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The Urban Lab of Europe !

The FED Project
Journal N°1

Project led by the ***City of Gothenburg***

ENERGY TRANSITION

European Union
European Regional Development Fund

Région Hauts-de-France

The FED project

With this project, the city of Gothenburg aims to develop, demonstrate and replicate a novel district level energy system, integrating electric power, as well as heating and cooling. This solution embraces and enhances the use of technologies such as PVs, heat-pumps and wind into a larger system. To overcome the main challenges, the proposed solution contains advancements in system development and operation, business logistics, legal framework as well as stakeholders' acceptance.

The FED solutions consists of three cornerstones:
FED demonstrator area – The selected demonstration is located at a campus with about 15 000 end-users. It has a well-balanced set of property owners, energy infrastructure, and users, including prosumers as well as buildings with different needs and usage profiles. The area is exempted from the law of concession for electricity distribution, providing the opportunity to test and validate a local energy market. The prerequisites to optimize the use of primary and secondary energy using intermediate storage are well developed, as they are for generation, storage and distribution.

FED System solution – Our solution will optimise the use of low-grade energy to replace primary energy. Adding fossil-free energy sources while optimising different buildings usage profiles; one building's energy needs will be balanced with the surplus of another. Intermediate storage, fundamental to be a success, consists of heating/cooling storage in the building's structure, accumulation tanks or geothermal heat pumps, and batteries for electricity. An ICT service will support future volatile energy markets.

FED Business solution – Create new sustainable markets. The success of FED depends on cooperation and energy exchange between several stakeholders. To make it happen, a local energy market creating business value for each stakeholder will be developed.

Partnership:

- Göteborg Stad
- Johanneberg Science Park AB - Public/Private Company
- Göteborg Energi AB - Public Company
- Business Region Göteborg AB - Public Company
- Chalmersfastigheter AB - Private Company
- Akademiska hus AB - Private Company
- Chalmers - Research Centre
- RISE
- Ericsson AB - Private Company

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1 Executive Summary

Dear reader,

As I travelled to Gothenburg to study the FED project I studied the quote from its mayor Ann-Sofie Hermansson, once more:

"The FED project confirms Gothenburg as a frontrunner in developing the energy solutions of a fossil-free society. The idea is to reduce energy consumption by establishing a local market place for electricity, heating and cooling. Hopefully, this model will prove capable of speeding up the energy transition across Europe."

I am really happy that I get to fully grasp what it takes to do that and accompany the project in the following years. I will be there when the partners will try to:

- reduce external energy input
- reduce peak loads
- establish a market place

The results of these type of projects come with good design and preparation and it is in this phase of the project that I visit them for the first time. As expected, the project lead walks me through the area and we prepare a partner meeting together. It is visible that the partners have been cooperating for many years and that they are well prepared for the challenge they have set themselves.

The project is now a couple of months after the final investment decisions and the Academics from Chalmers have shown their models and results. This report does not focus on these two deliverables, but kicks off with a look at the market design RISE has made to make trade in heat, electricity and services on one market at Johanneberg in Gothenburg, possible in the first place.

Zeno Winkels

2 Smart grids in Europe

Policy context

Improving energy efficiency is a priority of the EU's Energy Union strategy. Energy efficiency has been identified as a key element for fostering European competitiveness, and for ensuring a secure energy supply and the reduction of greenhouse gas emissions. This has been translated into the 2030 objectives of the Energy Union, notably reducing Europe's energy use by at least 27 % compared to the baseline, and a 27 % share of renewable energy consumption.

Since heating and cooling represent about 50 % of the final energy consumed in the EU, potential savings in this area have to be identified and promoted. Indeed, 84 % of heating and cooling in the EU is still generated from fossil fuels while only 16 % is generated from renewable energy. In order to fulfil the EU's climate and energy goals, the heating and cooling sector must sharply reduce its energy consumption and cut its use of fossil fuels.

In February 2016, the European Commission proposed a strategy to make heating and cooling in the EU more efficient and sustainable. This strategy highlights the capacity of district energy systems to integrate the increasing share of renewable electricity generation (e.g. through the use of thermoelectric equipment) and to replace fossil fuels with waste heat and cold from industrial processes, waste-to-energy and renewable energy sources such as geothermal, biomass, solar thermal.

Efficient district energy systems can play a key role in the energy transition towards a low-carbon economy, acting as a backbone towards efficient local energy systems. Some European cities have already recognized the benefits of these systems and developed efficient and sustainable heating and cooling systems, which are well-functioning and result in a high-quality, efficient and low-carbon heat and cold supply to its buildings and industries.

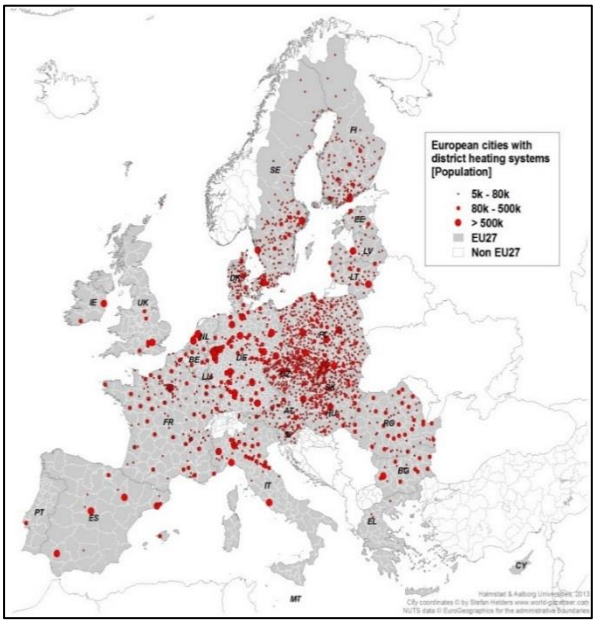


Fig. 1: District Heating Systems in Europe. Halmstad & Aalborg Universities 2013.

National

The first Swedish district heating system was introduced in Karlstad in 1948, when a thermal power station was converted to a combined heat and power (CHP) plant and heat was provided to an industrial facility. Nine major municipalities introduced district heating systems during the 1950s. Nowadays, all major cities and towns in Sweden have district heating systems. Current national statistics lists about 500 systems, also including small district heating systems in small towns and villages.

Customers buy district heat from the heat distribution systems in competition to other heat supply, since mandatory connections have no legislative support. Historically, district heat has mainly substituted fuel oil boilers as illustrated in

Fig. 2. This figure reveals also that the increase of market shares has been very steady during the fifty years presented. District heating is currently the market leader with a market share of about 55% during 2014 for all heat supply to buildings.

