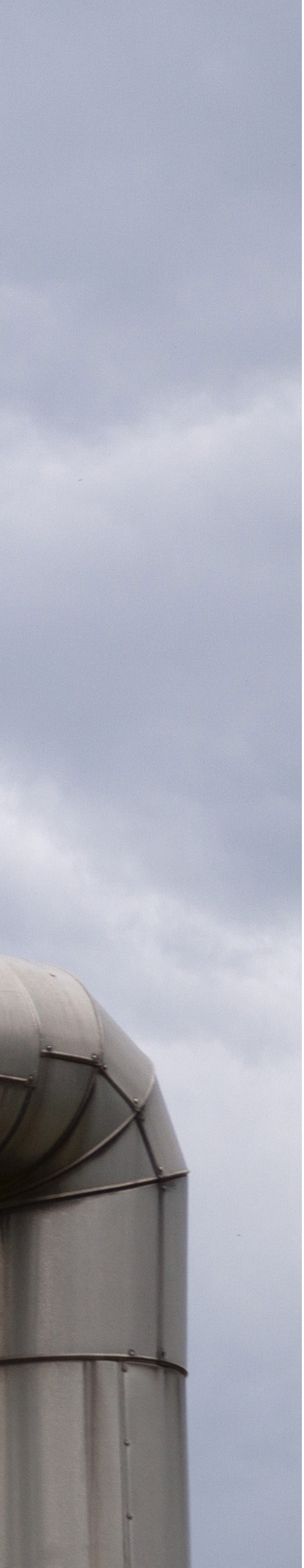
Flexi-Sync
Annual report
2021

Flexi-Sync

Flexible energy system integration using concept development, demonstration and replication

Content



“2021 – a productive year in the project”

2021 has been a productive year in the Flexi-Sync project. Together we have looked at the design flexibility and flexibility constraints for optimization, generated representative future weather data sets for the demo site areas, examined the maintenance effects of flexibility, surveyed how residents may perceive flexibility, defined future local energy system scenarios, and we have also had a minimum viable operational co-optimization tested in live operation.

In addition to this, researchers within the project have produced five scientific publications and conference papers and we have attended several conferences during 2021. We have also had a fruitful collaboration with the Celsius Initiative, spreading results from the Flexi-Sync project through articles in the Celsius toolbox, at forerunner group meetings and through a joint webinar. This has been a very welcome addition to the webinar we have hosted ourselves this year.

Flexi-Sync is now moving into the final year of the project and there is an exciting year ahead. During Spring 2022 we will evaluate the live tests of the co-optimization of demand and supply side flexibility at the demo sites, and most of the work packages will deliver their final results. We also hope that 2022 will be the year when the project members can finally meet physically again.

See you all in 2022!

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 such as 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.

