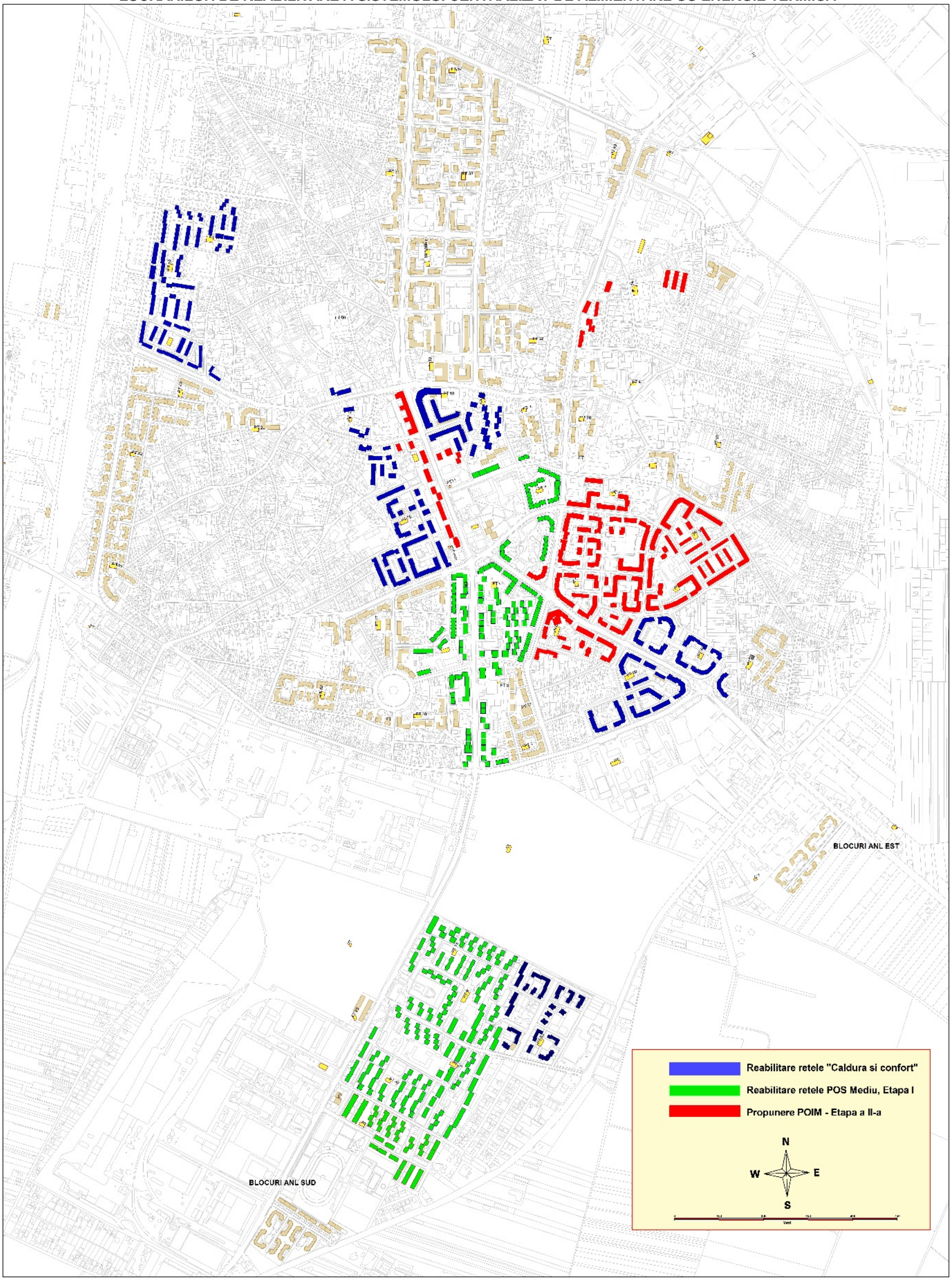


Figure 8-45 : Rehabilitation works for the district heating network of the Municipality of Focsani

8.4 Data Collection and Management

8.4.1 Utrecht

N.A.

8.4.2 Nice Cote D' Azur

Any technical and functional specifications connected to an operation and management system, are dependent on the retained operator from the public call for tenders.

No precise protocols nor standards are imposed locally through the call for tenders, nor through national regulation. The time granularity will depend on the technical and functional specification of the final choses proposition. What could be put forward is the fact that the operation should put in place a local energy management system, centralizing both data and management of the system within the district. This could be further extended to the definition of an open source standard for the sharing of partial or aggregated information generated by the system and its associated services, as the whole centralized operation system (data and management system) should be transposed to the public authority at the ending of the concession time.

8.4.3 Gothenburg

Data collected and processed will include

- Local cooling/heating demands of grid users;
- Temperatures of supply and return feeds;
- Availability of external energy sources;
- Weather forecast information;
- Statistical data on historic consumption;
- Electricity and domestic hot water used in each apartment as well as the building's energy consumption;
- Indoor temperature;
- Electricity from the solar cells will also be measured and
- Heat from the heat pumps and the DH.

Some of the data will be available to the tenants to make it easier to them to understand their usage. Some of the data will be used to regulate the energy system of the building both from an economic view as well as from an environmental view. Probably there will be some data from the vehicle pool as well, but this is still undecided.

8.5 Regulatory Framework per LH/FC

8.5.1 Utrecht

The majority of the DHN in the Netherlands are operated by private companies. They own and operate the DHN, supply heat to the end users and often also operate the production facilities that provide the heat for the DHN. DH operators that supply heat to "protected consumers" are regulated under the Dutch Heat Act. The Act protects these consumers who are unable to switch suppliers (about 90% of the customers) amongst others against being charged too high prices. The fact that the network is operated by private companies and regulated tariffs has a significant impact on the feasibility of the business case for DH operators.

8.5.2 Nice Cote D' Azur

Regulatory frameworks of the Public Code for DHCN, include the following representative framework:

- Art 33, 57, 58 and 59 from the Public Market Code - Code des Marchés Publics.

The “energy transition for green growth act” (national law 17/08/2015 - dedicated website: http://www.gouvernement.fr/en/energy-transition) leads French local authorities to define a local “Territorial Energy and Climat Plan”, with different level of objectivess and expectations according to the size of the local authorities.

The Metropole of Nice Cote d’Azur, with more than 500.000 inhabitants, has therefore its local action plan (http://planclimat.nice.fr/public/accueil.html).

- ADEME (French Agency for Environment and Energy Management - http://www.ademe.fr/en)
  - is an industrial and commercial public institution placed under the joint supervision of Ministry of Ecology and Sustainable Planning and Development and the Ministry of Higher Education and Research. ADEME aims to be the point of reference and privileged partner for the general public, companies and local authorities, acting as the State's tool to generalise the best practices designed to protect the environment and energy saving. ADEME is involved in the following sectors: air pollution, noise, waste, energy (energy management and renewable energies), environmental management, polluted sites and soils, transports. Within the framework of public policies defined by the government, the Agency's mission is to stimulate, animate, coordinate, facilitate and perform operations aiming at the environment protection and energy management.
    Also, ADEME regularly launches call for proposals to foster innovation projects.

- Guide to the development of district heating networks in France (mainly for the public authority):
  - http://www.ademe.fr/sites/default/files/assets/documents/creer-reseau-chaleur-guide-technique-2017.pdf

- Regulations on the TSO level flexibility market in France (products, services, market rules, roles and duties, e.t.c)
  - https://clients.rte-france.com/lang/fr/clients_producteurs/services_clients/regles.jsp

- Regulation on data interchange among flexibility actors and the DSO in the French context.
  - http://www.enedis.fr/sites/default/files/NEBEF_SI-_Echanges_de_donnees_entre_GRD_et_OE_-_v2.0.pdf
  - http://www.enedis.fr/sites/default/files/MA_SI-guide_dimplementation_des_echanges_entre_GRD_et_AA.pdf

- Self-consumption regulation
  - https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000032938257&categorieLien=id
  - https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000032966823&categorieLien=id
  - https://www.legifrance.gouv.fr/eli/loi/2017/2/24/2017-227/jo/texte

- Submetering chapter of the actual building thermal regulation (RT 2012)

https://media.xpair.com/pdf/reglementation/Consommations-RT2012.pdf

8.5.3 Gothenburg

There is currently no regulation governing the installation or use of DHN, except for building permits, which are issued by the municipal Building Boards.

8.5.4 Vaasa

No restrictions on regulatory framework directly related to LT networks. Replication more related to economically feasible business solutions.

