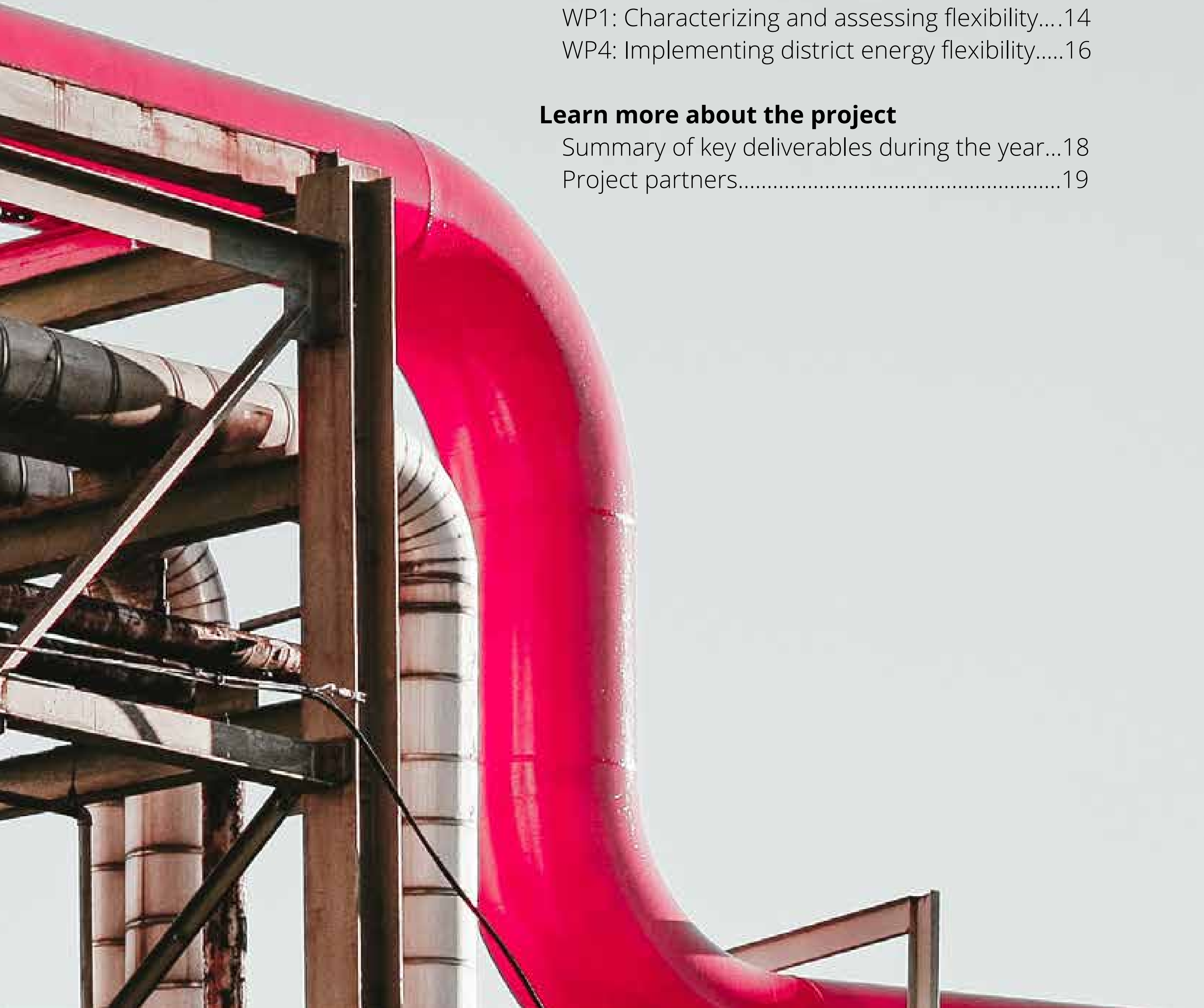
Flexi-Sync
Annual report 2020

Flexi-Sync

Flexible energy system integration using concept development, demonstration and replication

Content



“Integrating the heating and electricity sectors has never been so important as now!”