Flexi Sync in numbers

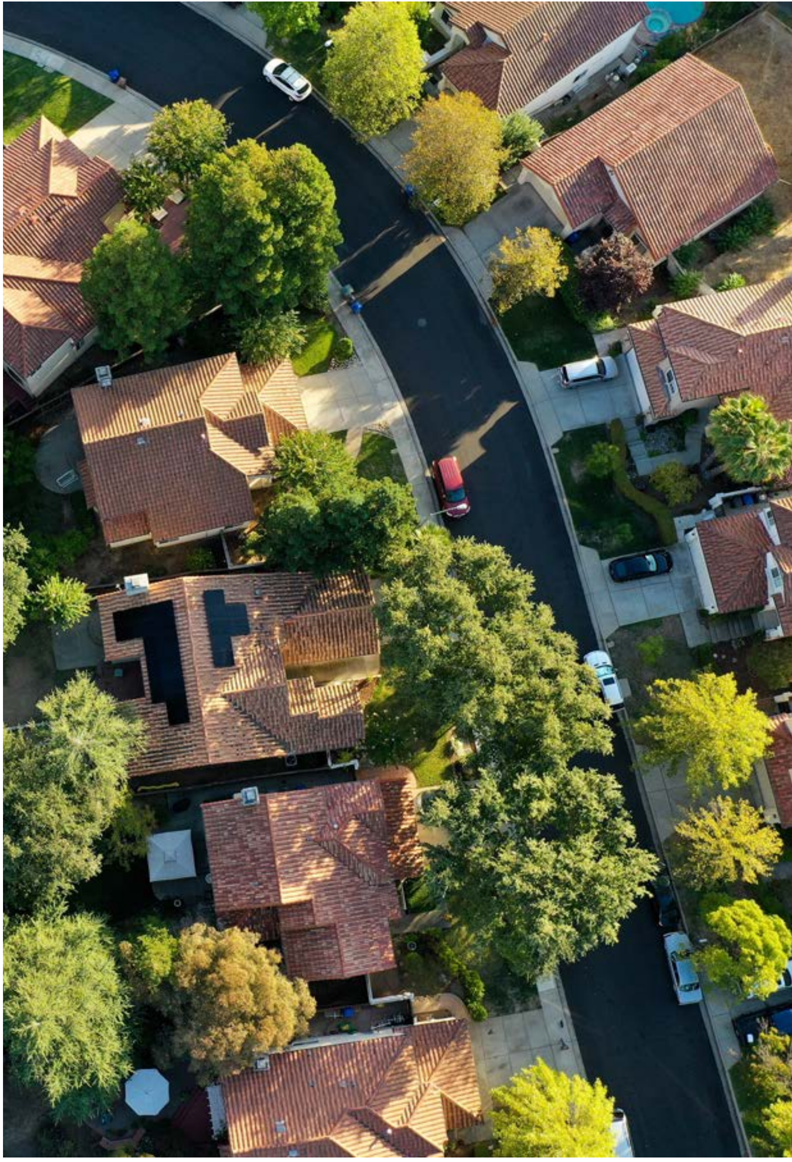
4 countries

16 partners

Project length **2019-2022**

6 demonstration sites

4.5 million Euros




oventrop

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.

Borås, Sweden

District heating was introduced in Borås in the mid-60s when two oil-fired combined heat and power plants (CHP) were taken into operation. Both these CHPs are still in operation, but today they are peak load units utilizing biomass as fuel. The base load units today are two waste-fired CHP boilers, delivering roughly one third of the total annual heat demand of approximately 600 GWh.

The remaining part of the heat demand is mainly produced at KVV Sobacken, a biomass-fired CHP boiler established in 2019 and located about 10 km south of the city centre. When the heat demand is temporarily high, there are additional heat-only boilers fuelled by pellets and bio-oil.

Delivering the district heating and cooling to the citizens of Borås is the municipal company Borås Energi och Miljö AB. In addition to heating and cooling, the company produces electricity, steam, biogas, and drinking water and they also manage municipal waste and wastewater. Together with the housing company Willhem, Borås Energi och Miljö AB form the Borås demo site in the Flexi-Sync project. Willhem is a housing company with approximately 26 000 rental apartments in 13 of the major cities in Sweden and one of the largest customers of Borås Energi och Miljö.

Stefan Hjärtstam, business developer at Borås Energi och Miljö, explains that the district heating company joined the Flexi-Sync project mainly to investigate how the flexibility of their heat customers, with multiple heat sources installed in their buildings, can lower the total costs and environmental impact of the district heating provider and heat customers. Together Willhem and the energy service providers Utilifeed and NODA will investigate how a co-optimization of the supply side (marginal production of district heating) and demand side (the shifting between heat pump and district heating as heat supply in buildings) can be obtained. The buildings selected are two multi-family residential buildings in Borås equipped with both district heating supplied by Borås Energi och Miljö and a local ground source heat pump. Magnus Åkerskog, head of property development at Willhem, explains that these buildings were selected because they can shift between the two heat sources, which in turn can be used to provide demand side flexibility to the energy system.

