FED

FOSSIL-FREE ENERGY DISTRICTS

European Union
European Regional
Development Fund

UIA URBAN INNOVATIVE ACTIONS

THIS BOOK TELLS THE STORY OF THE FED PROJECT – AN INNOVATIVE LOCAL INITIATIVE IN GOTHENBURG AIMING TO FIND MODERN SOLUTIONS TO GLOBAL ENERGY CHALLENGES.

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WHY FED?

"MODERN CITIES ARE FACING A NUMBER OF GLOBAL ENERGY CHALLENGES. THE SOLUTIONS NEED TO BE MULTIFACETED."

PHOTO: CHALMERS UNIVERSITY OF TECHNOLOGY

Fossil-free Energy Districts (FED) is a unique project. It is connecting cooling, heating and electricity into a single system in a way that has never been done before. By balancing the urgent need for energy transition with ever-increasing energy demand, the FED project can play a key role in creating fossil-free cities in Europe.

Cities face a number of energy related challenges. Global warming has made a transition from fossil-based to renewable energy sources urgent. At the same time the power demand is increasing due to, for example, electrification of transport and industry as well as high construction rates in our growing cities. Added to this is the challenge of increased market fluctuations brought on by a higher share of renewable energy.

There is not a single feasible solution to solve all these challenges. The answer has to be multifaceted. It can contain increased investments in renewable production, different energy storage solutions and also local market solutions that optimises the local energy consumption and productions while staying connected to the overlaying system. →

PHOTO: CITY OF GOTHENBURG

The local, digital marketplace that has been created by the FED project on the campus of Chalmers University of Technology in Gothenburg, Sweden, can be one piece of the puzzle.

It has already moved positions for local energy systems forward. Upscaled and replicated it can help meet the energy targets of the European Union to increase the share of renewable energy to 32 % and improve energy efficiency by 32,5 % in the coming decade, as well as the UN Global Sustainable Development Goal nr 7: to ensure access to affordable, reliable, sustainable and modern energy for all.

FED is an innovative effort by the City of Gothenburg that was among the first to be awarded funding by the Urban Innovative Actions (UIA) initiative of the European Union. The purpose of the UIA initiative is to provide resources to urban areas in order to test new and unproven solutions to address urban challenges related to issues such as housing, mobility and energy transition.

The FED system has been developed between 2017 and 2019 by nine local partners representing academia, industry and municipality. The project ends in October 2019.

359 MILLION PEOPLE – 72 PER CENT OF THE TOTAL EU POPULATION – LIVE IN URBAN AREAS. THAT IMPOSES BIG CHALLENGES WHEN IT COMES TO ENERGY SOLUTIONS.

GUNILLA ÅKERSTRÖM
LEADER OF THE INNOVATION PROGRAM, GÖTEBORGS STAD

How does the City of Gothenburg work with innovation?

– Through its Innovation Programme, the City of Gothenburg systematically work to increase the innovation capacity within its administration. The FED project is an example of initiatives where the city has received EU funding to try out new solutions.

It resulted in a new testbed for energy, and also made the city more clearly positioned on the international innovation map. Gothenburg was among the first European cities to win the EU's call within the programme Urban Innovative Actions in 2017.

What is the key purpose of the City of Gothenburg's Innovation programme?

– The Innovation Programme is a politically determined direction for the whole city. Projects like FED are key to succeed in achieving our three goals; to create impact and benefit for our residents, visitors and businesses; to provide our employees with opportunities and to become a recognised, innovation-leading city.

In what ways has the FED project been beneficial to Gothenburg?

– It has been beneficial in many ways!

This new marketplace has attracted many different stakeholders to Gothenburg and we have also been invited to participate in many interesting forums.

We know that the societal challenges ahead are not something that individual actors will manage by themselves. That's why it is important for us as a city, and the development of our core services, that we become a good player in various forms of collaborations with industry and academia. The cooperation itself as well as the international visibility have been important added values for the city.

PHOTO: CHALMERS UNIVERSITY OF TECHNOLOGY

THE CHALMERS POWER CENTRAL, CPC, IS AN ADVANCED RESEARCH FACILITY FOCUSING ON CARBON CAPTURE AND BIOMASS GASIFICATION. THE FIRST BOILERS WERE BUILT IN 1947.

THE PROJECT RESPONDS TO MANY CURRENT DRIVING FORCES AND SOCIETAL CHALLENGES:

100 % FOSSIL-FREE ENERGY SYSTEMS

The energy transition towards 100 % renewables requires digital solutions for optimising and balancing the energy system. The high volatility associated with renewable, weather-dependent electricity generation puts a high demand on all players to interconnect and interact.

LOCAL ENERGY SYSTEMS CO-EXISTING WITH CENTRALISED GENERATION

The price drop on solar PVs enables and entails new roles for property owners and energy companies. Local electricity generation and local energy systems need however to co-exist with the external energy systems for a secure energy supply, around the clock.

DIGITALISATION AS A DRIVER

The mega trend of digitalisation is a driver in itself and in this project the new digital era can be used as an enabler.

THE TOTAL PROJECT BUDGET IS 5.8 MILLION EURO.

HIGHER ELECTRICITY DEMAND AND MORE GRID CONSTRAINS

The current mega trend of urbanisation puts higher demand on cities to provide its citizens with electricity, heating and cooling. In combination with the electrification of the mobility sector and also industry, the need for electricity in cities is ever increasing. Existing grid infrastructure will increasingly face challenges responding to growing demand.

GRID STABILITY IN A VOLATILE POWER SYSTEM

In a future fossil-free energy system, there will be an increased need for further contribution to grid stability. Along with increased digitalisation new opportunities occur for small scale generation units to participate in this contribution, both locally and nationally. A local energy market like FED is able to facilitate and make such local contribution possible.

OPTIMISATION AND SECTOR COUPLING FOR MORE FLEXIBILITY

The possibilities of sector coupling are widely discussed: how can the dependence of a specific energy carrier be avoided in favour of more flexibility for the user, and thereby use the price volatility on the energy market?