The Flexi-Sync project year 2020 started with a physical partner meeting in Gothenburg, Sweden and ended with a feverish swarm of online activity in all four participating countries when Covid-19 put a hold on physical meetings and pan-European travels.

During the year the project has delivered one report about the state of the art methods of characterizing and assessing flexibility in the district energy sector, which will lay the foundation for the optimization strategy that will be developed in the project in order to exploit available flexibility in district heating and cooling. The first steps have also been taken in integrating the demonstration sites, more specifically the district energy companies participating in Flexi-Sync, with the software platform developed by one of the participating energy service providers.

In July 2020, the EU Commission presented a EU strategy for energy system integration, stressing the importance of sector integration for a decarbonized European energy system of the future. The release of the strategy highlights the timeliness of the Flexi-Sync project – integrating the heating and electricity sectors has never been so important as now!

With this report Flexi-Sync concludes 2020, and all project partners are very much looking forward to the coming year.
2021 will be a busy year! The project will be exploring operational and design optimization methods for flexibility, assessing the regional cost-efficient potentials of flexibility as well as the energy demand and renewable production with future climate, run the first live tests of operational co-optimization and report about the flexibility from an end-user perspective.

Exciting times ahead!

Anna Nilsson
Project coordinator, Flexi-Sync

About Flexi-Sync

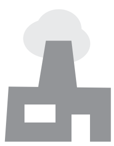
The emerging challenge of balancing weather dependent electricity production and variable demand is creating new demands on the energy system.

Without adding extensive flexibility to the power system these issues will lead to a costly transition to a decarbonized energy system. In Flexi-Sync, the need of balancing volatility in the energy system is met by increasing flexibility in district heating and cooling systems. The flexibility potential is identified by researchers and implemented by practitioners; energy service providers, district energy companies and housing companies. The project aims to identify how flexibility in district energy can be optimized and, thereby, contribute to the management of variable electricity production and demand.

4 countries

16 partners

Project length **2019-2022**



6 demonstration sites

4.5 million Euros

Demonstration sites

Six demosites are at the heart of the project. Four of the demo sites have district heating and cooling companies that are active in mature heat markets (Germany and Sweden), making the interconnection with electricity essential. Two of the demosites (Austria and Spain) are in district heating and cooling companies that operate on less mature heat markets, making the interconnection important for future efficiency in the energy system

Maria Laach am Jauerling, Austria

A district heating system with a heat plant, fuelled with biomass from agricultural residues, and a district heating grid.

Annual demand: 1.6 GWh district heating.

Flexibility used in project: central storage tank, distributed storage tanks and future CHP.

Palma de Mallorca, Spain

A district heating system with a district heating and cooling grid and a combined heating, cooling and power plant (CCHP, fuelled with natural gas, diesel, biomass and solar thermal.

Annual demand: 9 GWh district heating and 3 GWh district cooling.

Flexibility used in project: district heating and demand side swimming pool.

Mölndal, Sweden

A district heating system with a district heating grid and a CHP and multiple heat boilers mainly fuelled with biomass from forest residues and liquid biofuel (RME).

Annual demand: 300 GWh district heating.

Three multi-family residential buildings are part of the demonstration.

Flexibility used in project: building thermal inertia.

Borås, Sweden

A district heating system with a district heating grid, multiple CHPs and HWBs mainly fuelled with biomass, municipal waste and bio oil.

A 1.8 GWh thermal heat storage is used to balance the heat demand of the district heating system.

Annual demand: 600 GWh district heating.

Two multi-family residential buildings are part of the demonstration.

Flexibility used in project: building heat pumps in combination with district heating.

Eskilstuna, Sweden

A district heating system with one CHP and a heat only boiler, both fuelled by wood chips.

Four bio-oil fuelled boilers used as peak capacity and four oil-fired boilers for reserve capacity.