There are only a few examples of co-optimization studies with focus on mutual benefits for mid-sized district heating companies and housing companies so what is being done at the Borås demo site is of general interest, Stefan Hjärtstam emphasizes. Stefan is hopeful that the Flexi-Sync project will be able to show that a more flexible operation of the buildings' heating alternatives can generate both economic and environmental values. An additional strength with the Flexi-Sync project is that there are several different district heating companies, with different production systems, involved in the project. The operational strategy found in Borås might not be the same as for the other demo sites, which will show the importance of finding the right boundary conditions for each specific co-optimization case.

So far in the Flexi-Sync project, the project partner Utilifeed has developed an optimization tool for supply and demand side flexibility and Borås Energi och Miljö has assisted with the integration of the Borås demo site with the software. NODA and Willhem have installed indoor climate sensors and a control system in two of Willhem's residential buildings. In the beginning of 2022 tests will be carried out to see how the flexibility of the buildings' heating alternatives can be utilized. Magnus Åkerskog is explaining that a key finding this far is the need for clear descriptions of technical capabilities in the local energy systems to successfully connect this kind of overriding control systems in a transparent way and without major

investments in the facilities. He is asking for some standards so different suppliers in different cities and district heating networks can prepare their systems for this functionality.

In addition to the implementation done at the demo site, both Stefan Hjärtstam and Magnus Åkerskog are keen to learn from the business model work done within the project. Stefan explains that their current district heating price models do not take changing marginal production costs or electricity prices into account, meaning that individual heat pumps are often more economic than district heating for heat customers. Therefore, it is common that housing companies run their heat pumps as base load and use district heating only for peak demand or for redundancy. From an economical perspective, it is rarely beneficial for district heating companies to have these types of peak load customers and Stefan Hjärtstam hopes that the Flexi-Sync project can suggest new business models that can incentivize customers to choose the right heat source at the right time. Magnus Åkerskog at Willhem explains that the design of new business models will be crucial also for a major rollout of flexibility services, especially for commercial housing companies such as as Willhem. Since heating is included in the rent in most of Sweden's multi-family residential buildings there are no incentives for the tenants to accept any discomfort or variation of their indoor climate today. If we can create this incentive for our customers and allow larger variations, the effect of this kind of functionality can probably be higher, Magnus Åkerskog concludes.

Stefan Hjärtstam,
business developer at
Borås Energi och Miljö

Magnus Åkerskog,
head of property development
at Willhem

Facts and figures

Main production units:
- CHP Sobacken, 120MWth (wood chips), 32MW (FGC)
- CHP Ryaverket, 2x20MWth (waste), 9MW (FGC), 2x45MWth (wood chips)
- HWB Viared, 15MW (wood pellets)
- HWB Bäckeskog, 40MW (bio oil)
- 1.8 GWh thermal heat storage

Supply/return temperature: 95-98°C/40-45°C

Annual heat demand: 600 GWh district heating

Main fuels: Biomass and municipal waste

Parc Bit, Spain

Parc Bit is a science and technology park located in Palma de Mallorca, Spain. The district energy network in Parc Bit was built in 2000 connecting a tri-generation plant, including heating, cooling and electricity, to the office buildings located in Parc Bit technology centre. In 2002 the network was extended by connecting another branch to the university facilities, including the student house and a sports centre.

Pau Cortés, head of R&D at Sampol and project leader for the Spanish demo site, explains that the heating and cooling grid today provides thermal comfort to 25 customers. For district networks located in Mediterranean climates, and in particular this one in Parc Bit, the cooling demand may be as important as the heating demand. A noteworthy feature of this district network is the fact that some of the branches provide heating and cooling to certain users at the same time, nevertheless most of the users are seasonal users, meaning that they have a heating demand in winter and a cooling demand in summer. Moreover, according to the energy profiles of the customer, they can be split into three categories: office buildings, educational and specific usages such as residential, swimming pool and IT room. The profiles of these customers also differ during workdays and weekends.