8.5.5 Alexandroupolis

Geothermal energy exploitation is covered by Law 3175/2013. The promotion of renewable energy sources follows Law 3468/2006, as altered by Law 3851/2010. The development of DHN falls under the Law 4001/2011 and licensing procedure must be according to Ministerial Decision D5-HL/B/F.1/oik.17951. No specific regulatory framework for LT networks is currently in place in Greece.

8.5.6 Focsani

The Romanian regulatory framework is aligned to the EU legislation. All EU Directives and normative Acts have been transposed or shall be transposed in the future into Romanian legislation.

The Romanian Energy Strategy for the period 2007-2020 has as main objective meeting the energy needs both today and in the medium and long term, at a lower price, adequate to a modern market economy and a civilized standard of living, in conditions of quality, food safety, respecting the principles of sustainable development. So, the increasing of energy efficiency and the utilization of renewable energy sources is in complete accordance with European and national legal framework. Romania has set as goal achieving a primary energy savings of 10 million toe in 2020, which is a reduction in projected primary energy consumption (52.99 million toe) using the PRIMES 2007 model, for the realistic scenario of 19 %.

In accordance with the Law no. 121/2014 the Municipality of Focsani city has to implement the following:

- to develop energy efficiency improvement programs that include short-term and midterm 3 to 6-year measures;
- to appoint an energy manager certified according to the legislation in force, or to conclude an energy management contract with an authorized entity, attested by the law, or with a legal entity providing energy services approved under the law.

The Romanian legislation that sets the framework for this area includes the following:

- Law no. 121/2014 on Energy Efficiency with subsequent amendments and completions (Law no. 160/2016);
- The Law on Electricity and Natural Gas No. 123/2012, as subsequently amended;
- Law no. 325/2006 of the public service of heat supply;
- Law no. 51/2006 of the community services of public utilities;
- Law no. 372/2005 on the energy performance of buildings with subsequent amendments and completions;
- Government Decision no. 122/2015 for the approval of the National Energy Efficiency Action Plan;
- Government Decision no. 529/2013 for the approval of Romania's National Strategy on Climate Change, 2013-2020;
- Government Decision no. 1460/12.11.2008 for the approval of the National Strategy for Sustainable Development - Horizons 2013-2020-2030;
- Government Decision no. 219/2007 on the promotion of cogeneration based on the useful heat demand;
- Government Decision no. 1069/05.09.2007 - Energy Strategy of Romania for 2007-2020;

Government Decision no. 163/2004 National Strategy in the field of Energy Efficiency;

8.6 Bounds and Drivers per LH/FC

8.6.1 Utrecht

To be defined

8.6.2 Nice Cote D' Azur

- The "energy transition for green growth act" (national law 17/08/2015 - dedicated website: http://www.gouvernement.fr/en/energy-transition) leads French local authorities to define a local "Territorial Energy and Climat Plan", with different level of objectives and expectations according to the size of the local authorities.
    - The Metropole of Nice Cote d'Azur, with more than 500.000 inhabitants, has therefore its local action plan (http://planclimat.nice.fr/public/accueil.html)
- Nice's Agenda 21
    - http://www.nicecotedazur.org/environnement/agenda-21
- EU COMMISSION:
    - EU regulations and Evaluation Report covering the Evaluation of the EU's regulatory framework for electricity market design and consumer protection in the fields of electricity and gas Evaluation of the EU rules on measures to safeguard security of electricity supply and infrastructure investment (Directive 2005/89), Nov 2016, EUROPEAN COMMISSION
    - 7 COM (2016) 860 – "Clean Energy For All Europeans", European Commission, Brussels Nov 2016
- Investment aids from ADEME in renewables
    - http://www.ademe.fr/expertises/energies-renouvelables-enr-production-reseaux-stockage/passer-a-laction/produire-chaleur/fonds-chaleur-bref
- Tax reduction on energy bill for district heating cooling networks, providing at least 50% of energy from renewable sources.
    - http://bofip.impots.gouv.fr/bofip/1201-PGP.html
- Nice's Charta on ready to grid buildings
    - http://le-be.fr/wp-content/uploads/2017/01/Recommandations-pour-des-b%C3%A2timents-Smart-Grids-Ready.pdf

- Nice's environmental Charta on constructions
    - http://www.ecovallee-plaineduvar.fr/sites/default/files/fichiers/demarche_ecovallee_qualite_v2018_270218_light_0.pdf

8.6.3 Gothenburg

1) Technical Bounds & Drivers
    a. Drivers: Heat pumps have become much more efficient and much less expensive. This promotes the use of low temperature systems where heat pumps are used to obtain higher temperatures
    b. Bounds: Lower temperatures demands larger installations (for example heat exchangers, radiators) to achieve sufficient thermal comfort
2) Legal
    a. Drivers: Sharpened regulations concerning buildings' energy performance will drive the development of systems utilising waste heat, for example LT DH.
    b. Bounds: None identified so far
3) Social
    a. Drivers: None identified so far, energy poverty is not a problem in general in Sweden,
    b. Bounds: None identified so far
4) Financial

   a. Drivers: These systems provide lower costs of installation and lower operational costs. Also, the use of low grade waste heat is financially beneficial.
   b. Bounds: Still uncertainties connected to new and untested technology
5) Environmental
   a. Drivers: These solutions contribute to better energy efficiency which is environmentally beneficial
   b. Bounds: Storage media will need to be evaluated from an environmental point of view, as will installation procedures, life cycles and decommissioning issues

8.6.4 Vaasa

Technology already exists, but implementation is lacking or does not include hybrid solutions and smart solutions. Economic feasibility and business solution will have main role on implementing solutions. Investment needs to be attractive to investors and provide benefits to citizens relevant to their reduction of energy bills, and improvement of their quality of life.

8.6.5 Alexandroupolis

- Technical. A significant technical barrier for the case of Alexandroupolis is the reintroduction of the geothermal fluid to the reservoir. The efficient operation of LT DHN will be a challenge, but also a driver for low cost operation and expansion of the distribution network to more consumers.
- Legal. Licensing procedure for DHNs is bureaucratic and requires simplification in order to attract investors.
- Social. DHN are not common in Greece and in Alexandroupolis in particular. The information of citizens, that are potential consumers, for the benefits of such projects is crucial for the viable operation of DHNs.
- Financial. Such projects are eligible for EU funding according to the Regional Operational Programme of the Region of East Macedonia and Thrace. Nevertheless, the available budget can be considered as limited.
- Environmental. No environmental barriers are present. Reduction of CO_2 emissions due geothermal energy and potential waste heat exploitation acts as a driver for the implementation of such projects.

8.6.6 Focsani

- Technical Bounds & Drivers: Different technical bounds regarding integration and efficient operation of the heat storage tank. All proposed measures can lead to increasing energy efficiency of DH company.
- Legal: High efficiency cogeneration needs more support and thus the existing legal framework can be extended for bonuses for high efficiency cogeneration. Heat tariffs are still regulated by the local and national authorities. There are still subsidies for population for heat.
- Social: There are still energy poverty for a part of population, which leads to delays in bills' payment and to disconnections from DH.
- Financial: On the local/national level there is a bound regarding the available financing from the Government. On the other hand, there is available financing through different EU funded programs.
- Environmental: All energy efficiency measures can surely lead to reducing pollutant emissions and thus reducing environmental impact.

8.7 Business Models

LT instead of high temperature heating network (ALL) – The business model will be developed on the basis that DE network operators will have less OPEX in advantage of citizens and communities, which can have a reduction of their energy bills. The reduction of energy bills is further accelerated by the fact that even lower supply temperatures provide the possibility to further extend DH's environmental potential by accessing heat from sources formerly considered as with little to no value like mine water or ground heat.

8.7.1 Utrecht

To be defined

8.7.2 Nice Cote D' Azur

No information can be given so far on the business model that will be proposed within the public call for tenders. Information will be provided in D3.2.

8.7.3 Gothenburg

Currently there are no business models coupled to this solution.

8.7.4 Vaasa

At the moment two options for business model is foreseen:

1) an locally based company which is owned by the housing associations on Ravilaakso area and possible investors, they will acquire required operations locally, heat is purchased from local DHN operator (Vaasan Sähkö) or produced itself in the area
2) 2) network is owned and operated by one of the heat providers or DHN operators (Vaasan Sähkö, EON, Fortum e.t.c), which will purchase heat from local heat DHN operator (Vaasan Sähkö), produce themselves or use extra heat from the area. Housing units will purchase heat from the local area DHN operator. If other business models are developed or used in LHs, Vaasa will study their feasibility.

8.7.5 Alexandroupolis

Currently there are no business models coupled to this solution. Information will be provided in D3.2.