Annual demand: 700 GWh district heating.

Two multi-family residential buildings are part of the demonstration.

Flexibility used in project: building heat pumps and building thermal inertia.

Berlin, Germany

An office and multi-family residential complex consisting of six buildings is part of the demonstration.

Annual demand of complex (estimated): 2.9 GWh district heating and 1.2 GWh cooling.

Flexibility used in project: combining excess heat sources (subway, sewage, cooling), solar photovoltaics (PV) and building thermal inertia.

Eskilstuna, Sweden

Per Örvind, technical investigation engineer at Eskilstuna Energi & Miljö AB, is the important link between the Flexi-Sync project and the daily operations of the energy company. He explains that the expansion of district heating in Eskilstuna started in the mid-60s and today the district heating system incorporates the county town Eskilstuna as well as the town of Torshälla and the Hällby village.

The major part of heat that supplies the network is generated in the biomass-fired CHP and both the CHP and the heat only boiler have flue gas condensation, which increases the efficiency of the plant. Almost half of the heating demand consists of multi-family houses, but there are also some detached houses, public buildings, industry and service buildings that are supplied with heat from the heat grid.

Eskilstuna Energi & Miljö is participating in Flexi-Sync mainly to test the possibilities for operational co-optimization of flexibility and supply side, including the optimization of electricity trading. They will also compare their existing tool for production prognosis and optimization, which uses machine learning techniques based on the supply side, with the tool that is mainly being developed by the project partner Utilifeed and that is based on a prognosis of the heat demand.

Per Örvind says that the energy company is keen to explore how flexibility can work and how future business models in the heating sector could look like, but also to learn about the total economic potential for the entire district energy system in using flexibility. In the Swedish energy sector, there are a lot of discussions on the possibilities to use different kinds of demand side flexibility, he explains. So far, mainly the large players on the district energy market in Sweden have experimented with demand side flexibility but with Flexi-Sync smaller actors are also given the resources to participate in the development of the future district energy landscape. The district heating grid in Eskilstuna is representative for the systems of many Swedish mid-sized towns, so the experiences from Flexi-Sync could benefit other regions as well.

Lukas Lundström, energy strategist at Eskilstuna Kommunfastighet AB, coordinates the housing company's participation in Flexi-Sync and manages the demand side part of the Eskilstuna demonstrator site. In Flexi-Sync the flexibility of two apartment buildings with rental apartments will be assessed: a new-built low energy student housing building, Nordstjärnan 13, and an older multi-family building, Nordstjärnan 9, with an exhaust air heat pump. The buildings are located in the Energy Evolution District in Eskilstuna, an area consisting of a variety of different businesses, utilities and dwellings. The area is undergoing a transition process and as part of this Eskilstuna Kommunfastighet is testing new products and services that tackles issues related to energy consumption.

In Flexi-Sync, the housing company will test building side flexibility by utilizing the buildings as energy storages, e.g. utilizing the thermal inertia of the buildings, and a flexible operation of the exhaust air heat pump. Lukas Lundström explains that NODA Intelligent Energy Systems will be responsible for interconnecting the demand side management with the production side management as well as the data collection from the buildings.
By participating in the Flexi-Sync project, Eskilstuna Kommunfastighet wants to explore how the integration between different types of building management systems can be set up to operate smoothly, gaining practical experience from flexibility and what the tenants will say about potential changes in indoor temperature. They are also interested in exploring viable business models for alternating between a heat supply from the district heating grid and a building heat pump.

Facts and figures

Generating units:
- CHP (92 MW/560 GWh heat, 38 MW/180 GWh electricity)
- Heat only boiler (67 MW/170 GWh)
- Four bio-oil fired boilers (50 MW/10 GWh), peak capacity
- Four oil-fired boilers (250 MW), reserve capacity

Supply/return temperature: 75-100/40-50°C
District heating network length: 33 km
Annual heat demand: 700 GWh
Main fuel: biomass (wood chips)

Maria Laach, Austria

The district heating plant Maria Laach is a typical biomass plant for the rural regions in Austria and is operated by the agricultural cooperative Bioenergie NÖ, which operates in total 70 heating plants in Lower Austria. The plant supplies more than 30 heat customers, among these restaurants, hotels, schools, public buildings and multi-family buildings.