Sampol operates and maintains the tri-generation plant which produces electricity, hot water and cold water for Parc Bit, including of 4000m2 or 18 buildings, two schools and the university campus of Universitat de les Illes Balears. The tri-generation power plant is a high-efficient production plant based on a combined heat and power (CHP) gas engine and absorption chillers which provides heating and cooling through a district heating and cooling network. The efficiency of the power plant can reach 85%. However, depending on demand and weather conditions this performance can decrease considerably. Reasons for the poor performance could be that the CHP is working out of the nominal load, that there is an increase in the consumption of the cooling towers or if there is a need for less effective auxiliary resources such as electrical chillers for cold water and conventional boilers for hot water. Pau Cortés hopes that flexibility can improve the operation of the tri-generation plant and decrease the emissions of the plant.

In the Parc Bit demo site several types of flexibility will be tested. The flexibility of the district energy network will be utilized by implementing a control system for smart substations with the aim to enhance the efficiency in the distribution of the energy as well as the ability to store energy in the network. By using the water of the district network as an inertia tank the district heating and cooling grid can be used as a large thermal storage. On the customer side the flexibility will be optimized by installing controllable valves and control systems for the energy meters. These new solutions will allow the operator to change the temperature of the district heating and cooling depending on the needs of the tri-generation plant, and without affecting the quality of the energy supply.

The Flexi-Sync project partners Sampol, Utilifeed and Luleå University of Technology are working on simulation models of the Parc Bit power plant, the district heating and cooling grid and the customer demand to optimize the energy production planning and the operation of the network. The simulation is crucial to obtain the optimal point of operation, reducing the energy cost and emissions while considering all the parameters involved. During 2020 and 2021 all the control systems were installed, data was collected to develop the models and in 2022 the Flexi-Sync solution will be validated in the live operation. Pau Cortés from Sampol is looking forward to studying the real savings that these solutions can achieve.

Pau Cortés, head of R&D at Sampol and project leader for the Spanish demo site

Facts and figures

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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:

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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
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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:

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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:

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WP5: Business implications from increased flexibility

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

Lead by:

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RISE
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WP6: Coordination and management and
WP7: Communication and dissemination

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

Lead by:

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Climate change adaptation of energy solutions

In public debate there is much focus on how the transition to a renewable energy system is one of the keys to tackle climate change. Less is being said about the impact of climate change on the energy system, and in particular energy demand and renewable generation. In Work Package 3 (WP3) of the Flexi-Sync project, researchers from Chalmers University of Technology are highlighting these aspects of climate change.

Fact is that climate change can affect both energy demand and renewable generation. This becomes challenging for the sustainable energy transition of societies, especially due to extreme climate events and weather variations. Climate change can induce unprecedented weather extremes and variations that our buildings and energy systems are not necessarily designed for. To avoid energy system failures in the future, we should account for the climate change adaptation of energy solutions, says Vahid Nik, Associate Professor in Building Physics at Chalmers and work package leader for Work Package 3 in Flexi-Sync.

Vahid Nik, Associate Professor in Building Physics at Chalmers and work package leader for Work Package 3

Within Work Package 3, several future climate projections for the demo site regions are investigated to synthesize future weather data sets representing typical, extreme cold and extreme warm conditions. The considered climate projections include different climate models and greenhouse gas concentrations, enabling us to consider a wide range of future climate scenarios, Vahid explains. The synthesized weather data sets will be used to assess variations in the future energy demand and generation and quantify impacts of climate change on the energy system performance.

In other words, the work package investigates if the flexible energy solutions are climate resilient or not. The generated results and future weather data sets can help both energy utilities and housing companies to estimate the future needs and plan better for the required adjustments during the coming years.

For example, it might be the case that the average annual heating demand decreases in the future, while the peak demand increases due to climate variations. Such an insight, while it is quantified using scientific analysis based on high spatiotemporal resolution future climate scenarios, can become very valuable for the companies and stakeholders to develop the energy system towards higher flexibility.