8.7.6 Focsani

Integrated heat storage and cold production: the implementation of heat storage solution and cold generation using heat can become a business model for replication in other cities with DHN in Romania as well as in other countries.

9. ANNEX for IRIS Solution IS-2.3: Utilizing 2nd life batteries for smart large scale storage schemes

9.1 Pre-pilot Areas description and Available Infrastructure

Disclaimer

In the Pre-Pilot description section, data is provided about the scope, structure, results and conclusions of the past related activities. The herein stated information represents the state-of-the-art on which IRIS is going to proceed as a one step further. For the case of more information needed, the interested stakeholder should contact the responsible entity of the pre-pilot site.

9.1.1 Nice Cote D' Azur Pre-Pilot

IRIS Nice ecosystem is made of a large amount of companies, not only local SME and companies, but also global groups as the world leading energy company EDF, specialised in renewable and low carbon energy, through its businesses and subsidiaries, covers the whole energy value chain. Within the IRIS project, it represents the energy generation, operation and service businesses. Complementary to that, the electricity distribution businesses is represented by ENEDIS, the French leading distribution system operator (DSO).

Thanks to the national "energy transition", a profound transformation of the French energy sector has been initiated, as the set objectives are ambitious, corresponding financing have already been partially put in place. Nevertheless, the energy transition is in first place an economical transition and many challenges among the whole value chain have still to be addressed. As a common consensus among the national and European industry, is the need of a more flexible management of the production means (renewable or not), the transport and distribution network operation and the demand side management. The more intermittent renewable energy generation connect to the grid, the more the grid flexibility from different systems will become a real need.

What has to be understood, is that in France, more than 90% of the existing renewable generation systems are connected to the medium and low voltage grid, so impacting directly the distribution grid operation. Similarly, the electric vehicle development will have to be considered, as development plans are ambitious and it will not happen without impacting the distribution grid operation. From both cases, it can be understood that when considering grid flexibility, the DSO in an unavoidable actor in France.

A more flexible management of the low and medium tension grid are in the main interests for ENEDIS and similarly, it is a forerunner in experimenting and testing of the use of different storage solution at the grid level, from upstreams at the interface with the transmission system, down to the interface with the consumer premises. Within the same framework EDF, as leading company in the sector, has an interest in testing and adopting new systems and solutions to adapt its products and services towards an optimise management of flexibility products and services.

That's why ENEDIS and EDF, two key partners of IRIS, have participated to the "IssyGrid" project [23], first pilot project in France dedicated to energy optimization at district level. This originated in 2012 from the initiative of Issy-les Moulineaux and Bouygues Immobilier, bringing together stakeholders who have all the strategic and technical skills of the smart grid.

Objectives of the project were:

1. the optimization of the local renewable energy integration
2. the optimized operation of the distribution grid, also by integrating storage means and testing the 2nd life batteries and
3. an enhanced demand side flexibility.

Figure 9-1 : Battery stack and associated automation and control system. Renault was the 2nd life battery provider.

With a total budget of 2 M EUR, the IssyGrid consortium involved following partners:

- Bouygues Immobilier and Bouygues Telecom
- EDF
- Enedis
- Former Alstom Grid (GE)
- Schneider Electric
- Steria
- Microsoft
- ETDE
- Total
- Ijenko
- Renault (as 2nd life battery provider).

IssyGrid had the vocation of being a first of a kind living lab and be used for real life sized experimentations. Among other experiments, the reutilisation of 2nd life batteries was one of the main axis of development, under the development and testing of a “smart secondary substation”. The objectives for the experimentation was twofold:

- For the battery supplier: identify the needs and interest of recycling battery stacks from electric vehicles for energy related applications. More precisely, on how to re-fabricate the batteries to better serve such needs.
- For the DSO: identify operating strategies and technical limitations to better control the electricity distribution grid by having a battery storage system (activated by a third party operator) at the secondary substation level, in order to:
    - reduce the peak load;
    - avoid inversion of energy flow at the substation;
    - provide a more uniform charging curve by controlling the battery system and
    - maximise the integration of local renewable energy.

These elements were clearly accompanied by sub-areas of development such as the needed software infrastructure (data analytics, forecast and optimisation) or the ICT infrastructure to be associated (protocols and standards).

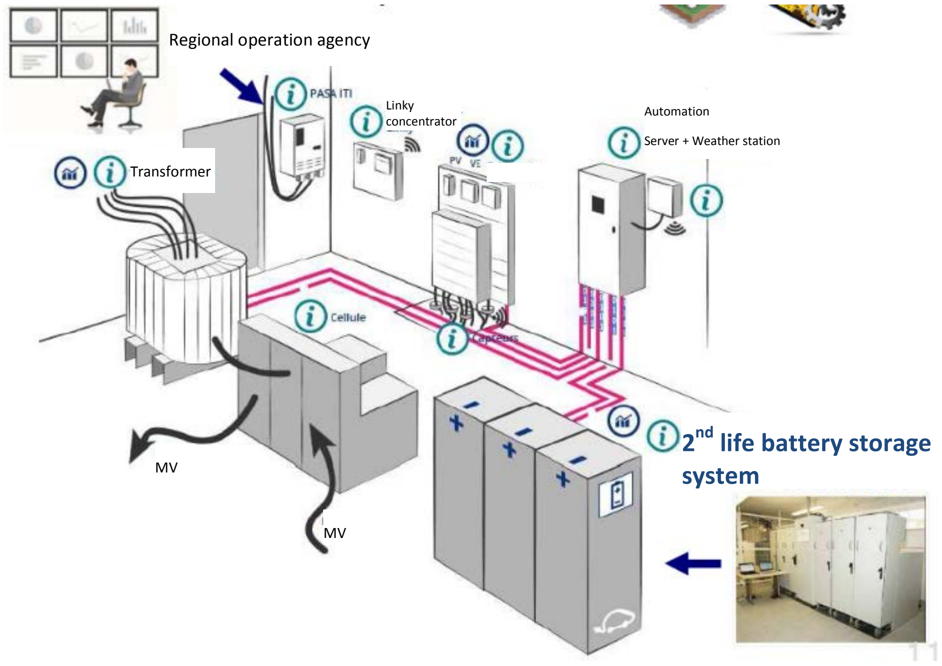


Figure 9-2 : scheme of the tested « smart secondary substation »

9.1.1.1 Pre-Pilot Area and Geographical Overview

Being firstly developed in Issy-les-Moulineaux and subsequently on the district of Fort d'Issy, the case study structure is very similar to the Nice Meridia and Grand Arenas projects. With a floor space of 160 000 m² and nearly 10 000 people, the project laid the basis for a nationwide replication. With about 770 000 secondary substations among the French territory, the possibility of integrating such type of technology is theoretically given. Within this project, the smart secondary substation was connected to 2 PV systems, 6 e-vehicles charging points and 166 Linky smart meters. The place of the pre-pilot is not in Nice, since there was no similar project available. Issy-les-Moulineaux is located in south-western area of Paris.

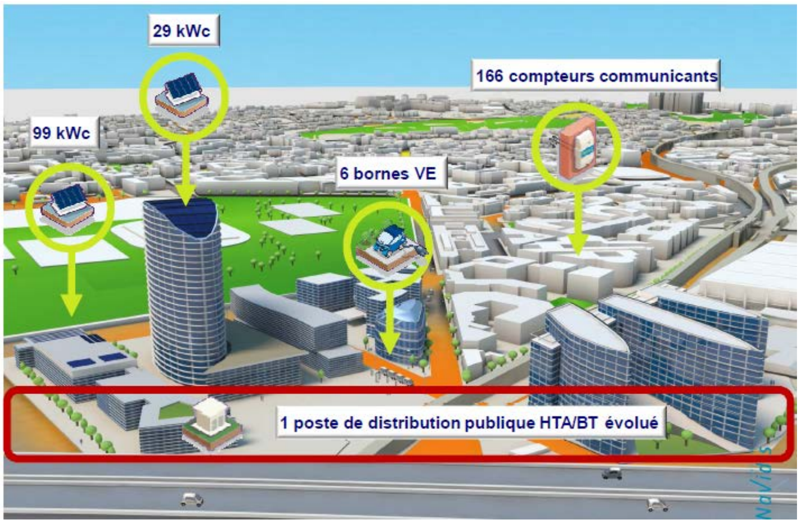


Figure 9-3 : Simplified scheme of the demonstration district

9.1.1.2 Lessons Learnt by the implementation of the Solution in the Pre-Pilot

The project enabled the testing of the technical feasibility and the validation of the potential interest of using 2nd life batteries for a distribution grid level application through a smart secondary substation. Furthermore, it enabled the definition of potentially economically interesting services and the identification of first business models and associated products. By integrating all major actors in the French context among the sector, it has enabled to the main French business related to the 2nd life battery value chain, to gain competitive advantage and ensure to be at the upfront of the developments. A cost-benefit analysis, providing a quantitative and qualitative return of experience of the project is still underway. The aim of this is to be able to provide advice and decision making support to the regulatory institutions at national and European level.