The heat supplying these buildings is generated by two biomass boilers, one that was taken into operation in 2006 and the other in 2009. The biomass used in the boilers is sourced from 16 farmers and members of Bioenergie NÖ. The boilers are connected to an 8 m³ buffer storage tank that functions as load compensation. A large share of the substations in the district heating grid are also equipped with buffer storage tanks. The central storage tank and the substation storage tanks have potential to be utilized for dynamic load management.

In order to enable a high utilization of biomass in the Maria Laach plant, there are also plans to invest in a small biomass CHP of 50 kW electricity. The CHP, relying on wood pyrolysis, would cover the base load (about 100 kW of thermal energy) in the district heating network and prevent inefficient part load operation of the biomass boilers. The CHP could theoretically also act on the balancing markets in Austria. However, currently biomass CHPs requires and receives support in Austria for feeding the electricity into the grid. Therefore, practically there is no economic reason for a biomass CHP to act on the balancing markets.

Josef Petschko, project manager at AGRAR Plus and demo site responsible, explains that during the project the plant operation parameters will be optimised for the application of the future biomass CHP plant and other renewable heat sources by active and flexible management of grid temperature, buffer storage temperature and the buildings connected to the heat grid.
The optimization of the plant focuses on grid temperatures, real use of the buffer substation storage tanks and an increased potential to use the CHP for base load.

To test the flexibility from buildings connected to the district heating grid, six substations with different heat demand characteristics has been chosen: public buildings, a primary school with kindergarten, some multi-family apartment buildings, a restaurant and a hotel. The substations can be remotely controlled through the Maria Laach SCADA-system and during 2020 an integration with the service supplied by NODA Intelligent Systems have been set up to enable the use of flexibility from the buildings.

As the integration of the NODA service was performed, data preparation was made manually. This required a lot of work and computer performance, and Josef Petschko, recommends using some software for automatic processing of the data. In general, a more efficient management of data can also benefit heating companies in the long run as it can lead to a more stable and efficient operation of the plant. It can also enable early fault