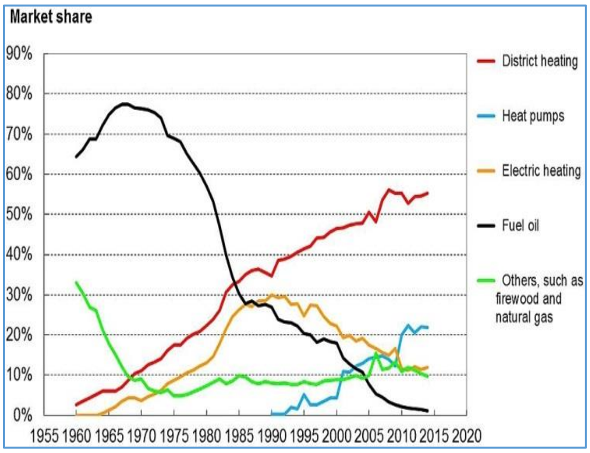


Fig. 2: Market shares for heat supply to residential and service sector buildings in Sweden between 1960 and 2014 with respect to heat delivered from various heat sources. Sven Werner.

During the last two decades, the use of individual heat pumps has been expanding and is now the main competitor to district heating with a market share of almost one quarter in 2014.

Smart Grids, however, are usually synonymized for electrical grids. In fact, when asked for a definition on Smart Grids, Google returns more than 4 Mln. hits of which the first one sums it up nicely: *'an electricity supply network that uses digital communications technology to detect and react to local changes in usage'*. Nicely, but not perfect as heating grids can be smart too.

The EU's JRC report on Electrical Smart Grids includes a total of 950 smart grid projects, launched from 2002 up until today, amounting to €5 billion investment. There are strong differences between Member States in the number of projects and the overall level and pace of investment, but private investment is clearly the most important source of financing of smart grid projects. European and national funding however, play an important role in leveraging private finance and incentivizing investment. Distribution system operators (DSOs) are the stakeholders with the highest investment, but non-traditional actors such as public institutions and other emerging stakeholders are steadily increasing their investment in the field.

The domains with highest investment are smart network management, demand-side management and integration of distributed generation and storage, together accounting for around 80 % of the total investment. Many projects however address several domains at the same time to investigate and test the systemic integration of different solutions.

The distribution of these projects is shown in the next figure although one must keep in mind that these projects are around electricity rather than heat networks, let alone the combination, as demonstrated in the FED project in Gothenburg.

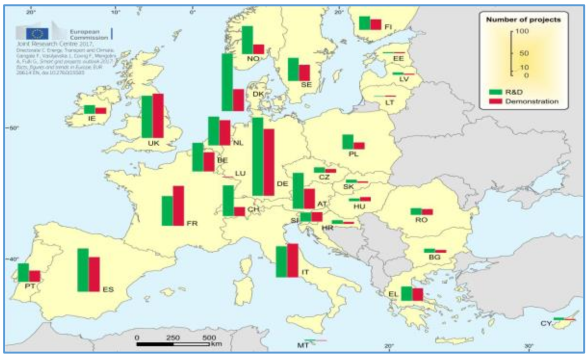


Fig. 3: JRC Report, 2017.

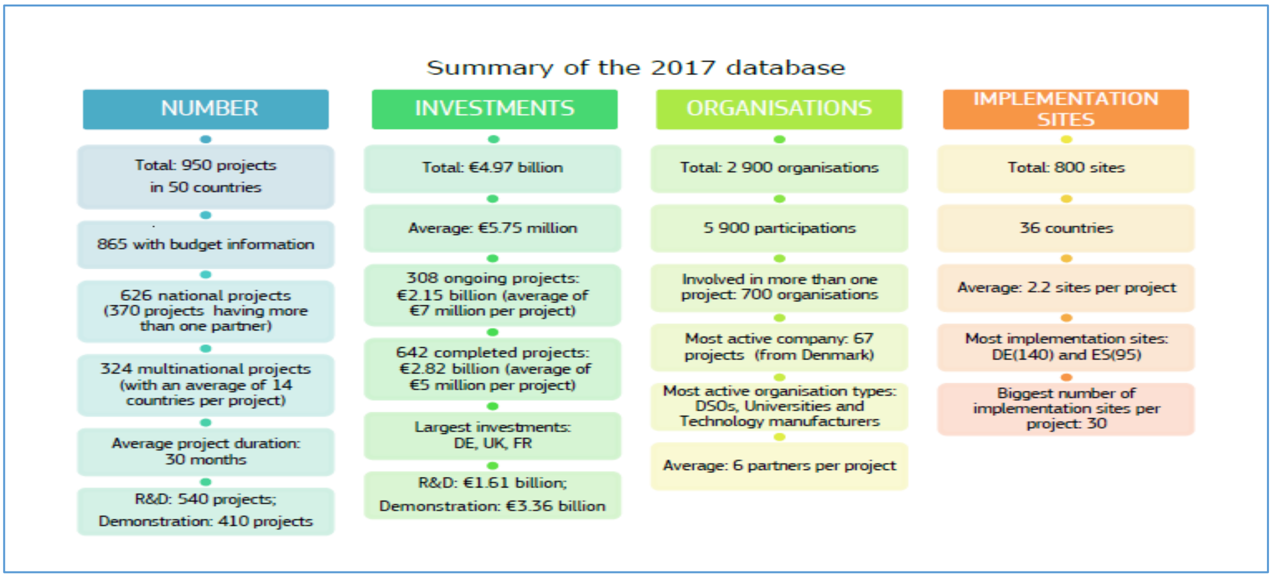


Fig. 4: JRC Report, 2017.

The JRC report also concludes that besides strengthening the national export potential, a favourable national policy and regulatory framework is important to make the country attractive for foreign smart grid investment. In particular, the adoption of smart grid roadmaps is a clear sign that smart grids are high on the national agenda, thus attracting foreign investors to seek partnerships with local stakeholders to enter the national market. So far only a few Member States have adopted roadmaps for the swift development of smart grids (e.g. Denmark, Germany, Ireland, France, Austria, Slovenia, Sweden and the United Kingdom) and one can already notice a clear positive correlation with the number of smart grid projects in these countries.

It is the EU's SETIS website[1] that goes into details of **smart heating grids** and explains: Smart district heating and cooling grids manage the supply side through the intelligent use of heat storage and absorption refrigerators, with appropriate control systems. Such systems balance the heating or cooling available – taking into account the availability of stored energy, waste heat from industry, heat from CHP plants (which varies according to electricity demand), and solar heat – with the current demand.