Linked Projects: IssyGrid

9.2 Demonstration in the Lighthouse Cities

9.2.1 Utrecht Demonstration

9.2.1.1 Use Case and Brief technical description

Utrecht's ambition is to integrate smart energy management and renewable energy storage for (a) maximum profits of renewable power, (b) maximum self-consumption reducing grid stress, (c) unlocking the financial value of grid flexibility and (d) optimizing the second life of car and bus batteries. For this aim Utrecht plans to demonstrate a district V2G storage using solar V2G e-cars and e-buses, along with a stationary storage that uses 2nd life batteries for energy storage in garage-boxes of apartment buildings that will be renovated by the housing cooperation Bo-Ex (see TT #1). The objective is to realize a storage capacity of 3600 kWh/y (12 x 300 kWh/y). Different suppliers of 2nd life batteries will be approached to make an offer. Figure 9-4 provides an overview of the integration of the 2nd life batteries in the district management system.

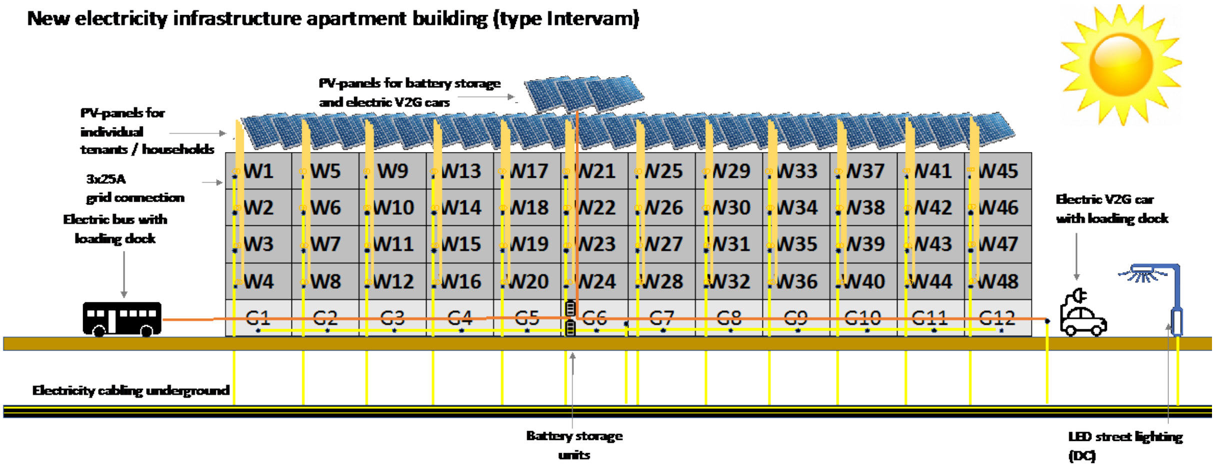


Figure 9-4 Outline of integration of the 2nd life batteries in the district management system

9.2.1.2 Demonstration Area and Geographical Overview

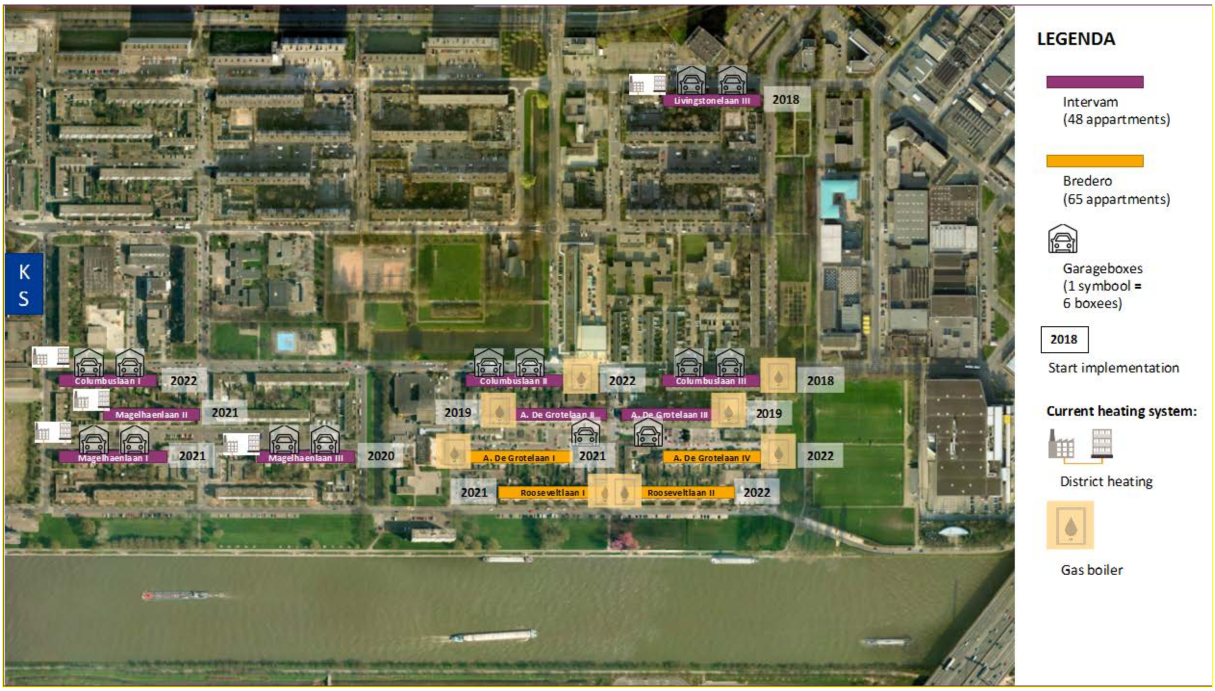


Figure 9-5 Overview of the apartment building that will be renovated and current energy infracture providing the heat.

9.2.1.3 Objectives, Needs and Opportunities to be served by the implementation of the Solution in the Demonstration

Opportunities	Needs
Create smart storage	Further penetration of RES increases the need for smart storage of locally produced electricity to reduce peak loads on the grid on e.g. a sunny day with maximum production of electricity from PV panels and a low local demand. This calls for a need to create smart storage in amongst others 2nd life batteries. “Smart” refers to the development of storage schemes resulting in maximizing local consumption of locally produced electricity, hence reducing local grid stress and ultimately the needs for additional investments. This calls for hardware and software equipment for monitoring and control of RES resources. A data platform enabling dynamic estimate of the flexibility of a RES based microgrid.
Test performance of 2nd life-batteries	Demonstrating how grid stress and grid investments can be minimised and how to best deploy storage at a district level. This needs to be supported by an open ICT system for interconnection, performance monitoring and cost effective new information services for aggregators, grid operators, municipality and citizens.

9.2.1.4 Key technical components

Hardware:

Main Component	Technical Specifications	**Demonstration Area**	**IRIS partner (owners and providers individually)**

Stationary 2nd life batteries	Power: 200kW / 250kWh yearly Noise@: storage cabinets may produce max. 35dB Connection to PV-panels: 20kW Available grid connection: 3x25A Fire-retardant (closed system) Degradation: max. 10% within 5 years	Kanaleneiland Zuid	Bo-Ex LomboXnet

Software:

Main Component	Technical Specifications	**Demonstration Area**	**IRIS partner (owners and providers individually)**
Application Program Interface (API)	Compatible with Last Mile Solutions software	Kanaleneiland Zuid	Bo-Ex LomboXnet

9.2.2 Nice Cote D' Azur Demonstration

9.2.2.1 Use Case and Brief technical description

The foreseen use case includes the integration of second life batteries within a "conventional" Li-Ion stationary battery storage system, serving as a whole to the optimization of a "self-consumption" endeavour (based on a PV system). The role of the storage management is to maximize the local valorisation of such auto-produced intermittent renewable energy. The whole system's design is not finalized yet and still work in progress. Similarly, the 2nd life battery system is in its early stage of design and the possible technologies are still under benchmark. To underline is the premature stage of industrialization in France of the use of 2nd life batteries for energy related applications and products.