Stakeholder workshop in Maria Laach in October 2020.
Photo: Josef Petschko

Josef Petschko, project manager at AGRAR Plus and demo site responsible

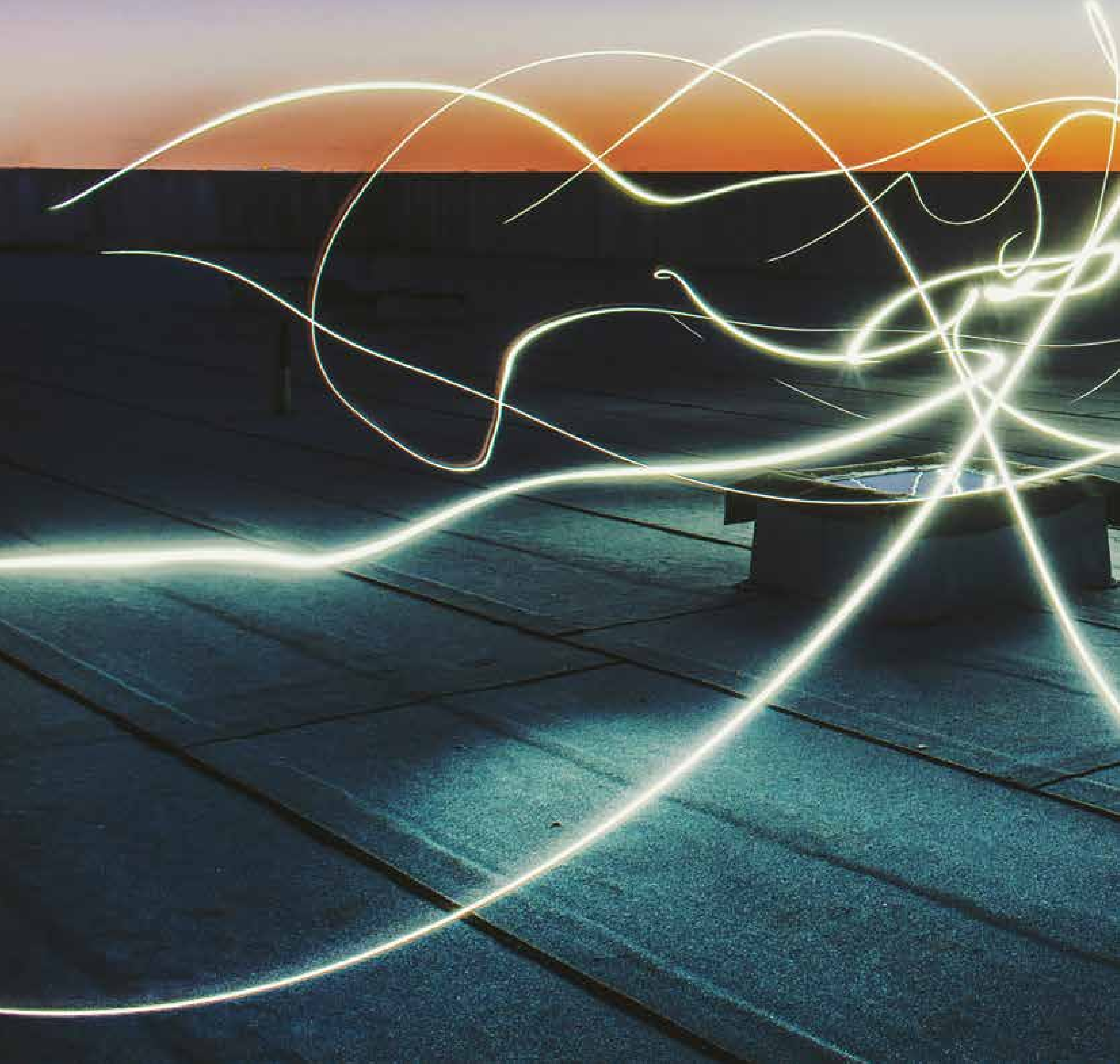
detection which in turn can reduce major damages to the plant. District heating in Austria dates back to the 1950s when the first networks were taken into operation in Baden, Klagenfurt and St. Pölten. In 2019 25% of the apartments in Austria were supplied by district heating and the main energy sources used were biomass and natural gas.

The number of biomass district heating plants, and the share of biomass in the district energy sector, have increased since the 1990s on the expense of coal and fuel oil. As the Maria Laach heating plant is very typical for biomass plants, the results from the project could be applied for other plants in Austria as well.

The older biomass plants are characterised with a relative long heating network in comparison to the heat demand. For these types of systems, but also for other plants, the results of the project will help to increase the efficiency and the heat demand coverage through district heating in buildings. The Flexi-Sync project partners Austrian Institute of Technology and AGRAR Plus hope that the demo site will demonstrate the contribution of biomass district heating plants to locally integrated renewable heat and electricity systems in Austria.

Work packages

The partners in Flexi-Sync will bring their areas of expertise to the project. The combination of experts on district energy flexibility, district energy companies and their customers gives the project an unique approach in the context of district energy flexibility research.