Several smart district heating networks have been already implemented in Sweden and Denmark, predominantly in residential sector. In the mid-term they can be expected to spread across Europe's residential sector. Existing systems are also being upgraded to smart status.

Future developments include the further optimisation of control systems, improved supply management to integrate renewable and waste heat, new or improved energy storage technologies and the greater adoption of trigeneration (combined generation of electricity, heating and cooling).

The Heat Roadmap Europe 4 project is mapping and modelling the heating and energy systems of the 14 largest users of heat in the EU, to develop new policies at local, national, and EU level to ensure the uptake of efficient, sustainable and affordable heating and cooling solutions. HRE4 plans to cover the 14 countries in the EU ranked largest by heat demand.

With these 14 countries, it will cover 85-90% of the heating and cooling demands in Europe; this means its results are hugely relevant for the EU level. See www.heatroadmap.eu.

[1] https://setis.ec.europa.eu/.

3 Project goals FED

FED aims to develop, demonstrate and replicate a novel district level energy system, integrating electric power, as well as heating and cooling. This solution embraces and enhances the use of technologies such as PVs, heat-pumps and wind into larger system. The solution will drastically reduce peak loads and the use of fossil primary energy to such an extent that Gothenburg has the possibility to be a no-carbon City if deployed on a greater scale.

To overcome the main challenges, the solution contains advancements in system development and operation, business logistics, legal framework as well as Stakeholders' acceptance.
So the FED solutions consists of three cornerstones:

1) FED demonstrator area –

The selected demonstration is located at a campus with about 15 000 end-users. It has a well-balanced set of property owners, energy infrastructure, and users, including prosumers as well as buildings with different needs and usage profiles. The area is exempted from the law of concession for electricity distribution, providing the opportunity to test and validate a local energy market. The prerequisites to optimize the use of primary and secondary energy using intermediate storage are well developed, as they are for generation, storage and distribution.

Hardware investments include additional infra structure, adaptation and reconstruction of district heating and cooling systems in the test area (e.g. new storage capacity), and development of the electric system (e.g. increased non-fossil electricity generation), PVs and a bio-fuelled CHP-turbine, and battery storage capacity. Furthermore hardware to connect electricity/heating- and cooling system infrastructure to the energy market trading system will be installed, and a showroom will be built.

The total amount of investments in control systems has been decided but the actual tender has not taken place yet. The investments will enable functions needed to meet the system requirements of controlling the integrated energy systems, and to enable the local energy market trading system. This includes for example a metering systems enabling real-time measuring (electricity and district heating/cooling), a control system, for the PVs and connected battery storages as well as the CHP-turbine, and interfaces/applications to connect the local electric-, district heating- and cooling system to the local energy market trading system.

2) FED System solution

The solution will optimize the use of low-grade energy to replace primary energy. Adding fossil-free energy sources while optimising different buildings usage profiles; one building's energy needs will be balanced with the surplus of another. Intermediate storage, fundamental to be success, consists of heating/cooling storage in the building's structure, accumulation tanks or geothermal heat pumps, and batteries for electricity. An ICT service will support future volatile energy markets.

A web-/cloud-based local market energy trading system will be developed, deployed and put in operation. The total investment has also been agreed, but not bought yet. The system will enable the partners to trade electricity- and district heating/cooling in the area.

Although the fundamental energy systems and structures needed in order to build a FED system are already in place at the university test area, additional investments are required to make the physical structures meet and become able to exchange energy flows. Increased capacity of fossil free energy generation is another crucial component in the test area to meet FED objectives. From an innovation perspective it represents an expected increase of prosumers. When it becomes good business for a real estate owner to self-generate part of the energy needed instead of buying from the grid, the business interest for matching temporary surplus/demand with other stakeholders is likely to grow.

Energy storage capacity is another key. Ability to save energy surplus from one time to another increases the chance of making use, and hence business, of temporary fluctuations. Investment in several energy storage technologies working on different time-scales are motivated for functional reasons and for innovation reasons, since the market is early-phase and the potential large.

3) FED Business solution

Create new sustainable markets. The success of FED depends on cooperation and energy exchange between several stakeholders. To make it happen, a local energy market creating business value for each will be developed.

To make the FED hardware useful and synchronised, development of control functionality is required and motivates investments in corresponding control systems. The local market place is the revolutionary enabler of the FED system and makes it possible for prosumers to create business with the neighbours, which motivates investments in a web/cloud-based trading system.

4 The FED partnership

Intro

As in all UIA projects the city is the first partner and the official leader of the project. They are the owner and Urban Authority and carry the project. Sweden has a great legacy and history in terms of environmental and social sustainability and Gothenburg is a living example of sustainable urban development. The city is among the world leaders in sustainable construction, waste management and re-usable energy, and at the cutting edge of environmental certification of hotels and events. In autumn 2013 Gothenburg also became the first city in the world to issue a green bond for investments that benefit the environment and climate.

Gothenburg, is the second-largest city in Sweden and the fifth-largest in the Nordic countries. It is situated by Kattegat, on the west coast of Sweden, and has a population of approximately 580,000 in the urban area and about 1 million inhabitants in the metropolitan area.

A great deal of environmentally beneficial work is taking place in Gothenburg although it is evident that more powerful initiatives are required if it is to achieve all its environmental objectives. That ambition is to contribute to a sustainable society and not pass on environmental problems to future generations. To achieve this, Gothenburg produced the first Environmental Program for the City of Gothenburg, a common starting point for the future. The Environmental Program includes an action plan, complete with actions that all City of Gothenburg administrations and companies are now set to implement in order to successfully realise the 12 environmental objectives.

"In the FED project, Gothenburg City is presenting and testing new solutions that will lead to a fossil-free society. FED, the Fossil-free Energy Districts, is an innovative pilot project at the Chalmers University of Technology's campus area, Johanneberg, which will last for three years, where a holistic approach to energy systems and the environment will be in focus. Several organizations and companies in the city will together and in an integrated way create a local energy system market and trading venue, to reduce energy needs and cut energy bumps. With the FED project, Göteborg City continues to be at the forefront of a sustainable society".

Eva Hessman, CEO City of Gothenburg

Gothenburg is also home to many students, as the city includes the University of Gothenburg and Chalmers University of Technology. Key-companies are Volvo, SKF and Astra Zeneca.

Johanneberg Science Park was established in December 2009 by the Chalmers University of Technology Foundation and the City of Gothenburg together to create better conditions for regional sustainable growth, based on the activities currently conducted within Chalmers University of Technology at Campus Johanneberg in Gothenburg, Sweden.