However, at this stage, the opinion of the Nice Ecosystem's experts leads to focus on a battery system with a capacity of about 50 kWh, based on e-vehicle batteries, so Li-Ion technology. The latter, will be integrated into an additional 100-150 kWh battery system, also based on Li-Ion technology. The so composed storage system will be connected to the Building Energy Management System, which will define the operation strategy of the system. Its technical and functional specifications are not defined yet and under assessment.

Although no final choice has been done neither on the dimensioning nor on the technology providers, it is foreseen that the system will be composed by different cabinets containing the battery batches (new and 2nd life batteries), equipped with inverters, battery and energy management systems, room cooling system and fire safety equipment. It is estimated that the overall system will occupy a surface of about 5m x 2,5 m and be about 3m in height.

What has to be considered among the overall project duration, is the possibility to replace the 2nd life battery system by a "conventional" one, in case the performance is not efficient enough, which also impacts on the overall energy and financial efficiency degradation. Indeed, there are still many aspects of such technology, which bear big uncertainties. First of all, there is no international agreement or convention on the definition of the term "2nd life batteries". It's unclear if it is related to a certain residual capacity after a certain usage time or referring simply to a certain stage within a batteries product life cycle. Neither is it specified if the term 2nd life batteries applies also to batteries which have undergone a complete chemical overhaul to upgrade their efficiency for their next foreseen usage. A major issue concerning these aspects, is the correct estimation of the residual performance of 2nd life batteries and their integration is the overall system design and their impact on the related business model.

As no standardize products are available, the design variables to be considered are numerous and no final scheme or overall system design has been defined yet. The challenge relies in matching the self-consumption system requirements with the technical specification of different 2nd life batteries technology providers. Therefore, a benchmark is underway to explore the existing market and potential available product specifications.

9.2.2.2 Demonstration Area and Geographical Overview

A 5000 m² state of the art energy-efficient building, property of the Nice Cote d'Azur university and located in Nice Meridia part of the demonstration area will be operational in Sep 2018. This building will house IMREDD, Mediterranean Institute for environment and sustainable development and it ambitions is to be a state of the art show case in terms of energy efficiency and energy grid management. This building will be equipped with 836 m² of PV panels, corresponding to a capacity of about 175 kWp. In addition, a medium-scale electrical storage capacity will be implemented, both with standard Li-Ion and second-life EV battery technologies. The aim of this is the comparison of the efficiency of these technologies for dynamic energy balancing within a local micro grid, coupled with PV energy production.

In terms of the exact allocation of the storage system, two scenarios are considered. The first consists to host the system in a room in one of the underground storeys of the building, while the other is to install it outside of the building premises thus, a dedicated shelter system will have to be foreseen. By any mean, being battery storage a still "young" and fast evolving sector, it has to be expected that the legal and regulatory framework might evolve within the project's life time. Therefore, if this will be the case, changes will have to be implemented accordingly.

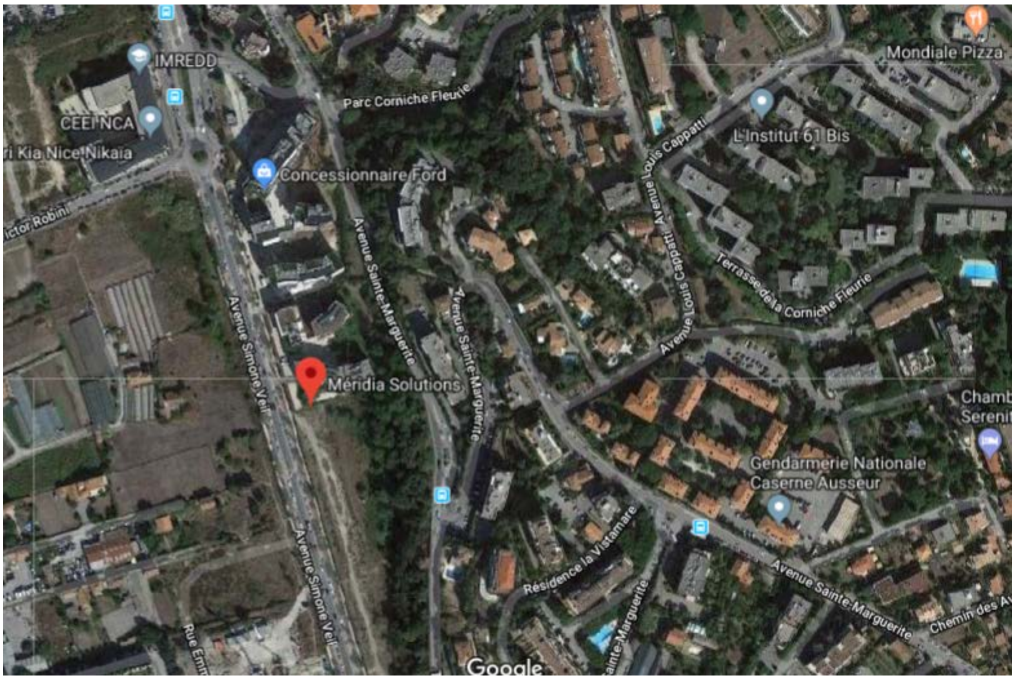


Figure 9-6 : Localisation of the future IMREDD building within the Nice Meridia district

Figure 9-7 : 3D rendering of the future IMREDD building

9.2.2.3 Objectives, Needs and Opportunities to be served by the implementation of the Solution in the Demonstration

What is primarily expected from the "reuse" of used e-vehicles batteries in storage systems for energy applications, is the extension of the batteries lifetime and the report of their environmental impact, as otherwise they would have to be disposed accordingly. Furthermore, if 2nd life batteries prove to be a cost effective and efficient storage mean, their impact on the overall battery industry could be considerable. By matter of fact, the growth of intermittent renewable energy production systems will be accompanied by the need of electric storage systems and 2nd life batteries could displace a part of the expected new batteries production and thus, increase their overall beneficial environmental impact. In parallel, the technology and processes for the recycling of used batteries is expected to evolve and mature and enable a more environmental friendly disposal of batteries.

From an economical point of view, the opportunities for such application of second life batteries are twofold: from the client point of view, so the building owner, the use of a storage system could enable to optimize the PV injection (so optimize operational efficiency) and at the same time, under the correct sizing of the system, generate economies as reduction of the subscribed power supply or reduction or displacement of peak demand, making the whole investment more profitable in the long run; from a battery manufacturer point of view, 2nd life batteries could enable to enlarge its overall value chain and thus, make more earnings from the re-adaptation of the product during its lifetime. This is even more valid in countries where battery manufacturers are responsible for the whole batteries' lifetime so also for their disposal or recycling. What could be argued, is that generated benefits from such reuse, could be transferred into the electric vehicle production industry, by reducing the cost of batteries for the e-vehicles market, making them more affordable and which would in turn, favour their adoption creating a positive feedback among the industry.

The overall societal benefit has also not be neglected, as the use of batteries will enable to integrate intermittent renewable energy sources more efficiently, for both decentralized and centralized generation systems. The real time control of batteries will not only reduce the overall grid impact and enable to rise the share of renewables in the energy mix (locally and globally), but enable to operators to further valorise their assets on flexibility and capacity markets.

Opportunities	Needs
Raise the RES (PV) share among the local energy mix	Increase further the penetration of RES on a district level while addressing needs the electric system and promoting green transportation. For its implementation, dedicated hardware and software equipment for monitoring and control of RES resources will have to be deployed. The Local Energy Management System solution to be deployed, will have to be able to dynamically forecast the generation and demand balance, foreseen grid constrains and identify possible flexibility means and globally ensure an optimized operation of the system and its components.
Valorisation of grid flexibilites	2nd life batteries for energy storage, both on grid level or building level, contribute to the raising the use of RES on district level, while promoting grid flexibility in link with IS 2.1

9.2.2.4 Key technical components

Hardware:

As already said, the overall system design is still in the planning phase, so changes will apply to what stated in the followings.