WP1: Flexibility characterization and operational flexibility

- flexibility characterization
- operational flexibility enabled by optimization
- design for operational flexibility

Lead by:
Wolfgang Birk
Luleå University of Technology
wolfgang.birk@ltu.se

WP2: Cost-efficient flexibility potential in the demonstrations site areas

- definition of future scenarios
- characterization of flexibility potentials for energy system assessment
- future energy systems and flexibility

Lead by:
Érika Mata
IVL Swedish Environmental Research Institute
erika.mata@ivl.se

WP3: Climate flexibility and resilience of the cost-efficient solutions

- representative future weather data sets for the demonstration sites
- energy demand and renewable generation potentials for future climate
- climate flexibility and climate resilience of the energy system

Lead by:
Vahid Nik
Chalmers University of Technology
vahid.nik@chalmers.se

WP4: Implementation of flexibility at the demonstration sites

- platform, service and application development
- platform integration
- input for demand optimization
- operation and output of operational co-optimization
- implementation of the flexibility services

Lead by:
Johan Kensby
Utilifeed
johan@utilifeed.com

WP5: Business implications from increased flexibility

- price models
- network asset maintenance and durability
- end-user flexibility potential
- replicability of the new service

Lead by:
Sujeetha Selvakkumaran
RISE
sujeetha.selvakkumaran@ri.se

WP6: Coordination and management and
WP7: Communication and dissemination

- management and quality assurance
- IPR management
- financial and technical reporting
- communication activities

Lead by:
Anna Nilsson
IVL Swedish Environmental Research Institute
anna.nilsson@ivl.se

Characterizing and assessing flexibility

Using flexibility to increase the efficiency in energy systems is not news and stems back to the 1990s and the operation of HVAC systems, explains Wolfgang Birk, professor in control engineering at Luleå University of Technology. Typically, energy demands are shifted to shave the peak loads, enabling a more efficient operation.

Introducing the concept in district heating and cooling systems is however more complex, due to the thermal inertia of all the components in the system, and it has only been realized on a city-scale in some rare cases.
The work that Wolfgang Birk is leading in Flexi-Sync is hence focusing on identifying the challenges to introduce the use of flexibility in district energy systems and to propose a systematic approach to realize this concept on a larger scale. The development of methods and tools with a higher applicability to flexibility is of value to district energy providers that wants to increase the efficiency and flexibility of their district energy systems.

Initially, the work package has focused on the asessment of the state of the art and to understand the challenges and barriers preventing the implementation of flexibility concept on a larger scale. This resulted in a report on flexibility characterization and assessment methodologies that is publicly available online. The gap analysis done will then serve to select the most feasible candidate approaches from literature and further develop the methods and realize as optimization tools that can be introduced in state-of-the-art service solutions.

While it was already clear from the start of the project that the thermal inertia is both a virtue and challenge in district energy systems, Wolfgang explains that it has become more evident that there are no solutions available on the market today that integrate the complete district energy system in the flexibility assessment and provide optimization solutions for operation that would make use of the flexibility potential that is inherent in the system. During the past year the Flexi-Sync partners involved in the work package have determined a harmonized way of representing the flexibility which is compatible for the optimization of operation. At the current stage of development, the findings are of interest for the service providers to the district energy providers as their solutions can consider the improved way of describing flexibility in the optimization context.

Further development will now focus on tailoring optimization problems and their solution that can consider the flexibility approach. For this end the Flexi-Sync project partner Austrian Institute of Technology (AIT)

Wolfgang Birk, professor in control engineering at Luleå University of Technology

Luleå University of Technology is leading the work in characterizing and assessing flexibility. Photo: LTU

is contributing with their approach to assess flexibility using a simulation based approach with model predictive control, RISE is assessing the effect of exploiting flexibility in the grid and how pipe wear is affected and Chalmers contributes with boundary conditions for operational flexibility on the basis of their design flexibility methods. Utilifeed and NODA, together with some of the demo site partners, also contribute with their expertise on real-life implementation of solutions for flexibility exploitation, peak load shifting and demand-response. Luleå University of Technology (LTU) leads the work and combines the partner contributions with their modelling and optimization approach to flexibility.

Deliverable 1.1: Flexibility characterization and assessment methodologies

The deliverable identifies the most feasible approach for characterizing and assessing flexibility from literature and further extends the approach. The focus is on operational flexibility which means a time scale of up to several days.