The organisation is owned by its founders the City of Gothenburg via BRG and the Chalmers University of Technology Foundation together with AB Volvo, Bengt Dahlgren Göteborg AB, Förvaltnings AB Framtiden, Göteborg Energi, HSB, MölnDala Fastighets AB, Peab Sverige AB, Riksbyggen, Skanska AB, Tyréns AB,Wallenstam AB and White arkitekter AB.

Johanneberg Science Park supports companies seeking to boost their competitiveness and growth potential through innovation projects together with other companies, universities and institutes. Its role is to broker, formulate and sometimes run projects, but more often involves training and coaching companies to lead collaborative projects themselves. They can act as an intermediary between networks, contacts and skills.

Johanneberg Science Park is one of 80 innovation environments throughout Sweden – of which 6 here in the region – which together comprise more than 5,000 companies with around 72,000 employees.

Fig. 5: Picture from Johanneberg Science Park.

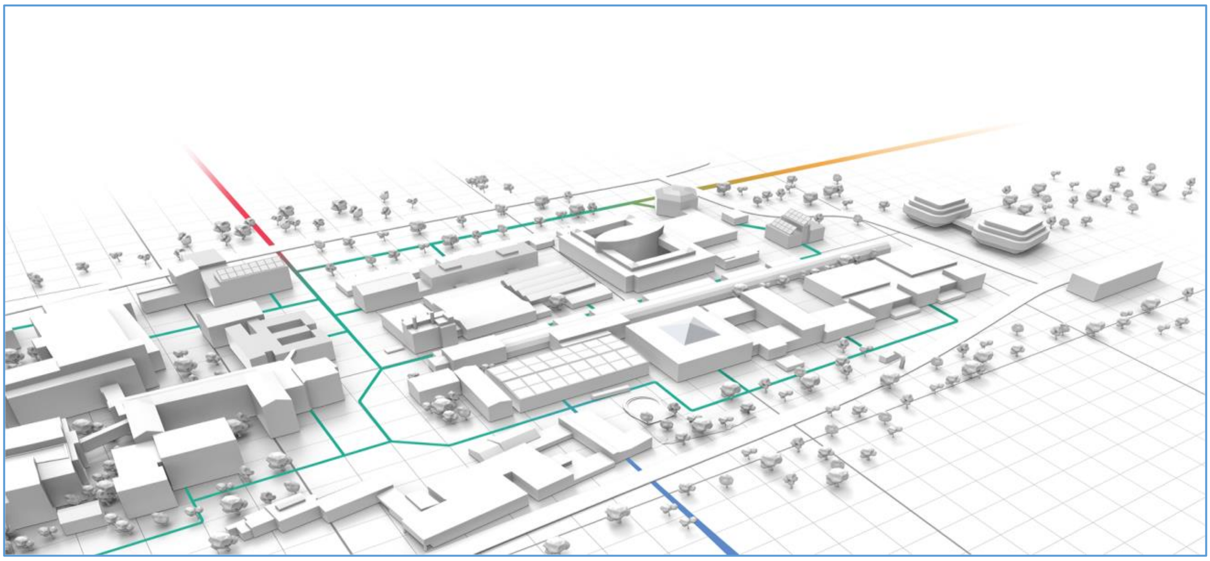


Fig. 6: Demonstrator area Johanneberg Science Parc.

"Johanneberg Science Park is used to lead projects as the Fossil-free Energy Districts. As being co-owned by Chalmers University of Technology, the City of Gothenburg and industry, we have a natural role as the central part of the project. As we are nine strong partners we hope to extend the best from each and every partner to fulfill our goals for this innovative and important project towards a fossil-free world".

Iréne Svensson, Project Coordinator Johanneberg Science Park.

Göteborg Energi is one of the leading partners and a provider of Energy supply both to buy and sell over the grid. Both electric grid and district heating and cooling. Göteborg Energi will be involved in operating the economic control room and therefore an important part of setting up the trade criteria, as well as the R&D department with Patrik Arvsell; project leader and part of the R&D department.

Business Region Göteborg (BRG) has been involved in the design phase from the start due to their long experience of promoting business development in the City, for marketing activities nationally and internationally, and for creating and collaborating with international networks.

BRG's competence for replication and dissemination will be of great value for the FED project. BRG has collaborated with all the other FED partners in different Smart Cities project and activities.

"Innovation is key to sustainable business and our expectation is that the outcome can both be new services, business models and international opportunities for outbound and inbound businesses. Showcasing the test bed is a great way to market Gothenburg, Chalmers and our industry."

Lars Bern, Area Manager Innovation

Chalmersfastigheter (CF) is one of the two main real estate companies on Chalmers Campus. CF together with Akademiska Hus (AH) has the responsibility for energy supply to the entire Campus. CF is working closely with the City of Gothenburg, as well as with all other partners in the FED project, in different energy efficient projects. Involvement in the implementation phase Chalmersfastigheter (CF) is one of two main real estate companies on Chalmers Campus. CF together with Akademiska Hus (AH) has the responsibility for energy supply to the entire Campus. CF and AH plan to develop the energy networks (heating, cooling and electricity) on the Campus.

Akademiska Hus (AH) has a long and solid understanding regarding all matters in the operative energy questions within the local grid. AH has also knowledge regarding all technical requirements of the buildings within the area as well as the specific supply abilities. AH internal personnel is also, together with Chalmers university, responsible for the daily operation of the "Kraftcentralen", a local district heating, cooling plant and electric grid for high voltage system for Campus Chalmers. The regional organisation of Akademiska Hus is running the local district system on a daily basis in symbiosis scientists from Chalmers university.

"The opportunity to retain heat in our building and use the inertia at the economically best moment can be of value not only as a proof-of-concept in this project since we have similar conditions on 15-20 locations around Sweden. '
Peter Karlsson, Head of Innovation
'The extended cooperation with tenants and other partners, the inclusion of technical systems and know-how in our rental model and the need to collaborate to solve tomorrows energy challenges are clear reasons for us to fully embrace this project."

Per Loveryd, Energy engineer

Fig. 7: Project lead Irene Svensson overlooking the location were Akademiska Hus will invest in a new CHP and buffer storage. The wall is ready for dissemination material!

The role of **Chalmers** is to ensure that state of art technologies are implemented and that the micro grid can be used for future research purposes. Division of Electric Power Engineering (EPE), Department of Energy and Environment and Division of Building Technology (BT), Department of Civil and Environmental Engineering will be involved. Additionally BT and EPE will conduct measurement and evaluation of the technical performance of the micro grid.