Main Component	Technical Specifications	**Demonstration Area**	**IRIS partner (owners and providers individually)**
PV power production	PV solar cells : foreseen installed capacity is 175 kWp, covering a surface of 836 m^2	IMREDD building	UNS No provider yet identified
Electric storage	2^{nd} life Li-Ion e-vehicle batteries Foreseen capacity: 50 kWh or 30-40 kW No other information on system design and auxiliary equipment available at this stage	IMREDD building	UNS Providers under benchmark
Metering equipment	Metering equipment is foreseen for enabling a fine grain and optimized system operation – no functional and technical specifications can be given yet	IMREDD building	UNS
Building	University building of 5000 m^2 with dedicated programme covering offices, services, laboratories and test benches.	IMREDD building	Nexity UNS

Software:

Main Component	Technical Specifications	**Demonstration Area**	**IRIS partner (owners and providers individually)**

Communication Platform and management system	Building Management System to be implemented not defined yet. Option considered, not definitive: Modbus, TCP/IP. System should ensure to be partially open and be able to serve to educational usage and experimentations	IMREDD building	UNS Solution and service providers to be defined
Available Algorithms and a short description of them:	No specifications yet defined. The management system should probably be able to perform load and generation forecasts (long and short term) and a stable and consistent optimization methodology to provide an optimized management system of the battery.	IMREDD building	UNS Solution and service providers to be defined

9.2.3 Gothenburg Demonstration

9.2.3.1 Use Case and Brief technical description

Gothenburg is interested in experimenting energy storage and optimisation with the case of 2nd life bus batteries, instead of EV ones, as in the case of NCA. In Gothenburg, energy storage with batteries will be installed in the demonstration area of the Riksbyggen's brf Viva, with the goal of installing 200 kWh. The energy storage will be finalized during 2018 and the housing cooperative will be in place in 2019, after which a five-year period of research will be conducted, focusing on controlling and optimizing the energy system with the batteries being a part of the energy system.

In addition to the batteries, the energy system will be will include PV-cells on the roof, heat pumps, a borehole and DHN. The research will include optimizing self-consumption of solar energy, reduction of peak production, peak shifting, utilization of hourly rates for electricity, frequency regulation services and balancing power among others. The electricity production from the solar cells will foremost be used for DC and AC consumption in the housing cooperative such as charge an electric vehicle pool. When there is an overproduction of electricity the batteries will be charged or the electricity will be sold to the grid depending on the electricity prices. Thus, the batteries will store energy from solar PVs and charge an electric vehicle pool, as well as run heat pumps and/or provide energy to the grid.

The energy storage will consist of:

- 14 2nd life bus batteries with energy storage optimizers;
- Six bidirectional inverters/rectifiers and smart power meters for controlling power flow in DC power and to/from the power grid. Maximum injection from solar cells and batteries towards the grid are 168 KW and
- A cooling system for the batteries in order to main proper temperature and pressure

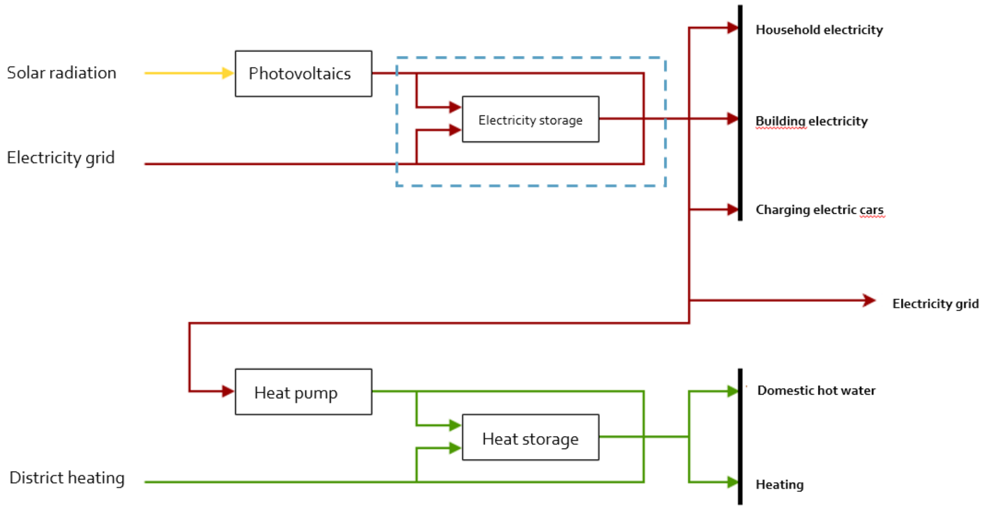


Figure 9-8: Descriptive scheme of the energy system in the Gothenburg demonstration

The batteries are currently in operation in a bus route serving the two larger campuses of Chalmers Technical University. The solution has been developed in collaboration with Göteborg Energi (the local utility company) and **Volvo Bus**, who will also use this demonstrator to evaluate the usefulness and thus value the batteries have after their first service life in the bus. The busses will normally replace their batteries when their capacity is reduced by 20-25%. The battery modules will be connected in larger groups and fitted with systems for cooling, smart management and capsuling. They will be placed in protective steel boxes together with circuits, cables and cooling plates.

This demonstrator is also included in a project together with **Göteborg Energi, Volvo Bus and Stena Metall** (an important actor since this company works with recycling of a variety of materials). This project will look specifically at ways of recycling the lithium-ion batteries.

9.2.3.2 Demonstration Area and Geographical Overview

The demonstration area is the Riksbyggen's brf Viva, situated next to Chalmers campus Johanneberg.

Picture 9-9. A bird view of the housing association Viva

Picture 9-10. One of Viva's pairs of buildings

9.2.3.3 Objectives, Needs and Opportunities to be served by the implementation of the Solution in the Demonstration

It is estimated that owed to the energy storage system, the amount of electricity that is produced by the PVs and has to be sold to the grid, will be reduced from 20% to 4%. This will result in financial gains for the housing association, due to the higher purchasing price than the selling price of electricity from and to the grid, respectively. It is also expected to have environmental benefits, since there will be a smaller demand of electricity that is produced in less environmental friendly ways than the beneficiating from RES available (solar). The storage system can also reduce peak loads while charging e-vehicles, with the same environmental benefits, and contribute to an overall stability and balance of the energy grid.

Opportunities	Needs
RES (PV) availability in the demo located houses	Increase further the penetration of RES on a district level addressing needs for electricity and promoting green transportation. Hardware and software equipment for monitoring and control of RES resources. Software platform able to dynamically estimate the flexibility of a RES based microgrid. Deployment of a MV/LV substation for the interconnection of the MG with the distribution network. Smartening the microgrid through the Local Energy Management System (LEMS) to allow the monitoring and control of available RES resources, when connected on a DC operating grid, instead that of an AC.
Verified 2nd-life value of EV-batteries	Measuring the capacity, performance and life span of reused vehicle batteries in stationary service.
Energy awareness among residents	Information dissemination among the residents in Viva Housing Association buildings. Active engagement in knowledge transfer from residents to the broader society. Window in the door to the battery storage room, making it directly visible.

9.2.3.4 Key technical components

Hardware:

Main Component	Technical Specifications	Demonstration Area	IRIS partner (owners and providers individually)
Power Production RES	140 kWp roof-top solar PVs	Roofs of the three 11-story buildings and the southernmost 6-story building.	Riksbyggen, Göteborg Energi
Electric storage used in EVs	3-4 electric cars, of type to be decided (1st life).	Assigned parking for the pool cars on road level.	Riksbyggen, Göteborg Energi
Auxiliary Equipment Type #1	Six bidirectional inverters/rectifiers and smart power meters		Riksbyggen, Göteborg Energi
Auxiliary Equipment Type #2	A cooling system for the batteries	Battery room in joint energy centre	Riksbyggen, Göteborg Energi
Electric storage used in buildings with the use of 2nd life batteries	10-14 2nd life Li-Ion batteries of a total 200kWh energy storage	Battery room in joint energy center	Riksbyggen, Göteborg Energi

Software:

Main Component	Technical Specifications	Demonstration Area	IRIS partner (owners and providers individually)
Management and control software	Software to coordinate the energy flows for several plausible service cases.		Riksbyggen, Göteborg Energi,

9.3 Replication Planning in the Lighthouse and Follower Cities

9.3.1 Utrecht Replication

9.3.1.1 Use Case and Brief technical description

Utrecht region will deploy PV panels on a large scale through the whole city of Utrecht, so the use 2nd life batteries is of interest to the whole Utrecht region to ensure that locally produced electricity is consumed locally and peak in the electricity grid are avoided as much as possible.

9.3.1.2 Objectives, Needs and Opportunities to be served by the implementation of the Solution in the Replication

Opportunities	Needs
Create smart storage	Further penetration of RES increases the need for smart storage of locally produced electricity to reduce peak loads on the grid on e.g. a sunny day with maximum production of electricity from PV panels and a low local demand. This calls for a need to create smart storage in amongst others 2nd life batteries. “Smart” refers to the development of storage schemes resulting in maximizing local consumption of locally produced electricity, hence reducing local grid stress and ultimately the needs for additional investments. This calls for hardware and software equipment for monitoring and control of RES resources. A data platform enabling dynamic estimate of the flexibility of microgrid RES.