WHAT IS FED?

"FED IS CONNECTING COOLING, HEATING AND ELECTRICITY INTO A SINGLE SYSTEM IN A WAY THAT HAS NEVER BEEN DONE BEFORE."

FED is a bold demonstrative project testing a local digital marketplace that combines the three energy carriers electricity, heating and cooling, for the first time. Together, nine local partners – including academia, property owners, global ICT provider Ericsson and Gothenburg's municipal energy company, Göteborg Energi – has designed and implemented the FED-system and successfully delivered four vital outputs in the project; **the energy system, the local energy market, the testbed** and **the replication strategy.**

JOHANNEBERG SCIENCE PARK AT CHALMERS CAMPUS.

In the first step, the existing energy system of the campus area was supplemented with additional solar PVs, heat pumps and energy storages. The second step involves the real innovation of the project which was to connect the energy system to the local energy market, the fully automated ICT-solution developed by Ericsson where AI-agents trade energy on behalf of the different market actors, like buildings consuming and/or generating energy. In parallel the project made sure to invite third party actors to use FED as a testbed, thus ensuring that the investments of FED would have a greater reach. Last but not least, the project has laid the ground for a future where it can start to become a real solution to the energy transition challenge. The replication strategy provides insights on drivers and barriers as well as a number of policy recommendations for the local and national levels, as well as the EU-level.

Energy system

Local energy market

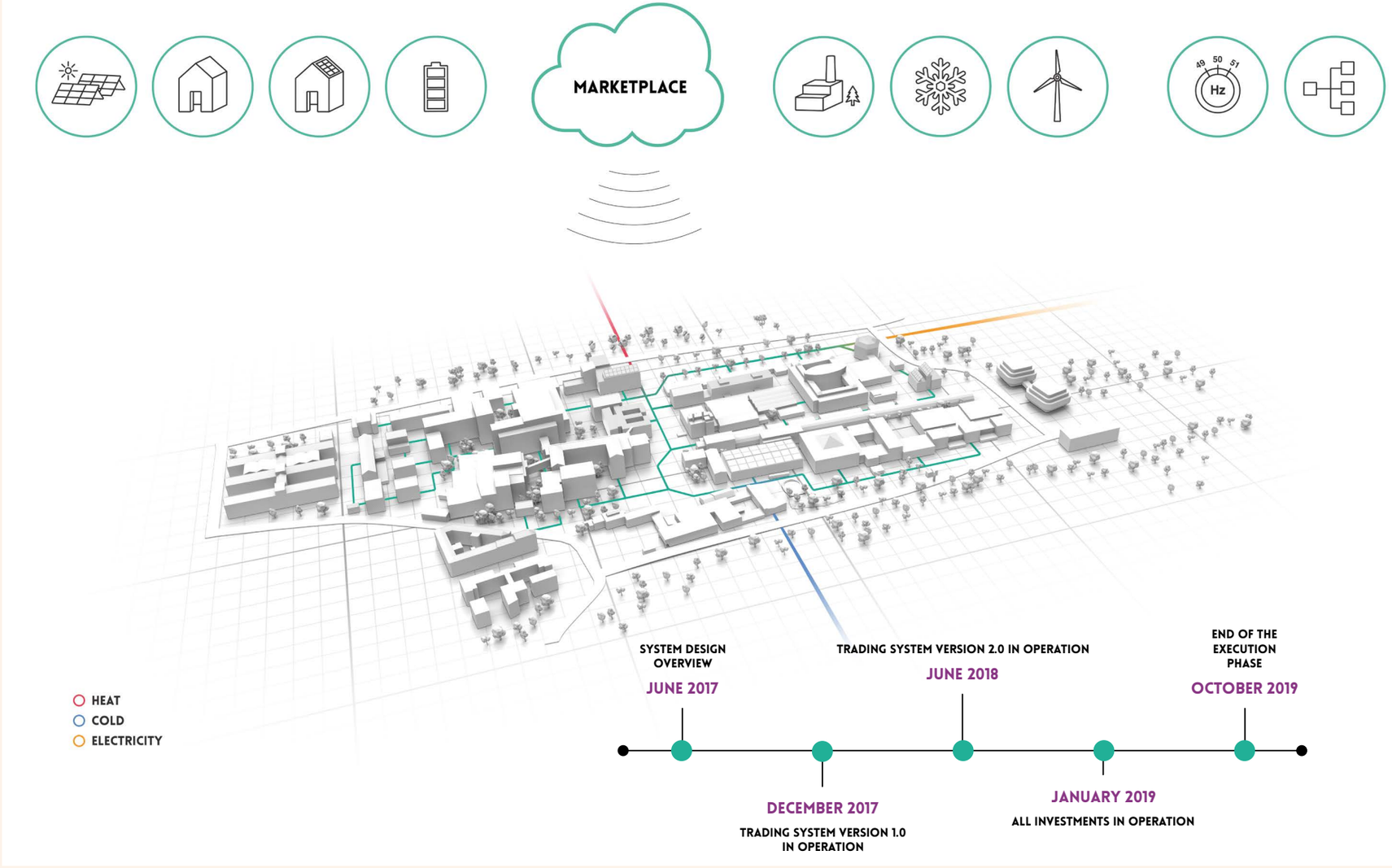
Testbed

Replication strategy

THE ENERGY SYSTEM

THE ENERGY SYSTEM INVOLVES MORE THAN 50 FED MARKET PARTICIPANTS:

24 consumers	Premises, homes, electrical car pools, electrical buses etc.
11 prosumers	Buildings with solar PVs, heat pumps and cooling units.
2 producers	Buildings with biofuelled heat and power, heat pumps, cooling units and solar PVs.
16 storage	Building thermal inertia for heating and cooling, water storage for cooling, PCM-storage for cooling, Li-Ion batteries.
3 external producers	Electricity, district heating, district cooling.



Most of the units were in place before the FED project, but some investments were made in the project; a new heat pump that recovers heat from the cooling system, two new Li-Ion batteries, solar PV installations, a PCM storage, upgrade of control systems, solar PV inverters with grid services and upgrade of a steam turbine to provide grid services.