A method to characterize the flexibility is proposed where flexibility is introduced as a means to relax the operational optimization problem. Introducing the notion of level of flexibility enables to harmonize flexibility in terms of energy. The assessment of flexibility will then require a simulationbased approach to determine how flexibility spatially translates from consumption, distribution, storage, and production units to actuation points. The approach is then exemplified on a city-scale case with a seasonal thermal storage as the component providing flexibility.

Implementing district energy flexibility

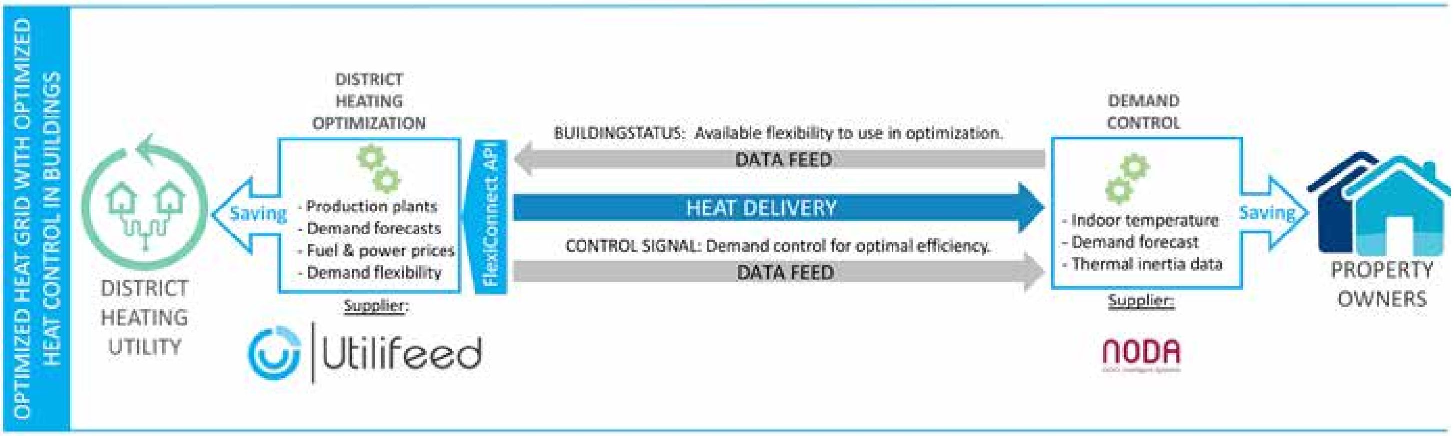
Our energy system is becoming more and more interconnected and the share of intermittent renewables is increasing. Optimizing parts of an interconnected system individually without a bigger picture leads to sub-optimization and missed potential for economic and environmental benefits.

The district energy sector is in a unique position with possible access to very large and cost-effective flexibility in storage tanks, distribution grid and connected buildings. The sector also has a strong coupling with the electricity grid through combined heat and power plants as well as heat pumps. This makes it especially valuable for district energy providers to interact with connected systems and optimize the combined operation and investments with a system perspective, says Johan Kensby, co-founder and CTO at Utilifeed, who is leading the work that deals with the implementation of flexibility at the demo sites. Together with NODA Intelligent Systems and the demo sites, Utilifeed is one of the main project partners involved in this work.

In the work package, the project partners are putting theory into practice by developing, testing and evaluating a software that optimizes the operation of district energy systems with an extended system boundary. In addition to the production and distribution of district heating and cooling, the system boundary also includes flexibility in connected buildings as well as a connection to the electricity grid. The main questions the work package is trying to answer are: Is it technically possible to co-optimize several systems with such a wide system boundary? And how large are the economic and environmental values that can emerge from such co-optimization?