9.3.2 Nice Cote D' Azur Replication

9.3.2.1 Use Case and Brief technical description

Integration of 2nd life batteries from e-vehicles in a "self-consumption" endeavour based on PV generation system and electric storage. In the long-run, 2nd life batteries could displace the use of "new" Li-Ion batteries for small to medium size stationary storage systems in industrial or tertiary activity buildings. The challenge relies in validating the technical performance of 2nd life batteries in trade-off to their potential lower costs than conventional batteries. Nevertheless, the replicability will be influenced by the upcoming industrialization and standardization of this type of product. However, the advancement of the battery industry can't be directly influenced by the IRIS project and thus has to be considered as a totally exogenous process to the replicablity.

9.3.2.2 Replication Area and Geographical Overview

In case the 2nd life battery system proves to be a viable product, it could be foreseen to achieve more demonstration cases in the follow up urbanization phase of the Nice Méridia or even the wider territory of Nice Eco Valley. At present date, the Nice Méridia urbanization project covers about 26 ha, representing a first phase among the wider 200 ha project, for which a high level master plan has already been developed. The latter does not yet provide a fine grain land use planning or phasing, nor identifies major energy infrastructure or energy related actions. The area will be a prolongation of the current development project; however, a higher housing share is expected to for the long term overall program. If the current obligation in local renewable energy production and on-site consumption is maintained or even its obligations enforced, potential is given to enlarge the adoption of this solution is buildings related to further urbanization phase. The development of the electric vehicle and battery manufacturing sector will have a decisive impact on the replicability potential.

Figure 9-11 : Contextualization of the existing urbanization project within the long term plan.

As a further replication area, the greater Eco Valley area can be targeted. The project has to be seen in a long term perspective, aiming at a strong territorial mutation and revitalization. Its developments will be divided into further urbanization phases and related construction programs. Yet, the projects to come are not defined, but the whole area will be developed under the same objective of sustainable development, driven by innovation and green technologies. This whole area, represents a potential pool of 3 000 000 m² of new constructions and developments. A Spill Over effect could be expected, fostering an adoption of the solutions which have proven their upper value in the first demonstration projects.

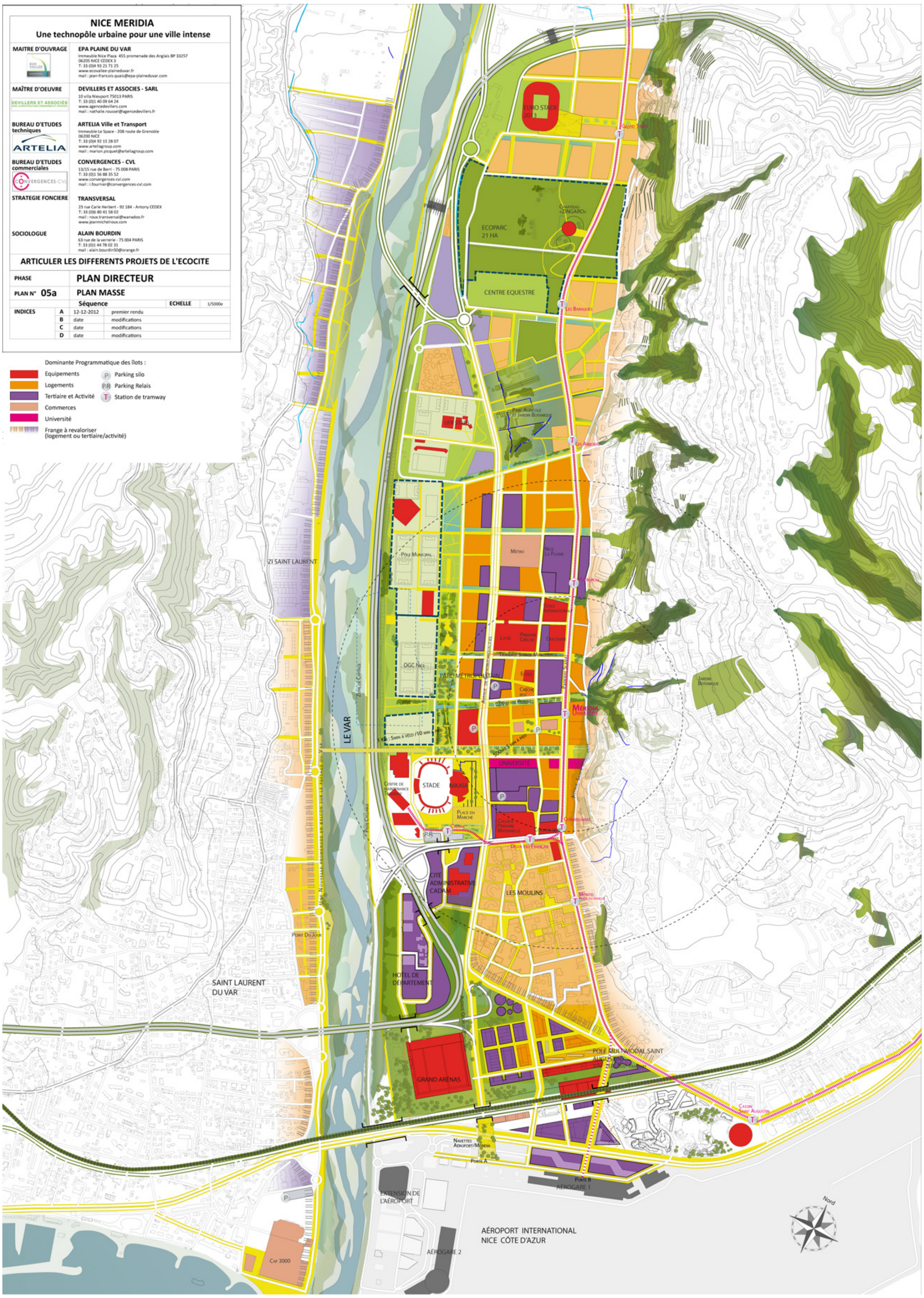


Figure 9-12 : master plan of the 200 ha area (source : D&A – Agence Devillers).

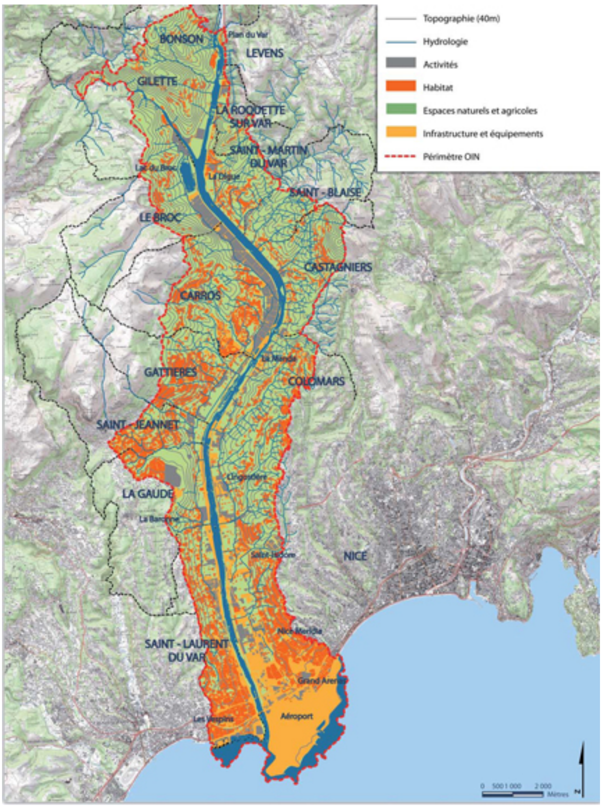


Figure 9-13: Perimeter of the Nice Eco Valley project : a territory with potentially up to 3 000 000 m² of new constructions.

9.3.2.3 Objectives, Needs and Opportunities to be served by the implementation of the Solution in the Replication

The replication, seen the early development of the technology, should yet enforce the objectives provided in the demonstration section. The technology needs on one side to proof its feasibility, on the other, the industrial sector has to develop standardized and demand driven and adapted products in order to see an adoption take-off of the technology. The trade-off between cost and efficiency are key aspects that have to be addressed, as well as to solve the related business models.

Opportunities	Needs
Penetration of 2nd life batteries in self consumption endeavour in tertiary and industrial buildings.	It can be argued that self-consumption endeavours based on PV systems, represent a potential market driver for the adoption of 2nd life batteries. Nevertheless, this market section is by itself a new market nice. The future price of electricity and related services will be determinant for the adoption of stationary storage technologies. 2nd life batteries should proof their feasibility and bankability and boost the development of tailored products for the industrial and tertiary sector in order to compete with “conventional” new Li-Ion based battery systems. The definition of a related regulatory systems could help to give clearer signals to the market and favour the adoption of the technology.
Standardization of 2nd life battery systems	The acceptance of stationary storage systems within industrial and tertiary buildings could be increased if the modularity and sizing of the systems would be better adapted to the needs of the construction industry. Size, weight and modularity are a determinant factor to better address the worries and needs for building owners and constructors alike. For this, a key aspect will be the processes that will emerge for rearranging of the used battery stacks form electric vehicles and well as processes for

	their chemical overhaul, ameliorating their performances. It is expected that the battery industry will have to let their products evolve taking such aspects into consideration, in order to achieve a market penetration and compete with traditional more efficient, smaller, lighter (but more expensive) battery systems.