THE FLEXIBILITY IN THE SYSTEM IS ABOUT 10-20 % OF THE MAXIMUM DEMAND FOR EACH ENERGY CARRIER:

	Electricity	Heating	Cooling (kW max)
Consumption	**5 800**	**14 000**	**4 000**
Production	**1 100**	**15 725**	**1 740**
Flexibility	**1 050***	**1 500**	**625**

*Includes loads that can be shifted to other utilities.

FED IS A PIONEER PROJECT LOCATED TO GOTHENBURG, BUT REPLICABLE IN OTHER CITIES OR PLACES OVER THE WORLD.

THE LOCAL ENERGY MARKET

The local energy market is built on the Ericsson IoT Accelerator platform. In the energy market a solver clears the bids every hour with an optimisation routine developed in the project. Every market participant is represented by an agent that analyses the situation and then places or accepts bids. Artificial Intelligence is used in some agents to improve the performance.

- Bids are placed every hour for the coming 10 hours, around the clock, for electricity, heating and cooling.
- Bids on production, consumption and flexibility.
- The system optimises the overall cost, but can also consider CO2-emissions and/or primary energy.
- Systems services are also supported with the service market module, down to near-real-time.
- Grid limitations are considered within the market.
- More than 100 000 transactions were registered during the first six months of operations.

BENEFITS WITH THE FED SYSTEM:

Adaptation to renewable energy systems

Conditions change when wind power and solar energy gradually replace today's fossil-fuel and nuclear based power supply. A digital system like FED is crucial for manging large supply of volatile power and optimising the use of renewables, using weather forecasts and prognoses for energy use.

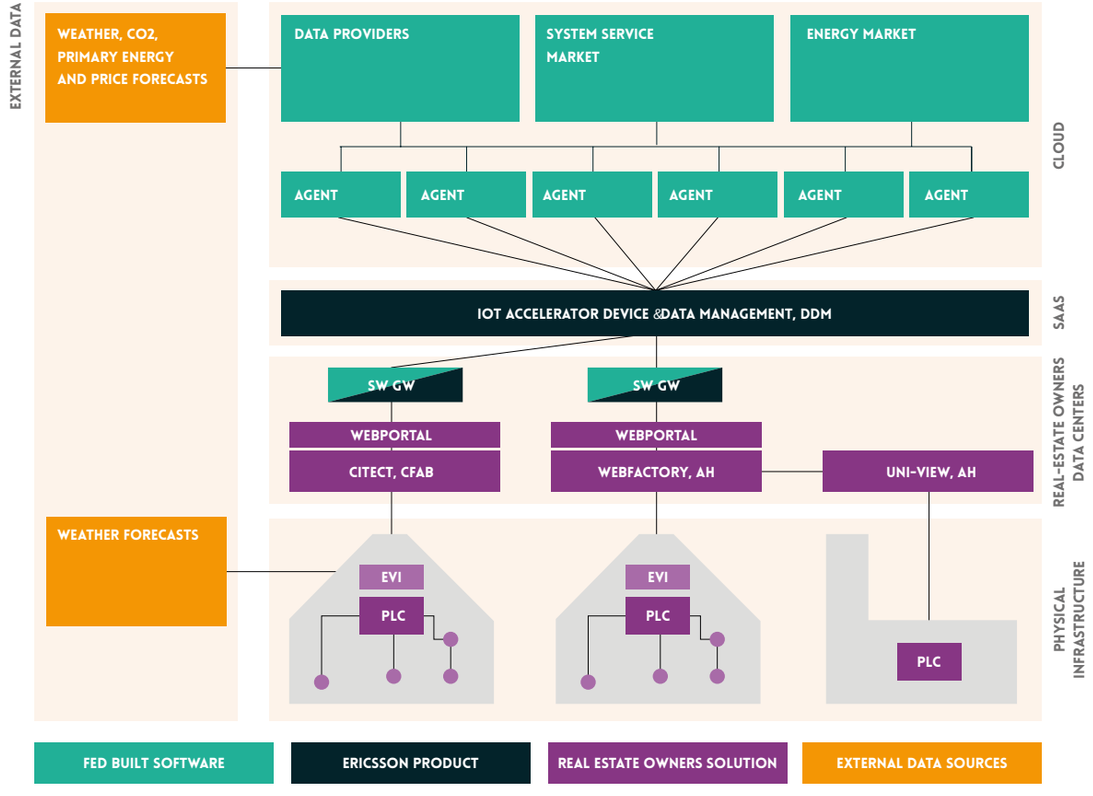
Avoid fossil peaks in the city's networks

The FED local energy system is connected to, and dependent on, the electricity grid and Gothenburg's district heating network. By optimising the use of energy storages in the FED energy system, batteries, thermal inertia in buildings and cooling storage using phase changing material, the import of energy from the city grids can be lowered and more balanced. If this were to happen on a larger scale, Göteborg Energi would be able to reduce the utilisation of its remaining fossil-fuelled power plants.

Remedy power shortage

Demand for energy is increasing due to electrification in the transport sector, and in industry. To build new power lines from centralised electricity generation is both expensive and time consuming. →