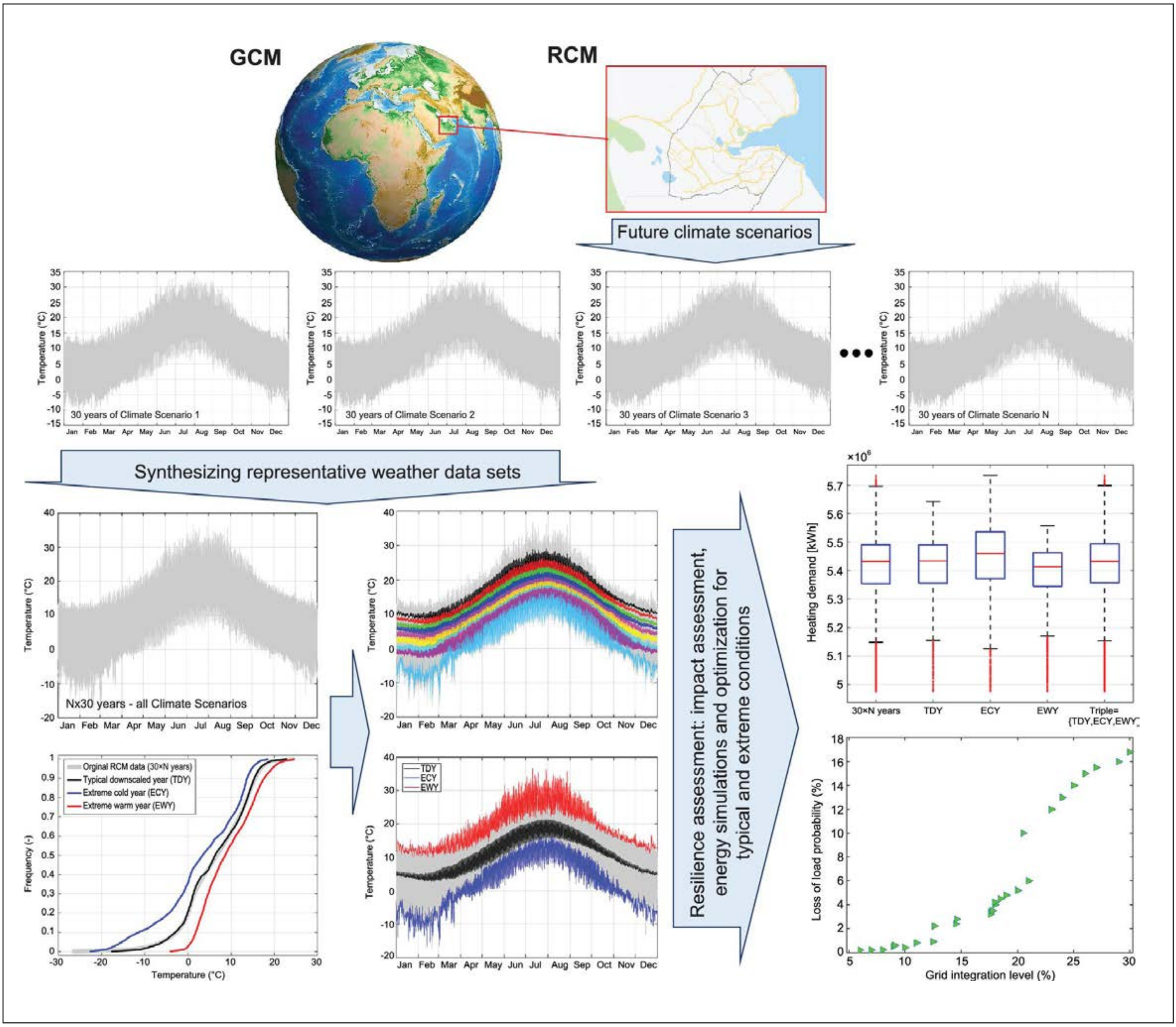


Figure from Nik VM, Perera ATD, Chen D. "Towards climate resilient urban energy systems: A review", National Science Review, March 2021, 8, 3. doi:10.1093/nsr/nwaa134."