9.3.3 Gothenburg Replication

9.3.3.1 Use Case and Brief technical description

The replication plan of Riksbyggen, from the sub-district of the housing association Viva, revolves around a newly deployed national Tool for Sustainability Management. When a new housing development is initiated in Riksbyggen, several actions or measures are suggested in the tool to increase the sustainability performance of the building. Good examples from Viva, as concluded by various evaluations, will be incorporated in the tool and given national replication within Riksbyggen. Additionally, within Riksbyggen's research and innovation platform Positive Footprint Housing, that is hosted by Johanneberg Science Park, and where the innovation process for Viva has taken place, there are now two new incoming projects. These are very likely candidates for replication as well as further development of some of Viva's demonstrations.

Lastly, replication is likely to be aided through Riksbyggen's partners. Since so many other actors in Gothenburg are involved in the innovation process around Viva, both through joint externally funded research projects or through placing their own R&D in Viva as a case or test-bed, it is in their own interest to learn and disseminate from the project.

9.3.3.2 Replication Area and Geographical Overview

More relevant information will be given in D8.1.

9.3.3.3 Objectives, Needs and Opportunities to be served by the implementation of the Solution in the Replication

More relevant information will be given in D8.1.

9.3.4 Santa Cruz de Tenerife Replication

The Tenerife replication plan is not yet available. Relevant information will be given in D8.1.

9.4 Data Collection and Management

9.4.1 Utrecht

A final monitoring plan will be drawn up in the coming months. It is anticipated that the data will be collected on the amount of energy which is produced by the PV panels and stored in the battery, energy which is flowing from the batteries to the electric vehicles and (possibly) to the households.

9.4.2 Nice Cote D' Azur

« At Month-7, the data collection and management is being defined as part of WP4 "City Innovation Plateform", and more specially the deliverables D4.1, D4.2, which final version is under review with both CERTH and UTR.

During CPB in Goteborg (March 2018), a working session dedicated to WP4 was held, with the following conclusions:

"After a general introduction of the City innovation platform architecture three sprints were done based on different "use cases", addressing economy, mobility and energy challenges.

The use cases were developed in design sprints which resulted in a better understanding of the specification of the data required from the digital services needed and of the role and benefits of the city innovation platform.

The sprint method was highly appreciated by the participants. It is a motivating way to get input with people from different backgrounds. "

A "T6.6 preparatory workshop" dedicated to the set-up of the CIP was held on the 29th of May with Nice Ecosystem partners.

The "use case" approach enabled to address and anticipate the different transition tracks issues and challenges, whilst anticipating and covering potential technical constraints."

9.4.3 Gothenburg

The Data collection plan in not available yet. Information will be provided in D5.4.

9.5 Regulatory Framework per LH/FC

9.5.1 Utrecht

Current regulatory barriers in the Netherlands for energy storage, in static as well as in E- vehicles these encompass:

- Current netting rules do not provide any incentive for optimisation of storage in batteries behind the meter. E-drivers with (their own) solar panels are not financially stimulated to optimally use the self- generated renewable electricity and its storage capacity through a V2G system;
- Double energy tax discourages bidirectional V2G. (Each charging and discharging cycle (bi-directional charging), energy tax need to be paid on either the stored or consumed kWh. Private charging points at low-volume consumers are currently exempted from this rule. It is currently, however, unclear which regime applies to (semi-) public charge points).

Uncertainty about the possible use of smart charging for the grid operator's congestion management. The Electricity Act currently prohibits regional grid operators to own/operated storage capacity themselves. It is unclear whether they may use the flexibility that can be accessed using storage in batteries.

9.5.2 Nice Cote D' Azur (NCA)

At the European level, no regulation exists, which enables to better identify the framework or perimeter for the use and development of stationary storage systems. 2nd life batteries are thus neither regulated. At present state, the French regulation (as probably in Europe more in general), storage systems are treated as a conventional load (instead as a generation system) and thus, it is not exempt from the grid related taxes (connection and use charges), degrading the business model and hindering the development and adoption of the technology. A dedicated tariff system could favour their development. In the French case, large grid scale storage systems, fall under the public domain and are thus regulated accordingly, obliging to proceed under a public call for tender process. This makes it less attractive to private investors and operators.

For the integration of stationary storage systems in buildings, no clear regulatory system is given, leaving constructors and owners with many uncertainties and risks. A dedicated regulatory system could ease the development of adapted solutions and give clear signals to the concerned industrial sectors.

9.5.3 Gothenburg

The Gothenburg regulatory framework in not available yet. Information will be provided in D5.4.

9.5.4 Santa Cruz de Tenerife

The Tenerife regulatory framework in not available yet. Information will be provided in D8.1.

9.6 Bounds and Drivers per LH/FC

9.6.1 Utrecht

- Technical Bounds & Drivers: Utrecht has no experience yet in operating 2nd life batteries for storage of sustainable electricity and placing these in garage boxes with the apartment buildings. This implies that the demonstration will need to be carefully designed and performance of the batteries will be closely monitored,
- Legal: Current regulations in the Netherlands are not providing incentives for optimal operations of 2nd life batteries behind the meter because of: (1) double charging of energy taxes, (2) lack of financial incentives for storage behind the meter, (3) restricted rules regarding the role of grid operators in energy storage.
- Financial: Investment in 2nd life batteries behind the meter are currently not yet viable. Without subsidies there is no business models for operating 2nd life batteries. Legal and financial circumstances need to be changed to ensure replication of the solution.
- Environmental: Storage of electricity in 2nd life batteries can potentially lead to lowering of CO2 emissions as it enables higher shares of renewable energy sources to be integrated into the grid and reducing demand for peak capacity (usually based on fossil fuels).

9.6.2 Nice Cote D' Azur

Besides from the needs of increasing 2nd life batteries standardization and performances, the main issue to be addressed is the underpinning business model, as the operation of the battery needs the integration of a new actor in the existing economic landscape. The building sector is undergoing fast changes by current trends as the IoT or decentralized renewable energy systems, increasing the complexity of services and related contractual arrangements. 2nd life batteries and its related value chain, is increasing even more the complexity of the related technology procurement, contractualisation and operation chain. 2nd life batteries, are related in principle with the electric automotive industry; thus putting a new industrial player into the market-scape, together with the service provider who will ensure the correct functioning and maintenance of the battery system. The emergence of a more integrated market actor, able to provide the full service on the related value chain (from EPCM to BOT), could enable to reduce the barriers of acceptance for the client, by reducing the complexity of the interfaces for clients, which at date have no or little experience with such type of systems.

9.6.3 Gothenburg

The Gothenburg bounds and drivers are not available yet. Information will be provided in D5.4.

9.6.4 Santa Cruz de Tenerife

The Tenerife bounds and drivers are not available yet. Information will be provided in D5.4.

9.7 Business Models

9.7.1 Utrecht

The project will develop business models whereby second-life (former automotive) batteries may profitably be used for static energy storage on a building and/or a district level. The project will also examine depreciation against longevity of these specific batteries and potential extended use of stationary battery storage.

9.7.2 *Nice Cote D' Azur*

Reserve power as an income source - Up to now, power storage systems are mostly used as a way to increase self-sufficiency, do peak shaving and provide backup in case of power outage. Storage providers could use second-life batteries to provide complementary services and revenue streams, by participating to flexibility or capacity markets. The correct sizing of the system, considering this type of services already in the design phase, is a key factor for a successful business model. The sizing of a battery system should identify the correct factor of overinvestment which could make the overall business model more efficient.

9.7.3 Gothenburg

The Gothenburg activities, too, will look closely at developing business models for second-life batteries used for stationary energy storage in a building or district. The project will examine depreciation against longevity of these specific batteries and potential extended use of stationary battery storage. Joining parties in this project are Göteborg Energi, the publicly owned utility company; Volvo Buses, who are owners of the 1^{st} life of the batteries; and Stena Metall, a leading recycling company; and Chalmers University of Technology.

9.7.4 Santa Cruz de Tenerife

The Tenerife business model development plan in not available yet. Information will be provided in D3.2.