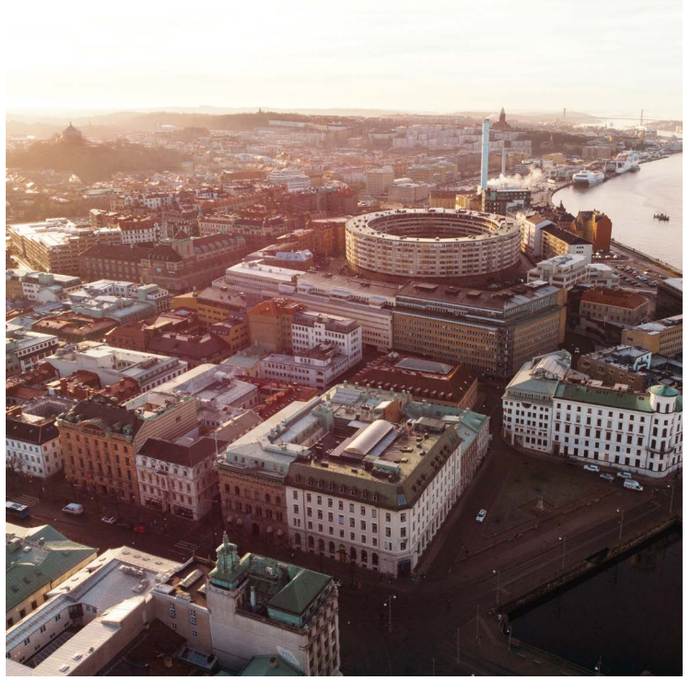
"A SYSTEM LIKE FED IS CRUCIAL FOR MANAGING LARGE SUPPLY OF VOLATILE POWER AND OPTIMISING THE USE OF RENEWABLES."



A local energy system with its own power generation and balanced with a FED ICT solution and marketplace could offer a flexible solution to meet these challenges.

Grid stability as a service

A higher input of renewable power risks jeopardising frequency and voltage stability in the networks. Based on the batteries and turbine available as well as reactive power from solar PVs, FED has the potential to offer energy services to compensate for this.



Collaboration between multiple energy carriers

Flexibility in the sense of lower dependence on one certain energy carrier can be utilised and managed in a system like FED. We have proven a system that can automatically switch between energy carriers, dependent on availability which is mirrored in the price signals. Electrically driven heat pumps can be used for heating or cooling purposes when there is a lot of wind or solar power available, either from internal sources or external from the grid. The biofuel boiler or district heating from the external grids can be used when electricity prices are high.

Local waste heat recovery

Local excess heat from cooling of houses and server halls can be recovered by means of heat pumps and district heating systems with a lower temperature than normal; 70°C in FED's case. FED uses several so-called cooling heat pumps for this purpose. FED's ICT solution facilitates trade in local waste heat.

JOAKIM PONTÉN
SENIOR IOT SOLUTION ARCHITECT, ERICSSON

What part of the FED project have you been involved in?

– One part of the energy solution is automated software agents, that will buy and sell energy in a digital marketplace. We have developed these agents, and this is the most rewarding work I've done since I started working at Ericsson. The technology is very interesting, using both artificial intelligence and distributed cloud solutions. And also, to meet all the experts from the other local partners in the project has brought many new insights.

How did you create the digital marketplace?

– My colleagues and I have linked the existing operating systems of the buildings with Ericsson's platform for Internet of Things (IoT) solutions. On top of this, a number of robotized smart agents are connected to constantly monitor energy consumption as well as weather forecasts and other factors that can affect the energy supply and consumption. The automated agents pick up data from the system and buy and sell energy whenever it is most beneficial. They are also based on machine learning, meaning that throughout the project they become better and better at managing their tasks.

What are the gains for the consumer?

– As the share of renewable energy from sun and wind increases, we will see greater differences in energy prices depending on the energy supply of a given time. Our system creates an economic incentive for the consumers to be flexible and use energy when the availability is high and the price low. This could for example mean that you would heat up a house a few hours before the cold weather is predicted. The consumer saves money, and at the same time we avoid using gas and oil to maintain the marginal production.

We are now also very interested to see how we can apply this globally. We work in 180 countries and believe that this may be even more relevant in other parts of the world, beyond Europe and the more traditional energy supply networks.

PHOTO: CHALMERS UNIVERSITY OF TECHNOLOGY

WITH APPROXIMATELY 4200 SQUARE METERS, THE CAMPUS OF CHALMERS UNIVERSITY OF TECHNOLOGY IS ONE OF THE DISTRICTS IN SWEDEN MOST DENSELY COVERED IN SOLAR PANELS.

Describe Akademiska Hus and your role in the FED project!

– Akademiska Hus is a large property owner with many academic campus areas all over Sweden, and one of two property owners on the campus of Chalmers University of Technology. We are increasingly focused on innovation, and FED is one of several ongoing energy projects that we are involved in.

What parts of the project have you managed and why are those important to you?

– We are mainly working with the buildings' control systems. Among other things we are planning to use the buildings' thermal inertia to store energy, and for that reason the control systems need to be rebuilt. We also have energy-generating units on the campus area, for example pumps for heating and cooling as well as our power central where biofuels for generating heat and power with hot water and boilers are combined with combustion research.

During the project we have had busy days getting all the new installations ready on time. The big difference for us is that the FED marketplace will overrule our current control systems. Since trading in the FED system is done by digital smart agents there will be less manual work for our technicians.

What happens when the project is completed?

– Akademiska Hus' commitment is on a long-term basis and the marketplace will continue to run on Chalmers campus. The investments we are making now are real and will of course not be stopped when the project ends. There is a life after FED and we hope that it can also inspire new projects that will enable us to continue to develop the system. Hopefully we can implement it on more of our campus sites around the country.

PER LÖVERYD
INNOVATION COORDINATOR, AKADEMISKA HUS

URBAN AREAS FACE MULTIPLE CHALLENGES. BUT THEY ARE ALSO ENGINES OF NEW IDEAS AND SOLUTIONS – DYNAMIC PLACES WHERE CHANGES HAPPEN ON A LARGE SCALE AND AT A FAST PACE.

TESTBED

The FED-system is created as a testbed to be used also after the project ends.

Five companies have already tested their products in the FED-system. This includes advanced control systems for buildings, smart charging of cars, advanced battery control systems, phase shifting material storages, prognosis of the production in the electricity system, heat pumps in co-operation with district heating and cloud services for energy data.

Twelve new projects are based on the FED-testbed. Six of these projects are large EU-funded projects that will use the FED results in various ways:

- IRIS, H2020 Smart Cities Lighthouse.
- Micro to mega grids, Era-Net Smart Grid Plus.
- United grid, H2020.
- ACCESS, Interreg North Sea region.
- Celcius Initiative, Climate KIC, Swedish Energy Agency and DG Energy.
- Flexi-grid, H2020. The operation of the FED market will probably continue within the Flexi-grid project.