Deliverable 3.1: Report on representative future weather data sets for selected demo site areas

This report is about synthesizing future climate data sets for the demo sites investigated in the Flexi-Sync project. Several long-term weather data sets using regional climate models (RCMs) have been used to synthesize representative weather data sets for near-term, mid-term and long-term future climatic conditions. The generated weather data sets will be used in the next stages of the project to assess the climate flexibility and resilience of energy solutions.

Business implications of increased flexibility

If flexibility should be implemented at a wider scale in district energy systems, business models are needed to compensate and incentivize building owners and tenants to take an active role in district heating and cooling network operation and optimization. The established business models and price models for operation may therefore need to be adjusted, or even replaced with entirely new ones that take account of a more dynamic operation of the heating and cooling systems

Inger-Lise Svensson, director of Energy and Environmental System Analysis at RISE, is leading the work within Work Package 5 in analysing changes to district heating business models from increased flexibility in the system. This is being done by trying to answer what price models the district energy sector could deploy to capture flexibility, what effects increased flexibility has on network asset maintenance and durability, what the constrains are from the heat end-users' perspective and how to replicate the new service developed in Flexi-Sync to fully utilize the flexibility. Flexibility, here defined as changes in heat demand, could influence the variable cost of production, the cost of operation and maintenance due to modified patterns of stress on the physical components and, as an implication of the previous two, the cost to the end-consumer. With flexibility the peak load of heat end-users, which is often a motivational element of price models, may be reduced.

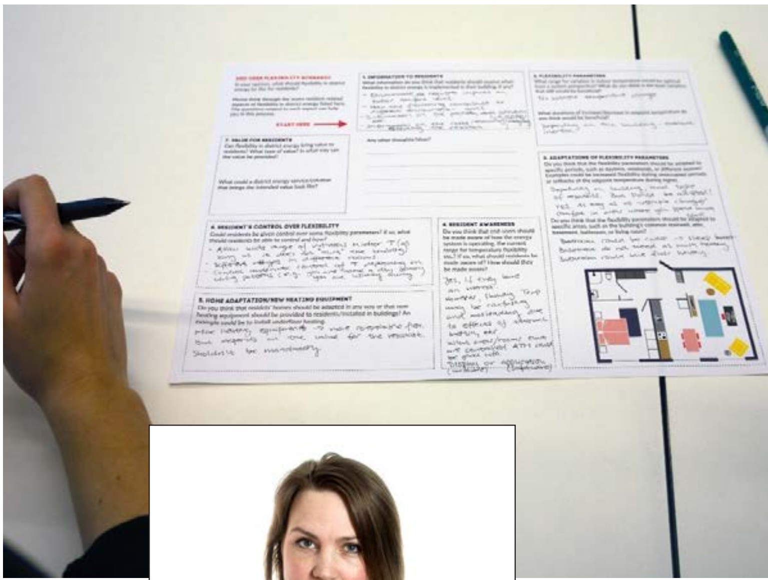
During the past year, inputs have been collected from the participating district energy companies on price components that they would like to include in the analysis of flexibility price models. New price models will be evaluated and assessed, both from an individual heat customer's point of view and for an aggregated grid, to see the effect it has on operation of flexibility enabling services but also the cost of heat for different customers. The work package has also surveyed three end-user flexibility scenarios on Swedish residential heat end-users and analysed the result to understand what fluctuations in indoor temperature or comfort end-users can accept. Some main findings, presented in Deliverable 5.3, are that there is more than a temperature range that is important for residents, for example location of change and time of the day, and that control over both temperature and flexibility is very attractive to residents.

Even though end-users may accept variations in indoor temperature, the result from a literature review done by the work package show that today most district energy providers are slow to recognize and capture flexibility that can be catalysed through end-users, thermal inertia, heat pumps, and others. Therefore, current price models and business models lack the ability to transparently convey the value of flexibility. This indicates that there is a big potential for district energy companies to further capitalize on flexibility in the energy system. A win-win could be established by including flexibility incentives in price models that can induce a reduction of operational costs for the district energy provider and energy consumption costs of the end-user. In addition, district energy companies are suggested to deploy easily understandable price models, to be able to communicate with customers.