The role of **RISE** is to ensure the relevance of the project for stakeholders, including industry and authorities. RISE will contribute to the development and specification of ICT systems and electrical power components, with measurements, and with research on market designs and business models. Micro grids, intelligent energy systems and energy systems integration are foreseen to play a central role in a sustainable future energy system. As an institute, RISE has an interest and a responsibility to contribute to this development and to facilitate the introduction of technologies and businesses to various stakeholders. An important aspect of this is pilots and demonstrations.

RISE Measurement Technology has extensive knowledge on electrical power, sensors and ICT, and energy markets. The program Intelligent Energy Systems at RISE includes R&D projects in high voltage technologies, grids and systems, and demand-side and services. These projects relate strongly to the contents in this project.

Ericsson is a multinational networking and telecommunications equipment and services company headquartered in Stockholm, Sweden. The company offers services, software and infrastructure in information and communications technology (ICT) for telecommunications operators, traditional telecommunications and Internet Protocol (IP) networking equipment, mobile and fixed broadband, operations and business support services, cable television, IPTV, video systems, and an extensive services operation. Ericsson had 35% market share in the 2G/3G/4G mobile network infrastructure market in 2012. ER have excellence experience e.g. in transforming energy for distribution and have been participating in several EU projects. Locally ER have participated in the Electricity project providing the Service Enablement Platform collected data from the electrical Buses and made them available to App developers. ER has plan for providing Low Power Radio wireless access network to new sensors needed to enable the microgrid market place and the IOT platform and related services for the marketplace.

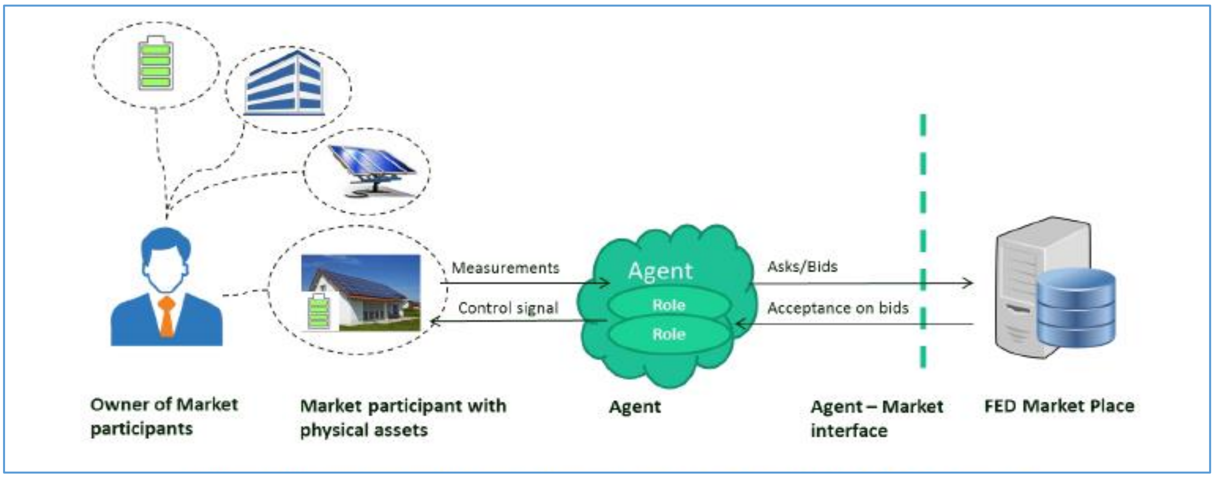


Fig. 8: RISE.

5 The FED solution

We know the energy system in general and the electric power system in particular, are undergoing significant changes, including integration of large amount of renewable energy sources on all system levels, new technologies on the demand side e.g. electric vehicles and heat pumps, and emerging technologies for energy storage and flexibility. This creates a new market environment, shifting the focus from the traditional perspective on large-scale facilities on transmission level to a local context and demand oriented perspective.

RISE, 2017

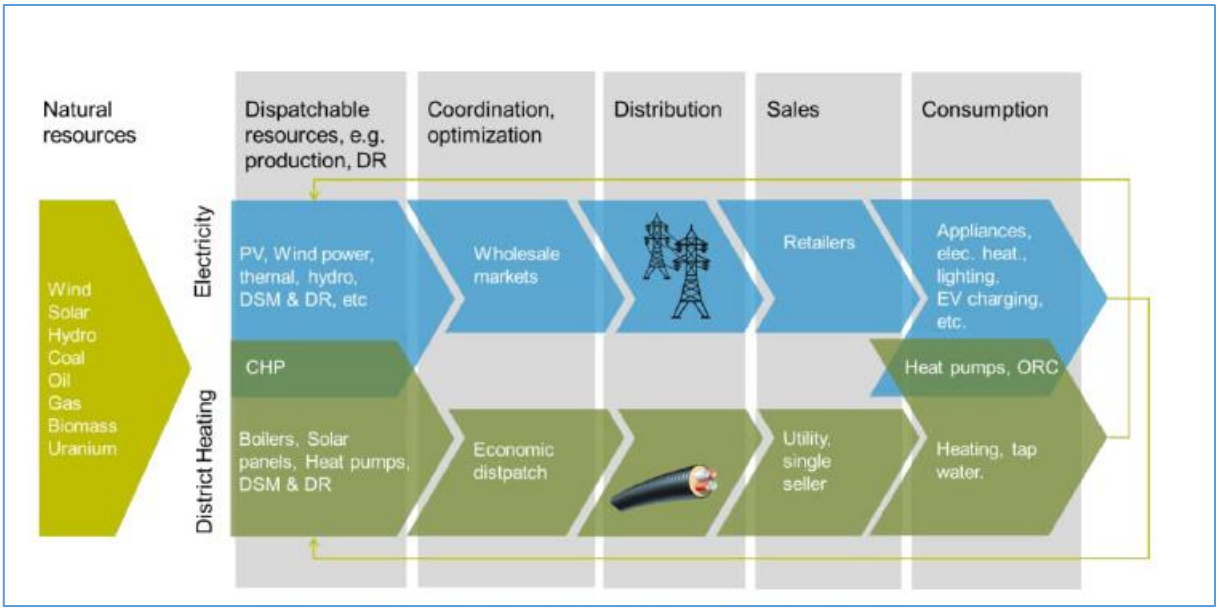
The foreseen establishment of photovoltaics and solar panels, electric vehicles and local storages will increase the demand for local exchange of energy and a more active market position of distribution system operators. Another factor emphasizing the local and regional perspective is the potential synergies of the integration of energy carriers such as electricity and district heating for e.g. balancing purposes.