Several other projects on this topic have also started, either in the FED system or in the testbeds HSB Living Lab and Riksbyggen Positive Footprint Housing in Johanneberg.

The campus area of Johanneberg together with nearby buildings is planned to be a testbed for local sustainable energy systems for years to come. The objective of the project to create an urban lab for these questions is fulfilled.

PHOTO: CHALMERS UNIVERSITY OF TECHNOLOGY

DAVID STEEN
RESEARCHER, DEPARTMENT OF ELECTRICAL ENGINEERING AT CHALMERS UNIVERSITY OF TECHNOLOGY

What benefits do you as a researcher get from the FED project?

– It is invaluable for researchers to have access to a real arena where we can put our theories to test. Being involved in the project has opened new doors. FED has become a springboard for our research group to look more into integrated energy systems, and the demonstration arena we are building now will be used in future research projects. We have already got two other projects granted, where the campus of Chalmers will also act as a testbed.

What will those projects look into?

– In the first one, called United grid, we will examine advanced solutions for the future distribution system. The other one, From Micro to Mega – GRID, is about how different micro-grids can interact in order to facilitate the use of renewable energy production. It is unique to have access to this kind of testbed and to be able to test solutions in close cooperation with industry. It has helped us a lot and I do not think we would have received the two projects mentioned if we had not had the FED-project and the test arena here.

What makes the FED project unique?

– One of the challenges with renewable energy is that it is not always produced when you need it the most. The local energy market that we are developing in FED is one way to provide customers and users with incentives to shift their consumption in time, and thereby use locally produced energy more efficiently. My colleagues and I have created a simulation model of the campus area in order to measure the energy flows of heating, cooling and electricity. Three different energy carriers are connected in one common system – that is what makes the project unique. We are trying to take advantage of the flexibility of, for example, the heating system to help the electrical system, and vice versa. As far as I know, no one else has done this before by using a local energy market.

STINA RYDBERG
PROJECT LEADER, FED JOHANNEBERG SCIENCE PARK

What would you consider to be the main benefits of the FED project?

– By making forecasts of the energy demand, FED can cut peaks where energy from the surrounding system would normally have had to be imported. This creates a more efficient and stable use of locally produced fossil-free energy from solar cells, for example.

I am extremely proud and happy that the project is operating in a stable and robust way around the clock. Real energy is flowing through the area in a different way than it did without FED.

Why is cooperation between the involved partners crucial in projects like these?

– To gather partnerships in this type of innovation projects is one of Johanneberg Science Park's strengths. A lot of people need to talk to each other in order to get a functioning system running. The programmers at Ericsson cannot make up how a power central works, so they need help from the people who operate the power central. And then there are people working for the property owners, who know exactly what the sensors are called that gives us the temperatures inside the offices. I think this is something we have succeeded with within FED – to find forums where these conversations can be conducted at a good level.

In what way is this local project part of a global context?

– As the world is facing a major energy transition, local energy systems such as FED can become an important part of the solution to slow down global warming. This is our goal, and of course it would be great if we can make an impact both in Sweden and in the rest of Europe, as well as globally. We are facing big changes where we will dismantle fossil electricity production and reduce the use of coal, for example. These are huge challenges, and FED can be a piece of the puzzle when creating the new energy system for the future.

REPLICATION STRATEGY

FED has during the course of the project laid the ground for a future where local energy systems with a marketplace for energy can start to become a real solution to the energy transition challenge. The replication strategy provides insights on drivers and barriers as well as a number of recommendations for further action and some changes in legislation.

Recommendations from the FED project are, among other things, to provide proof of concept for the local energy market solution. Social aspects must then be taken into consideration in case of market expansion, replication and future development projects. The feasibility of replicating the FED solution in other cities is both depending on the existing energy infrastructures and on the political, regulatory and societal landscape. Finding cities with a sustainable profile and engaged actors will increase the possibility for successful replication.

In this chapter, social aspects and aspects concerning legislation and regulations, on various levels, are discussed.

Social aspects on systems like FED

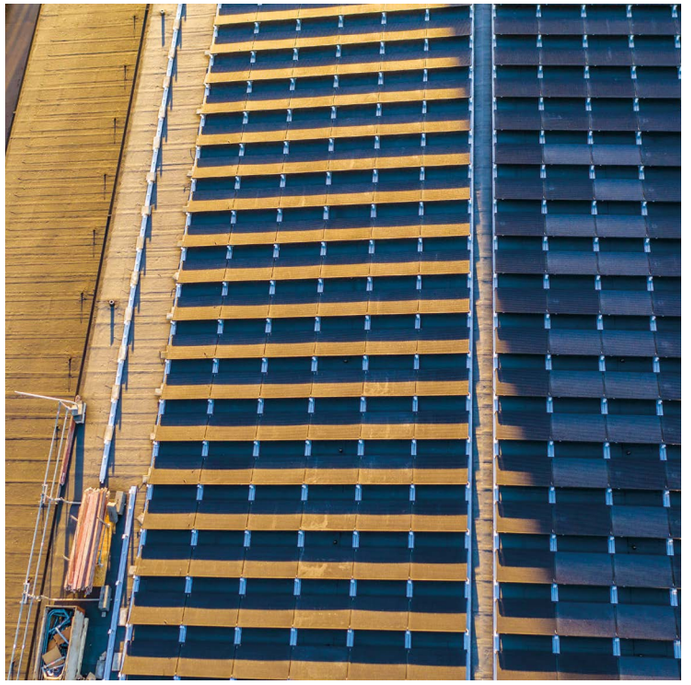
To increase the chances of a successful implementation of technologies such as local energy markets, social aspects should be investigated in depth and in the current context. It is important to remember, that what is true in for example a technology and change friendly country like Sweden, isn't necessarily true in the Netherlands, where people care more about private data integrity.