During 2022 the work package will develop a simplified algorithm to be able to evaluate how new price models of district energy influence the switch between the use of heat pumps and district heating for heat end-users that have both heating options installed. During the year new price models, based on the literature study, input given by demo site owners, and knowledge obtained from the simplified algorithm, will be implemented in the computation price model of the project partner Utilifeed. Discussions will also be initiated about business model elements and how to evaluate the possible business models of the service in the different demo sites of the Flexi-Sync project.

Deliverable 5.2: Report on maintenance effects of flexibility installed in demo sites

Operating the heat networks more flexibly can lead to higher temperature peaks, more temperature cycles, and higher average temperature. In this deliverable, a cost function for operating a district heating network at increased temperature volatility and at increased average temperature has been developed. This can in turn have an impact on damages to the heat networks which will eventually lead to maintenance activities, such as repairs or replacements of components.
In the model presented in D5.2, damage due to plastic deformations of service pipes, fatigue of service pipes, and degradation of polyurethane insulation at the interface between the service pipe and the insulation are considered. Including this model in optimization models could contribute to the decreased cost of maintenance for district energy companies, especially with the flexible operation.



Inger-Lise Svensson, director of Energy and Environmental System Analysis at RISE, is leading the work within Work Package 5

Deliverable 5.3: End-user flexibility potential

Flexibility in district energy systems can be realised in many ways; one of these is to allow for greater variations in indoor temperature. The aim of this deliverable was to understand what impact greater variation in indoor temperature can have on the comfort of occupants of such spaces. The deliverable showed that there are more aspects than the range in which the temperature is allowed to vary that is important for the acceptance of varying indoor temperature; that occupants understand the flexibility setup, when and where (e.g., in the bathroom or bedroom) the variation takes place and that there are specific and individual preferences regarding heating. Given the results, housing companies and district energy companies could apply different occupant-related flexibility measurements for different groups of end-users, their different preferences, different locations, different home adaptations and equipment, corresponding to different flexibility scenarios. This could also serve as important information for their business model design and price model design, incentivizing flexibility and enhance approval of possible comfort losses.

Learn more about the project

Website
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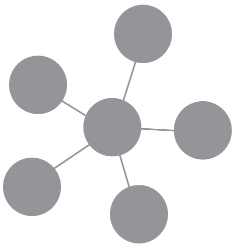
4 times/year
Sign up on website



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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 vård i Mölndal

NODA Intelligent Systems

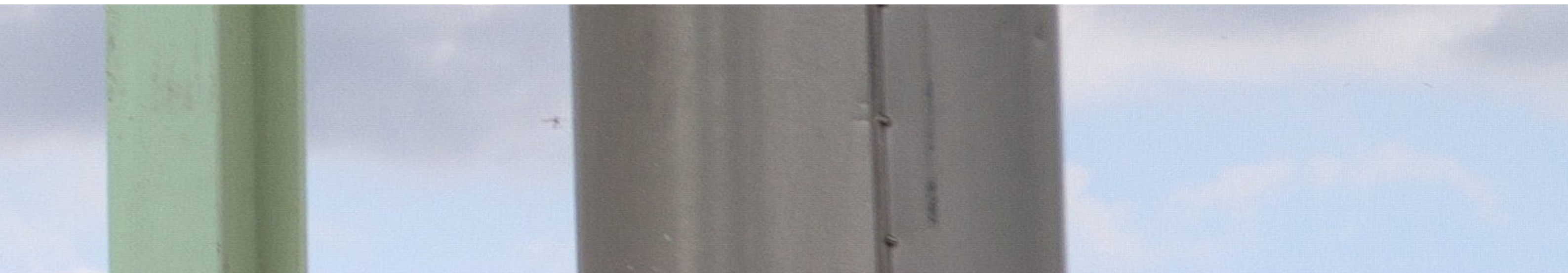
RISE

SAMPOL

Utilifeed

VATTENFALL

Willhem



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Smart
Energy
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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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