Altogether, the factors above points towards a demand for, and development of, local energy systems and markets. The aim of the FED market design is to facilitate a more efficient use of local resources and the provision of system services targeting distribution system operators. This is performed by development of a local market facilitating local stakeholder engagement through adequate economic incentives and low thresholds to enter the local market.

The focus of the work has been on the economic principles under which the market is organised and operates. The following lies within the scope of it:

- Market structure and organization.
- Roles and responsibilities.
- Market clearing and pricing.

Due to the different characteristics of an energy exchange and provisions of system services, the FED Market Place includes an Energy Market (FED-EM) and a System Service Market (FED-



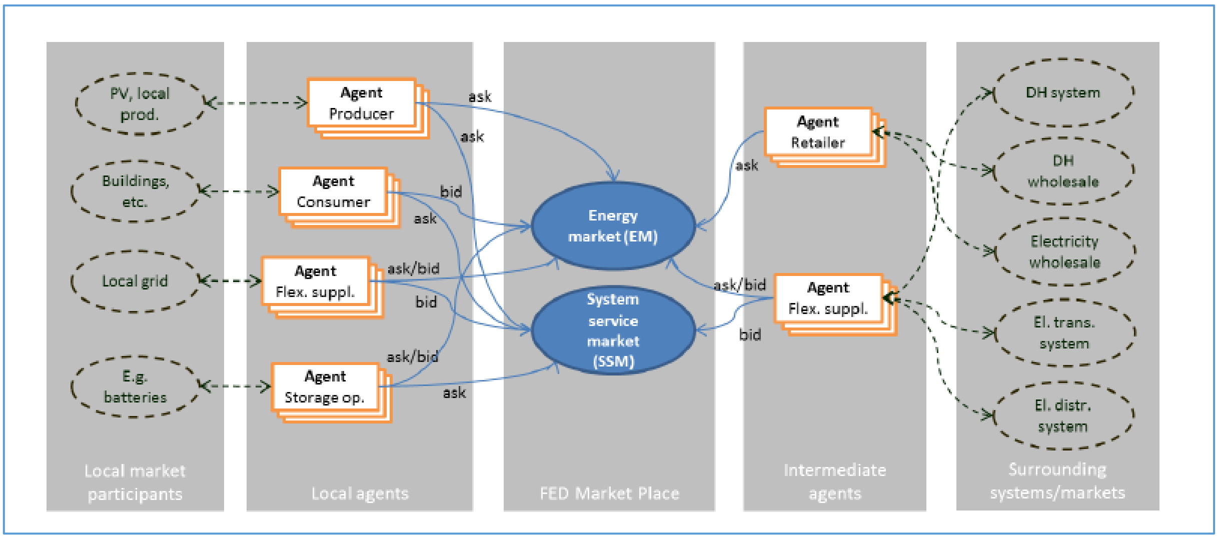


Fig. 9: RISE.

SSM). The design of these markets addresses interest of local stakeholders as well as the alignment with external markets and systems.

The commodity traded on FED-EM constitutes of energy quantities during trading periods, while FED-SSM is tailored for services targeting specific technical aspects of the distribution systems of the considered energy carriers. An important contribution of the FED market is the integration of different energy carriers, which are considered simultaneously.

The trading on the FED market is based upon bids submitted by software agents representing physical assets such as buildings, storages or local production. Agents are also defined linking the external market with the local market through retailers, flexibility suppliers, etc. The agents have the possibility to submit bids on different complexity levels according to their preferences and possibilities. The role of the FED Market Place is to clear the market and to facilitate and monitor the resulting transactions.

"Some of the FED strikes me as a natural follow up to parts of the work that has been done in the Horizon 2020 project[2] named Celsius"

Zeno Winkels, Expert UIA

6 Goals and process

The FED market concerns multiple energy carriers, e.g. electricity and heating. The characteristics of the electric power market and the district heating markets are however remarkably different. Electricity must be produced and consumed at the same instant and the electricity market must therefore be carefully balanced on different time scales.

District heating is a more inert energy carrier than electricity and therefore involves a different balancing process. While electricity is a commodity that can be traded cross-border via extensive grids, heat is a generally a locally traded product, transported via networks that are at most regional. The district heating market consists of many small and isolated local markets

[2] http://celsiuscity.eu/.

with little or no trade between different networks.

The FED project includes three specified energy related goals for the demonstration site according to the following:

1. Local energy production should be **100% fossil free.**
2. **80% less fossil energy peaks exported** (i.e. energy peaks from the local system causing external use of fossil energy).
3. **30% less energy imported from the overlying system** (as an effect of increased internal use of recycled energy, efficiency, and local generation).

The development of the FED Market Place should be viewed as one of the tools to achieve the fulfilment of these goals. This means that the market should be designed so that local actors and market players are incentivised to 1. invest in local renewable production; 2. reduce peaks in consumption; and 3. increase the efficiency of their assets through investments and/or more efficient operations.

The FED Market Place is therefore divided into two different markets:

- **FED Energy Market** (FED-EM), facilitating the coordination and matching of energy demand and supply over time.
- **FED System Service Market** (FED-SSM), facilitating provisions of system services to distribution system owners and system operators tailored to the demands of different energy carrier systems.

These two markets share a large part of the ICT infrastructure, but can be run separately from each other concerning clearing and settlement. Hence, they are not included in each other clearing or coordination functionalities. Depending on the application of the FED Market Place, the need for an implementation and application of FED-EM and FED-SSM may differ. Thus in order to further promote replicability of the developed solutions, FED-EM and FED-SSM are designed to work independently from each other.

The FED market has been decided to take the functionality of existing energy market places to the next step by including flexibility in terms of shift or loads in time or switching between energy carriers explicitly in the energy market clearing process. The different needs and characteristics of local exchange of energy and provisions of system services lead to the distinction and division of the FED Market Place to include an energy market (FED-EM) and a system service market (FED-SSM). These are operated under totally different principles, where FED-EM concerns trading in discrete time using trading periods and applies an integrated perspective on different energy carriers, while FED-SSM is tailored to specific energy carrier system needs and is operated in continuous time.

7 Interview RISE

The fika is a concept in Swedish culture with the basic meaning "to have coffee", often accompanied with pastries, cookies or pie. I was aiming for a fika over the deliverable on the report on the marketplace by RISE in the project, as I had some questions. Due to time restrictions this particular fika never happened. But I am glad that Johan Söderbom, Maria Thomtén and Magnus Brolin found time to answer my questions later.