To answer these two main questions a service for operational co-optimization of district energy systems, flexibility in connected buildings and interaction with the electricity grid is developed and tested in live operation at all six demo sites. A core part of this service is the Utilifeed Optimization Software that collects input from all connected systems, generates and solves optimization problems with the target to minimize the combined total cost from a system perspective. The software is built in a cloud environment with all the infrastructure necessary to enable fast and easy replication in many district heating and cooling systems. Forecasts for energy demand, volume flow and return temperatures are provided as input to the optimization from EnergyPredict, which is a machine learning algorithm tailored for predicting thermal demand utilizing metering data from all connected buildings in systems.

Another key component in the operational co-optimization is the NODA system that connects to the buildings and enables the utilization of flexibility in the connected buildings. This includes both shifting heat demand in time by utilizing the thermal inertia of buildings as well as enabling buildings with both district heating and heat pumps to shift heat source to the one that is most beneficial from a systems perspective each hour. The NODA system generates a model for the flexibility and sends it to the Utilifeed Optimization Software that calculates the optimal control of the combined system.



The Flexi-Connect API connects the two services. Picture: Utilifeed

The NODA system then actuates the optimal control in the buildings providing flexibility.

The co-optimization model generator and optimization algorithm are tested for all six demo sites. Johan Kensby says that it is gratifying to see that it does not only work but it also has good enough performance (approximately ten seconds solve time for seven days of optimization) for on-demand optimization. The modular approach of the model generator has also been proven successful and it is fast and easy to set the solution up for new district energy systems using a configuration based on a component library. Preliminary simulations of some of the demo sites also show promising potential for improving the operations by using the co-optimization solution at the demo site.

Universities and research institutes participating in Flexi-Sync are developing and evaluating state of the art methodologies, models and algorithms for many different aspects of the co-optimization. This is done in close collaboration with Utilifeed and key findings will be implemented in the optimization software so that it can be tested in live operation. The approach for collaboration between research partners and industrial partners in the project has already proven successful. Luleå University of Technology has developed a model for excess heat extraction from the subway at the Berlin demo site and it has been implemented as a module in the Utilifeed Optimization Software. This shows promising potential for implementing more results from research partners in live operation during the project. The approach can also facilitate commercialization of research results from the project and help bring them to the market, concludes Johan Kensby.

Deliverable 4.1: Platform integration

Utilifeed is responsible for coordinating the collection, cleaning and uploading of meter data to the Utilifeed platform. The data will be used to make thermal demand predictions that is an input to the optimization service that is being developed in Flexi-Sync. Demand side meter-data from the energy companies participating in the Flexi-Sync project has been gathered. The data includes values for energy, volume flow, supply temperature and return temperature.

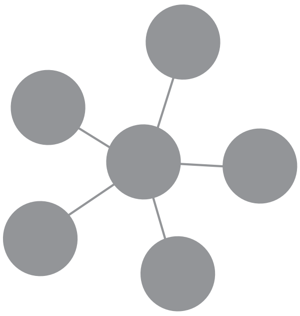
Johan Kensby, co-founder and CTO at Utilifeed

Learn more about the project

Website
Updated continously
www.flexisync.eu

Newsletters
4 times/year
Sign up on website

Webinars
4 times/year
Sign up on website



Social media
Follow the hashtag
#flexisync

Project partners

Agrar Plus | AIT Austrian Institute of Technology | Borås Energi och Miljö – Ingår i Borås Stadshus AB | Chalmers University of Technology

Eskilstuna Energi & Miljö | Kommunfastighet | IVL Svenska Miljöinstitutet | Luleå University of Technology

Mölndal Energi | MölndalsBostäder – En bättre värd i Mölndal | NODA Intelligent Systems | RI.SE

Sampol | Utilifeed | Vattenfall | Willhem

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The transnational joint programming platform (JPP) ERA-Net SES unites 30 funding partners from European and associated countries. It functions as a network of owners and managers of national and regional public funding programs in the field of research, technical development and demonstration.
It provides a sustainable and service-oriented joint programming platform to finance transnational RDD projects, developing technologies and solutions in thematic areas like smart power grids, integrated regional and local energy systems, heating and cooling networks, digital energy and smart services, etc.

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