The various actors and end users in a local energy system/market must be understood and therefore a number of questions need to be asked and answered: Why would these actors decide to participate in the local energy market? Under which conditions are they willing to invest in their own local production capacity, and how? Under which conditions are they willing to accept local market rules and procedures? Are they willing and able to change their energy consumption practices? Under what conditions can such willingness be promoted and increased? The project implementation can then be designed accordingly.

A list of recommendations regarding aspects to consider for different actors has been developed in FED. These recommendations support the emergence of local energy markets by addressing factors that could promote a higher degree of social acceptance.

- Market operators are recommended to involve the local community, show capability, openness and transparency as well as apply tools and methods to increase social acceptance, for example involvement, education and similar.

PHOTO: CHALMERS UNIVERSITY OF TECHNOLOGY



WITH MORE WEATHER-DEPENDENT RENEWABLE SOURCES, SUCH AS SUN, THE ENERGY MARKET WILL BECOME MORE VOLATILE. LOCAL ENERGY DISTRICTS LIKE FED CAN HELP BALANCE THIS CHALLENGE.

- Policymakers are recommended to support the transition to local energy markets through long term and clear incentives, both financial and legislative.
- The local community and its actors, real estate owners, private households and others, need to understand the value of collaboration and local benefits should be promoted.
- Our recommendation is to, at least in early replication projects, involve researchers and other objective experts to contribute with knowledge and information to energy system development.

Legislation and governance

The term flexibility is widely discussed mainly in the electricity sector and is highlighted as an important tool in a 100 % renewable electricity system. However, the same principles apply to heating and cooling as energy carriers. Through flexibility, power companies can optimise the use of energy and power in the local grids and optimise their investments. By doing so, network companies can also reduce their costs of losses and overlying power grids or, in any case, minimise cost increases that are beneficial to end users. A local energy market could contribute to a sustained resilience and security of supply as renewable power generation make up a larger proportion of the production mix.

Today's electricity market is not built to provide price signals to grid companies. Nor is it built to send signals to end users to create flexibility, by using electricity more efficiently and stable. End users, large and small, are accustomed to use energy whenever the demand is there and not to balance usage in order to facilitate for producers and network operator. →

A local energy market could provide better price signals to the local actors and end users, in the FED case the property owners, to act on. A local energy market, like FED, could create flexibility in the local power grids, which could benefit the network operator if the legislative framework was adjusted.

BARRIERS TO ESTABLISH A LOCAL ENERGY MARKET

The FED project has identified the following barriers for establishing a local energy market in Sweden. They are based on the perspective of increasing the flexibility of local energy systems in order to provide the conditions for new business models, for property owners, grid operators and others, as well as developing new system services. Information and knowledge raising activities are also addressed.

Incentives/instruments:

- Lack of financial incentives for flexibility for local actors.
- Bad incentives for service and maintenance network companies and investments in new technology.
- Lack of incentives for network companies to procure flexibility services.

Roles:

- Unclear roles of actors such as aggregators, balance managers, electricity dealers and online companies. No player today has any real incentive to promote energy efficiency.
- No clear responsibility for flexibility through load management, energy storage, switchable electricity.
- Lack of a definition of what a local energy market is and suggesting geographical system boundaries which makes it difficult to describe the benefits.
- There is no structured cooperation between TSO (Transmission System Operator; in Sweden Svenska Kraftnät) and DSO (District Operator, e.g. Göteborg Energi) regarding current balance in local electricity grids and grid networks required for a larger share of renewable electricity generation at all levels in the grid.

Regulation:

- Unclear regulatory framework for the ownership and operation of energy storage and taxation in use.
- Difficult to test the regulations and analyse economic consequences for the players in the event of change.
- Difficult assessment of metering data for the operators.
- Missing established trade links between multiple energy carriers.

Other:

- There is a lack of knowledge among stakeholders on how price signals work in the electricity market and that price signals meet different purposes.
- Uncertainty about end users having social acceptance and integrity in the exchange of information / data in this kind of trade.
- Uncertainty about lack of loyalty to established energy suppliers in the current electricity market.
- May be a barrier in the absence of any type of IT architecture guidelines as the requirement for IT security increases.

"FINDING CITIES WITH A SUSTAINABLE CITY PROFILE AND ENGAGED ACTORS WILL INCREASE THE POSSIBILITY FOR SUCCESSFUL REPLICATION."

Many of the barriers and obstacles described are valid for both Swedish and European conditions. There is similar legislation for electricity in each country where network companies have monopoly and concession. There are also exceptions for a license like IKN, which is applied in Sweden. What separates Swedish conditions from those of Europe are generally more related to conditions created by instruments and incentives that exists in Sweden. It is important to remember that although the European Union has assured similar legislation on many of these aspects, a thorough study of legislative prerequisites is necessary in the current context, if a replication project is desired.

ACTIVITIES TO HELP ELIMINATE BARRIERS

Below are a few examples of activities which could be conducted in order to facilitate the elimination of barriers:

- Formulate policy documents that can promote the development of local energy markets and propose the necessary changes to the regulatory framework.
- Arrange knowledge-enhancing activities, like seminars and information meetings, to describe benefits and obstacles for end-users, policy makers, property owners, energy companies and other stakeholders
- Analyse revised EU proposals on clean energy and how it may affect local energy markets.
- Make suggestions to Swedish Energy Market Inspectorate, or corresponding national authorities, and the EU on obstacles that should be eliminated.
- Learn from other projects within the EU and relevant national context, where the consequences of changes in regulatory framework are analysed. →

LOCATION CRITERIA FOR A FED SYSTEM

As part of the work with the strategy for replication a checklist for the locations criteria for a FED system has been developed. See table to the right.

The 'must have' criteria are mandatory for replication of the FED marketplace. The optional and preferred criteria will allow for easier replication. For clarification, the reason why the possibility for community solution is preferred is because it takes the responsibility from the end users and puts it on the property owners, which reduces the need for public acceptance. Additionally, the cognitive gap of the property owners may be smaller than those of the average property owner, at least in terms of technology for energy.

