

Case Studies

<https://heatpumpingtechnologies.org/annex57/>

ANNEX

57

Flexibility by
implementation of heat
pumps in multi-vector
energy systems and
thermal networks

Demo No.: D-004	Location/City: Various locations within Austria	Country: Austria
Title (short and full title): Flex+ Large-scale deployment of prosumer flexibility in short-term electricity markets considering prosumer interests.		
Schedule of the demo project (research study): 2018-2022		
Leader organisation (owner, constructor, solution developer, research inst., etc.): AIT Austrian Institute of Technology GmbH		
Participating organisations – demonstration project part (involved other organisations): IDM Energy Systems GmbH Fronius International GmbH World-Direct eBusiness solutions GmbH Technikum Vienna GmbH aWATTar GmbH TIWAG-Tyrolean Hydropower AG TU Vienna - Institute for Energy Systems and Electric Drives Sonnenplatz Großschönau GmbH Software Competence Center Hagenberg GmbH Austria Email AG WEB Wind Energy AG neoom group gmbh ms.GIS Information Systems Ges.m.b.H. Energie AG Upper Austria Distribution GmbH University of Applied Sciences Technikum Wien		
Budget of the demo (invest/monitoring etc.): € 4m		
Published articles (paper, article etc.): <ul style="list-style-type: none">• Hemm, R. et al.: Flex+ - Large-scale deployment of prosumer flexibility in short-term electricity markets considering prosumer interests. Final Report 2022• Hemm, R. et al.: Marktteilnahme von EndkundInnenflexibilität durch Pooling, 16. Symposium Energieinnovation, 12.-14.02.2020		
Country: Austria	Participating Organisation: AIT Austrian Institute of Technology GmbH	Contact/name: Johanna Spreitzhofer



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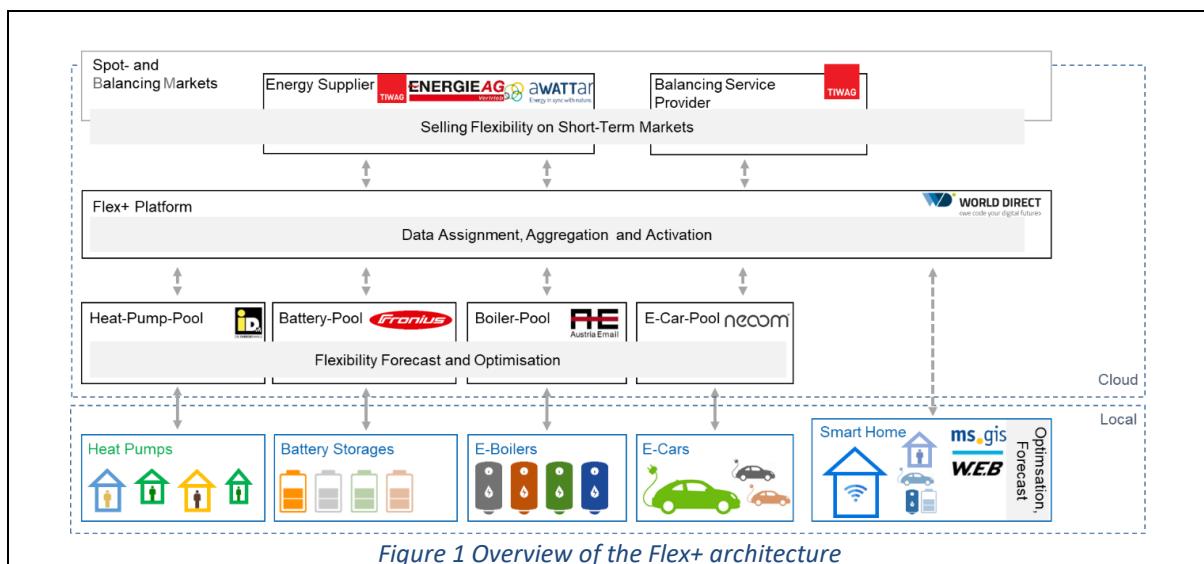
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Figure 1 Overview of the Flex+ architecture

Homepage address: <https://www.flexplus.at/>**Project classes:****RD&D status**

Large-scale demonstration (results based on measurements)	Lab scale (results based on measurements)	Design study (results based on simulation)
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Type of heat pump

Decentralized HP (cold district heating)	Centralized HP with a district heating system
<input checked="" type="checkbox"/>	<input type="checkbox"/>
Heating	Cooling
<input checked="" type="checkbox"/>	<input type="checkbox"/>

Heat source of HP: Air, Geothermal

Power supply for HP (electricity grid, PV, wind turbine etc.): electricity grid, PV



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ANNEX

57

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Buildings

New buildings	Existing buildings	Mix of new and existing buildings
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Residential	Non-residential	Mixed use
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Energy storage

Battery storage		Thermal energy storage	
Centralized	Decentralized	Centralized	Decentralized
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

Control for the flexible heat pump operation

Heat driven control ¹	Predictive control ²	Rule based control ³
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

1. General description of the project

In the Flex+ project, the deployment of remotely controllable prosumer components such as heat pumps, boilers, home storage systems and e-mobility in short-term electricity markets in Austria was researched. A special focus was on the economic use of flexibilities at spot and balancing energy markets (frequency restoration reserve) and on the consideration of the end consumers' own interests. The developed concepts were first tested by simulation and then validated in large-scale real operation. Based on these results, remuneration models and tariffs for prosumers were developed.