Did I understand your institute changed its name? Why? SP was such a household name?

Johan Söderbom:

Three of the large research institutes in Sweden; SP, Swedish ICT and Innventia, were merged into RISE Research Institutes of Sweden. The new constellation is a strong and competent innovation partner, well suited to address the complex challenges of today’s society. RISE is now an organisation of about 2200 highly skilled employees and having experimental facilities in about 60 different testbeds.

When I started to read about the market design I was expecting a market for electricity and a market for heating. You have designed a double market, one for commodities and one for services. Why was that necessary?

Magnus Brolin:

The overall idea of having a common market for heating, cooling and electricity is to exploit any synergies that can appear with a cooperation of multiple energy carrier systems. Such as the flexibility of using either district heating or a heat pump for heating purposes. So, when concerning the energy a coordination approach makes sense. However, when it comes to system services, these must be tailored to the specific technical needs for each energy system since these are very different from each other. This is also one of the reasons of having two different market places; one for exchange of energy and one for system services. Also, system services often requires a much shorter response times to be effective; the energy market is operated on an hourly basis, and this is not sufficient for supplements of system services. The different natures of the needs for energy exchange and supplements of system services therefore led to the decision on having two separate markets.

Johan:

Another aspect of creating a common market place for a local energy district is to lower the threshold for new actors to enter a market with assets that provide flexibility. This will hopefully attract more players to make assets available that otherwise would not be accessible for overall system balancing.

Did you find many examples of different energy commodities traded in one system?

Magnus:

This is mainly related to the different energy carriers in the system. Concerning the energy market, this is specified through different demand and supply bids, which are defined for the different energy carriers considered (mainly district heating and electricity). These are however still expressed in terms of energy.

I understand the inertia of buildings can now be used to find optimum moments for heating or selling. Can an electric car fleet also work as a battery for the PV system?

Maria Thomtén:

Yes. The Vehicle-to-Grid idea has been around for some time but has not yet had a major breakthrough. This would imply great opportunities to store excess power when demand is low and feed it back to the grid when demand is high.

Magnus:

Yes. From a market perspective, it is up to the agents to decide upon how the underlying physical assets are being used; e.g. by letting EV batteries be applied for storage purposes for the system. An agent representing both a PV and EV can decide on having an "internal balancing" before deciding on what bids to submit to the market. This is up to the owners of the agents to decide.

Do you think that software can eventually optimise the system over costs or should the actors also have sustainability goals in their buying strategy?

Magnus:

Again, it is up to the owners of the agents to decide upon. There can be either purely economic factors, but also environmental factors such as CO2 emissions. The market software itself does not impose any restriction on this. Since energy market prices typically are correlated to the use of fossil fuels, the CO2 emissions are considered also when considering purely economic factors, but by including a specific CO2 signal this could be even further emphasized.

What happens with VAT when one building sells it surplus heat?

Johan:

As in all new endeavours there will be old structures that one come into conflict with, the taxation of energy is one. The FED-project is an excellent opportunity to get an understanding on the impact of this. There are parts of the project that are looking into acceptance and barriers for introduction of local energy markets.

What are the main legislative challenges when the system would roll out over a district with many different owners?

Magnus:

The EC has established the concept of Local Energy Communities (LEC), which in many aspects reflects the development of local energy systems and markets, such as FED. However, it is not clear as of today how these LEC should be interpreted or implemented in national legislation. There are a number of question marks and challenges that need to be resolved before this can be rolled out on a larger scale. Two of these challenges relates to the ownership and operation of grids (concession) and the role of balance responsible parties in relation to aggregators. Regulating authorities in many different countries in Europe are currently looking into such aspects. Further, the developed system includes operation of an energy exchange, which depending on country can be subjected to different monitoring requirements and practices.

To upscale the system to a real world setting – we all know an Academic Campus is not the real world- what barriers would you expect immediately?

Maria:

This is to a great extent depending on the contextual conditions where the local energy system is implemented, especially when it comes to regulations and legal barriers. Regulations for energy infrastructure and trade are not harmonised throughout Europe yet. Apart from the rather complex regulatory/ legal aspects that might arise, one can also expect social and financial barriers.

Social barriers e.g. trends, norms and values are present on societal, community and individual levels. Some examples of social barriers that might hinder actors to become active participants of the local energy system and market are:

- Knowledge thresholds;
- Lack of trust towards the local energy market (e.g. related to the markets' liquidity, size, transparency or other);
- Insufficient (non-financial) incentives that could stimulate Demand Response/flexibility in consumption;
- Lack of social comparison and peer pressure/triggers. Pro-environmental behaviour is often enhanced when there is a visible product to display (such as a Tesla car or Powerwall battery) that sends a message to neighbours and peers. In the local market, trade is "invisible" to others and might therefore not be considered interesting.
- And some examples of economic and financial barriers are:
- The need for (sometimes joint) investments;
- Lack of well-tested and robust business models;
- Lack of well-tested and robust models for distribution of risks and revenues among different market actors;
- Lack of financial incentives to join the market and trade in the system;
- Low electricity prices/small price differences (at least in some regions/countries.

We know the Nordic countries are quite advanced in district heating system. Is there a part in the design of immediate value in Europe?

Magnus:

The market design takes into account the presence of different energy carriers, but does not specifically define heating and electricity. From a Swedish perspective, district heating and electricity is the most natural combination to consider, but from a European perspective other combinations such as gas and electricity might be of greater interest. The market design would also allow such combinations.

Maria:

Further, as the market design facilitates a switch between energy carriers it could imply even greater environmental benefits on an EU level than in Sweden. Natural gas holds a relatively strong position as a fuel for energy production in the EU and the implementation of a local energy market for electricity and gas could increase the possibility to switch natural gas for other energy carriers, thus decreasing the climate impact.

It should also be noted that EU aims at an integration of energy markets and has already taken steps towards a single European market for energy. The implementation of several directives, regulations and common rules for the internal markets for electricity and gas is already in place.

Energy markets that enable trade and integration of different energy carriers can support this development from a local level.