General criteria	
Ability for interconnection with other integrated energy systems (IES)	Optional
Large enough IES to make the FED system feasible	Must have
Sufficient know how locally and regionally	Must have
Business model opportunities	Must have
Areas / cities / companies present with sustainable profile and ambitions	Preferred
Motivated and engaged actors	Must have
Network of actors with long-standing relationships	Preferred
Driver of project (actor)	Must have
Owner of project	Must have
Trust in project owner / driver	Must have
Urban region	Optional
Financially strong municipality	Optional
Non-renewable energy production in energy mix	Optional
Area with more than one energy carrier	Must have
Area with one energy supplier for heat and electricity (or other energy carriers)	Preferred
Financing and capability for increased customer support	Must have
Willing property owner(s)	Must have
Strong community feeling	Preferred
Possibility for community solutions	Preferred
Transparency (overcome distrust)	Must have

JONAS COGNELL
PROJECT MANAGER, GÖTEBORG ENERGI

What insights does the FED project provide for the future?

– Increased fluctuations in the energy market are predicted in the future, due to both higher use of weather-dependent energy sources and growing demand. In addition, we and other large energy companies, who own the networks, must find new ways to include smaller local energy producing players. By participating in the FED project we hope to improve our ability to meet these future scenarios. For us this as a great opportunity to train for a future that we believe will be a bit challenging in terms of price fluctuations, and also in terms of demand. A lot more flexibility will be required of us ahead.

What makes FED a unique opportunity?

– The best thing about FED, for us, is that it gives us the opportunity to test new things in a real environment. There are real properties and real production facilities and we can operate real physical things. Our role in the project is to connect the FED system to the surrounding city network. It allows the project to contribute to reducing energy peaks and at the same time reduce the use of fossil energy, which still dominates the European energy market. This way, FED contributes to providing the citizens of Gothenburg with a more robust energy system that can handle increased proportions of variable production.

What experiences have you gained from working with the FED project?

– I have very much enjoyed working with this project! To work with the researchers laying the theoretical foundation of the marketplace as well as with the experienced property owners, has taught me a lot. I like that there is a wide range of partners involved in the project, while at the same time it is anchored in the heart of Gothenburg.

LARS BERN
AREA MANAGER FOR INNOVATION, BUSINESS REGION GÖTEBORG

What role has Business Region Göteborg had in the FED project?

– FED is allowing smaller players in a defined area to participate in a local trade of electricity, district heating and cooling. Our task is to strengthen the competitiveness of local businesses through the project. There are a number of local companies delivering different solutions to the challenges we face. The benefit for these smaller companies is that they will be able to refer to FED and say: 'We have been part of testing this in Gothenburg. It works amazingly well and we could repeat this on any market, in Europe or globally'.

One of the conditions for the project is exactly that: To make the system replicable and possible to implement in other cities. What do you do to spread the word about FED to external actors?

– To increase knowledge and interest in the project, we at Business Region Göteborg include FED in some of the many international study visits we receive each year.

We do this to showcase green innovation in Gothenburg, and the delegations from all over the world are very interested in what we are doing. They want to know how they can bring this to their own market and create the same values with the technology we have tested in Gothenburg. From the perspective of Gothenburg, this kind of project provides opportunities for us to highlight Gothenburg and what we jointly create here. It is a great tool for keeping up the overall innovation level in the city.

What are the prerequisites for implementing the system in more cities?

– An additional task for us at Business Region Göteborg has been to define the necessary policy changes to make the FED system exportable to other locations. Our hypothesis is that there is an added value in creating a local marketplace for electricity, district heating and cooling. By pointing to the future outcomes of FED, we will be able to suggest how regulatory frameworks need to be changed in order to create incentives for investing in these types of energy solutions.

POLICY RECOMMENDATIONS

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"THE AIM IS TO INFLUENCE REGULATORY BODIES AND POLICYMAKERS."

PHOTO: CITY OF GOTHENBURG

THE FED TESTBED, SITUATED ON THE CAMPUS OF CHALMERS UNIVERSITY OFTECHNOLOGY IN GOTHENBURG, HAS BEEN DEVELOPED BETWEEN 2017 AND 2019.

Five regulatory and policy recommendations have been developed within the FED project, supporting the transition into low/no-carbon local energy systems and markets.

The aim is to influence regulatory bodies and policymakers to make necessary adjustments in order to enable realisation of local integrated energy systems.

1. Strive for social acceptance.
2. Make direct investments towards replication of FED through the European Investment Bank and the cities and direct incentives towards cities in order to reduce CO2 emissions.
3. Define the role of the city/municipality in decision making processes and local energy plans.
4. Enable the DSO to trade with flexibility.
5. Enable the possibility to test, make demos and proof of concepts in several places. →

1.

STRIVE FOR SOCIAL ACCEPTANCE

Local energy markets can contribute to a more effective use of energy and an energy system with less environmental impact. However, there is a lack of knowledge and understanding of how they would work, and the benefits they could create. Social acceptance is necessary for successful implementation of new technical solutions and to change behaviour.

What's the problem?

- Regulations to establish a local energy market are missing.
- Possibilities to trade with multiple energy carriers are today limited.
- Incentives to implement an energy society are lacking.

Policy

- Local and national authorities need to produce material for information and educational purposes.
- Information campaigns clearly expressing the possibilities with local energy communities need to be conducted.
- The member states within EU should implement regulations according to Article 16 in the Clean Energy Proposal.
- Local energy markets and the creation of energy communities needs to be promoted.
- Proof of concept of local energy communities, similar to FED which can be replicated to other cities within the EU, should be delivered.

2.

DIRECT INVESTMENTS AND INCENTIVES

Cities in Europe are emitting too much CO2. A large share of real estate heating in Europe is individual and consists of fossil-fuels as natural gas and coal. These real estates are not a part of the system trading in CO2 emission rights.

What's the problem?

- There is a lack of financial instruments for the cities in Europe to invest in solutions similar to FED, aiming at decreasing CO2 emissions.
- There are large financial differences between the heating of larger systems compared to individual heating.

Policy

- Make direct investments through the European Investment Bank (EIB) and local cities to enable solutions similar to FED.
- Design incentives to cities, which are obtained when CO2 emissions are decreased.

PHOTO: CITY OF GOTHENBURG

3.

DEFINE THE ROLE OF THE MUNICIPALITY

There is a built-in conflict between the goal of creating solutions which benefit the whole and the aim to optimise locally.

What's the problem?
The municipalities are lacking tools to ensure that local energy communities actually contribute to a robust energy system.

Policy
- Give the cities/municipalities possibilities to influence the design and localisation of local energy communities, so that the overall situation is taken into account.
- Facilitate collaboration between the different stakeholders in the city.

4.

ENABLE TRADING WITH FLEXIBILITY

Today there is no flexibility on the energy market, which is a hindrance to increase the amount of renewable energy and contribute to a fossil-free energy society.

What's the problem?

- A clear set of regulations to enable the realization of flexibility is lacking.
- The roles for the different stakeholders on the electricity market need to be clarified and there are no incentives to push to increase energy efficiency.

Policy

- Design a set of regulations and incentives for the trade with flexibility services together with stakeholders on the heating market.
- Allow new tariffs and pricing models to enable the use of flexibility services.
- Adapt legislation to new conditions for local energy markets where flexibility will become an important part for the creation of an energy society.
- Change the Electricity Act in regards to the regulation of the grid in Sweden, allowing for DSO to purchase energy services and including the costs within the revenue framework.
- Implement exemptions from the concession, as IKN, for local electricity markets.

5.

ENABLE TESTING, DEMOS AND PROOF OF CONCEPTS

Complex system solutions similar to the market solution of FED can be difficult to understand both for potential stakeholders and decision makers. This is because the solutions are comprised of multiple stakeholders, and they aim to solve problems which currently are not perceived as problems by many of the stakeholders.

What's the problem?

- Solutions such as FED need to be made visible to a larger extent.
- There are too few large scale demos.

Policy

- Create conditions for new business models for flexibility services with multiple energy carriers by allowing exemptions from current regulations in selected demo projects, on district or city level.
- Enable demos via financing from national and international programmes.

CLOSING REMARK

"THE PRODUCT OF THIS PROJECT IS KIND OF AN ADD-ON TO IMPROVE EXISTING AND FUTURE SYSTEMS."

– WHAT WILL THE FUTURE ENERGY SYSTEM IN A CITY LOOK LIKE? –LET´S BUILD ONE TO FIND OUT!

In short, that is what we did in the FED project.

The product of this project is kind of an add-on to improve existing and future systems. Some of its benefits are useful already today and some will help us when the share of solar and wind increases, and biofuels will be a more limited resource.

The design of the local energy market and the development of the IoT solution was surprisingly easy to agree on in the project, perhaps because the logic is quite easy to follow.

A little bit trickier was to decide what type of investment that would be the most useful. In our project we wanted to have as many different types of market participants as possible, but also to reduce CO2 and primary energy. To predict the value of a specific component required in our case an advanced simulation tool.

Connecting every market participant, including designing the agents, was perhaps the hardest thing and caused delays in the project. But it is also a great learning for future projects. The meters and the control systems of the buildings were far from adapted to this kind of solution.

WRITING THIS, THE system is running with more than 50 market participants and the evaluation of the performance is on-going. With one month remaining, the project is drawing to a close and our focus turns to the next steps. Replication of the FED project will be challenging, but we are positive that it can be done. Here are some key findings from our project:

- Social acceptance is important, the threshold is lower in premises and multi-family houses than single-family households due to aspects regarding personal integrity.
- Knowledge about these solutions is low. Educate!
- The license cost of an IoT-platform seems to be affordable, at least for larger communities.
- It´s a complex solution, start easy and advance in steps.
- Start to connect the most beneficial market participants.
- Who will be the market operator? Consider this role.
- Some of the benefits of FED might be blocked today due to regulation, but the rules can change in the near future. New possibilities to trade with flexibility can occur.

FED HAS BEEN a collaborative project and the product is also about collaboration, between local grids and overlying markets, all types of local production and storages, heating, cooling and electricity, small scale and large scale, house owners and energy companies.

Collaboration is needed to phase out fossil-fuels.

Claes Sommansson
Project coordinator, Johanneberg Science Park.

A STRONG PARTNERSHIP

Nine strong partners have collaborated closely and contributed to the FED project with their expertise and knowledge:

The City of Gothenburg, Johanneberg Sciene Park, Göteborg Energi, Business Region Göteborg, Ericsson, RISE Research Institutes of Sweden, Akademiska Hus, Chalmersfastigheter and Chalmers University of Technology.

Göteborgs Stad

BUSINESS REGION GÖTEBORG

ERICSSON

CHALMERS

Johanneberg Science Park

Göteborg Energi

AKADEMISKA HUS

RI. SE Research Institutes of Sweden

CHALMERSFASTIGHETER

READ THE FULL TECHNICAL REPORT AT JOHANNEBERGSCIENCEPARK.COM/FED

The fossil-free Energy Districts project, FED, is an innovative local initiative in Gothenburg aiming to find modern solutions to global energy challenges. FED is an effort by the City of Gothenburg to decrease the use of energy and the dependence on fossil-fuel in a built environment. A unique local marketplace for electricity, district heating and district cooling has been developed together with nine strong partners.

The City of Gothenburg, Johanneberg Sciene Park, Göteborg Energi, Business Region Göteborg, Ericsson, RISE Research Institutes of Sweden, Akademiska Hus, Chalmersfastigheter and Chalmers University of Technology are all contributing with their expertise and knowledge to make FED attractive for other European cities as well.

During 2017–2019 the FED testbed is situated on Chalmers campus Johanneberg. FED is co-financed by the European Regional and Development Fund through the Urban Innovative Actions Initiative, an initiative of the European Commission for cities to test new solutions for urban challenges.

European Union
European Regional
Development Fund