8 Challenges

It is worthwhile to have a look at the challenges encountered in the other UIA projects and the FED project. The following table provides an overview of the relevant issues, as an introduction to future Journals in which shall offer a closer look as to how the FED project addresses them:

TABLE 1: MAPPING FED AGAINST THE ESTABLISHED UIA IMPLEMENTATION CHALLENGES		
Challenge	**Level**	**Observations**
1.Leadership for implementation	Low	*As stated the FED project made up a consortium of partners that have a long working relation and synchronize in ambitions. Nevertheless it is extremely relevant here what Matti Mäkimattila, writes in his dissertation on systemic innovation (2014)[3]:* *Organizations develop certain knowledge bases embedded in structures and individuals, and these are dynamic in nature. Resources in organizations are often further discussed in terms of dynamic capabilities[4], mostly assumed to increase competence over time, but in dynamic contexts the direction can be also opposite, absolute or relative in a competitive environment. It is important to notice that certain path dependencies impact the interpretation of information[5] and the alternative choices available for organizations. This can also be observed from the perspectives of network maturity and integration development as presented in the Theory section of this dissertation – and the ability of centrally positioned organizations to orchestrate collaboration based on knowledge and network activities[6] On a larger scale, this is also seen as regime and landscape level changes[7].* *Partners will need to maintain and ensure their ongoing leadership throughout project implementation. The interconnections that are there by legal nature such as, ownership, tenant, legal enforcer, monopolist supplier, maintainer, to name a few, may become stretched , notably when hard decisions will need to be made. The commitment to the sustainability plans and the specific local ecosystem around the science park is a notably strong asset in that respect.*
2.Public procurement	Low	*Public procurement is increasingly viewed as having important potential to drive innovation. Despite this interest, often numerous barriers prevent the public sector from acting as an intelligent and informed customer.*

3 http://www.doria.fi/handle/10024/102205.
4 (Teece et al., 1997; Eisenhardt & Martin, 2000; Rothaermel & Hess,2007).
5 (Dixon, 1994).
6 (Powell & Grodal, 2005; Pfeffer & Salancik, 1978).
7 (Geels, 2002; 2004; 2005; Geels & Kemp, 2007; Geels & Schot, 2007).

		The combined knowledge in the consortium should help to solve the barriers related to processes, competences, procedures and relationships in the procurement and help to reap the benefits of innovation. *Since all investments will be made under normal regulation the typical public procurement challenges (timing, flexibility) will also have to be addressed by the project.*
3.Integrated cross-departmental working	Low	*The integrated cross-departmental working is a challenge identified in many UIA projects but not necessarily in the FED project. This is merely the case because many of the tasks & responsibilities of the –for example- landlord, of the tenant and of the energy supplier are legally assigned to the single organization rather than residing under one administration which could have been the case in earlier stages of development. One may argue therefor that some of the challenges found under the leadership list will have similar characters as other projects identify under integrated cross-departmental working.*
4.Adopting a participative approach	Low	*A participative approach has already been implemented in the FED project. However for smart grids to become mainstream project partners will need to find ways to include all consumers and producers alike.*
5. Monitoring and evaluation	High	*It is difficult enough to rate the renewable character of energy in one system but the mixing of various streams in multiple systems may sound nightmarish for those not so occupied with the material. The local input may be measured very well –for example from PV systems- but the national mix never has that granularity. Something different is that If the thermal inertia of a building is being used to supply heat to another building next door there is an argument to consider its residual heat, as well as an argument to consider the first building part of the heat infrastructure. It would be nice to see how different interpretations will be evaluated. The integration of different data if the FED system and their use and aggregation will notably be a strong focus point for the project.*
6. Financial Sustainability	Low	*Financial sustainability in this project is not negative to the normal. Where the project offers an opportunity is in higher efficiency which must long term enhance the financial sustainability of similar models. Different actors and real life investments as well as the academic scrutinizing of the results should inform the project which parts enhance and which parts weaken its financial sustainability.*
7. Communicating with target beneficiaries	Medium	*With up to 90% of the costs in office buildings connected to salaries and social insurances the argument for energy efficiency has not always been the most relevant for building owners and users.* *However in the light of Paris Climate agreements and the ambitions to have CO2 neutral urban areas in 2050, the FED project that explores –for the first time- the combination of heat and electricity in one smart grid system is very certain to create interest.* *The capturing of that interest, be it from municipalities, universities, other building owners, energy suppliers or even the private individuals owning small PV systems, or owning electric vehicles is must for the project, not to have been in vain.* *After all, one of the overarching goals of projects like the FED is to interact with partners that are doing the same but similar projects and explore the lessons learnt together.*

8. Upscaling	high	*The upscaling of the work will require considerable effort on almost all fields the demonstration works in. For starters: the area is exempted from the law of concession for electricity distribution, providing the opportunity to test and validate a local energy market. The question is really under which legal frameworks in Europe these solutions will be replicable. Furthermore the ownership structure is transparent and not complex which is often not the case in larger districts.* *However, one must realize that the energy transition is not going to be a race in which one solution emerges and is followed. It is very much a try & error process in which many particular technologies and consortia will benefit from each other and form an (excuse the pun) energetic landscape that works in its specific context. The current partners have interests enough in the rest of the Nordics and the world to play a significant role in the upscaling of the end results and should really aim for a clear articulation of the specific local characteristics and their relative importance to the business offer.*

9 Next steps

As I board my flight I start wondering about the next steps in the FED project. It is clear that to design a system that even uses the thermal inertia of buildings, you are going to need to invest in equipment. There are also some pretty decent investments on their way in a new CHP, in a thermal battery and of course in PV systems. I do not think the absorption chiller will make the list but look forward to the system analysis of its relative value.

Although innovations often struggle to get into tendering procedures I believe in this case the partners are doing pretty well as the specificities will be 'state of the art' no doubt, but as technologies not intrinsic innovative, hence not hard to tender.

Possibly except for Ericssons work, I must ask them next time. It is the system thinking and the communications in the marketplace with the real energy producing assets and the real buying actors that make the project so innovative and interesting.

So I make a couple of marks for my next visit:

- Where are these investments and how are they connected?
- What is the rationale of the different investments from the system perspective?
- Which of the decisions have a local character and which parts should be applicable all over Europe?

Zeno Winkels

Urban Innovative Actions is an Initiative of the European Union that provides urban areas throughout Europe with resources to test new and unproven solutions to address urban challenges. Based on article 8 of ERDF, the Initiative has a total ERDF budget of EUR 372 million for 2014-2020.

UIA projects will produce a wealth of knowledge stemming from the implementation of the innovative solutions for sustainable urban development that are of interest for city practitioners and stakeholders across the EU. This journal is a paper written by a UIA Expert that captures and disseminates the lessons learnt from the project implementation and the good practices identified. The journals will be structured around the main challenges of implementation identified and faced at local level by UIA projects. They will be published on a regular basis on the UIA website.

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