The main research question was: How can prosumer flexibility such as heat pumps, boilers, e-mobility and batteries be used on large scale in the various electricity markets, while considering the interests of individuals?

¹ Operation of heat pumps to the cover heat demand depending on ambient temperatures

² Operation of heat pump using a model based heat demand prediction

³ Heat pumps are controlled by a set of predefined rules (e.g. heat pump operation with blocking time)



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ANNEX

57

Flexibility by implementation of heat pumps in multi-vector energy systems and thermal networks

2. Building and system description of the project

Figure 1 shows an overview of the Flex+ architecture. The individual components (heat pumps, electric vehicles, hot water boilers and battery storages) are part of component pools. They send data regarding their storage levels and room and water temperature levels to the pools. Scalable optimization algorithms were implemented at the pool level, which not only take into account the interests of the aggregator, but also the needs/self-interests of the prosumers. Thus, an optimal cross-market use and marketing of the existing flexibility in private households can be achieved for all involved stakeholders. The Flex+ platform was planned and implemented as the interface between the pools and the market. It coordinates the pools and the electricity suppliers and is responsible for the aggregation and forwarding of balancing energy calls. The suppliers have the task of marketing the schedules created by the component pools on selected spot and balancing energy markets. The entire process was tested and evaluated in demo operation.

3. Energy supply – scheme of the heat supply system:

This project focused on heat pumps in single family homes, where the heat pumps were a part of a coordinated pool. The heating system of the individual households consisted of the heat pumps (both air and geothermal), domestic hot water storages, in many cases additional buffer tanks and the buildings themselves.

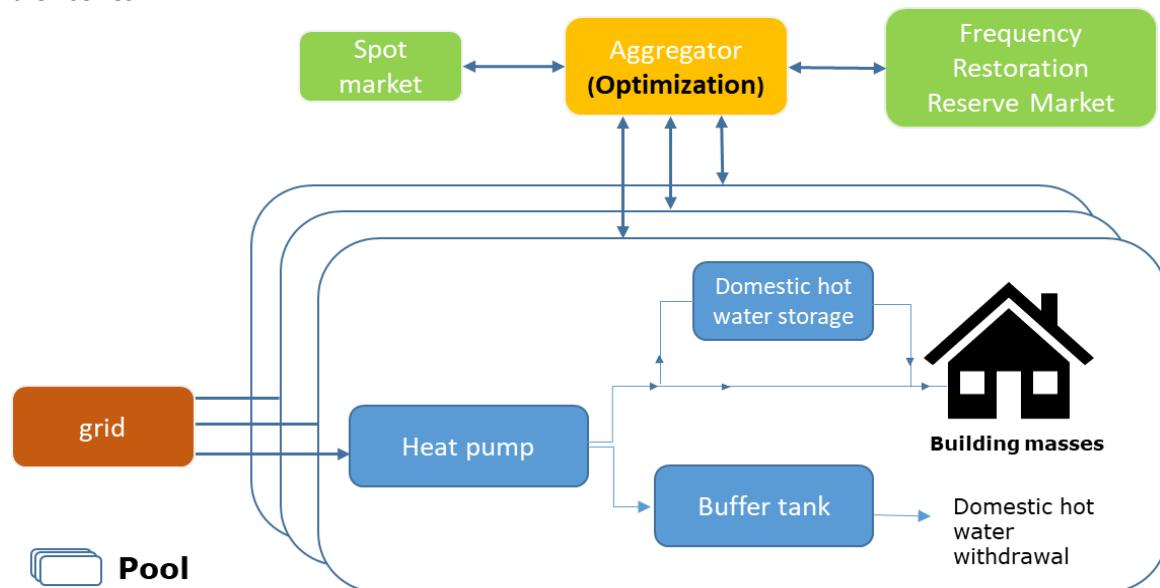


Figure 2 Interaction of the different components of the heat pump pool



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ANNEX

57

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4. Flexibility – scheme and control strategy of the system:

The project Flex+ investigated the flexibility provision by heat pumps in the context of the participation in various electricity markets (day-ahead and intraday spot market, automatic and manual frequency restoration reserve (aFRR, mFRR)). Different use cases were tested in demonstrations. A reference use case represents the conventional operating mode, where the heat pump is activated, in case the room temperature falls below a certain reference temperature. In another use case, the operating schedules are optimized based on day-ahead spot market prices. In a third use case, free capacities for frequency restoration reserve are reserved and considered when optimizing the schedules. Since the actually consumed energy can differ from the forecasted one, the deviations can be rebought at the intraday market. For the scheduling of the heat pumps, mixed integer linear programming algorithms were used. The buildings were depicted as RC models, which are thermal network models commonly used to predict building dynamics using thermal resistances and capacitance. Further, storages for domestic hot water and heating water have been used for load shifting. Measured heating curves were provided by the heat pump manufacturer and linearized.

5. Description of the business model with a flexible HP-operation

In Flex+ the optimal use and marketing of the existing flexibility of prosumer components was calculated. This was done, taking into account both the economic and non-economic interests of the different stakeholders. Different business models in the area of flexibility aggregation and marketing were also analysed. Based on these business models, different price models and non-monetary incentive systems for prosumers were developed. Appropriate price models and non-monetary incentive systems enable the supplier to achieve financial and qualitative goals, such as acquiring new customers and retaining them in the long term. For this purpose, the necessary adequate billing models for the end customers and suitable contracts were examined and assessed.

In all use cases, the supplier offers customers financial and non-financial value propositions at the same time, e.g. a reduction in energy supply costs (monetary) and an environmentally friendly energy supply (non-monetary), because low spot market prices usually correspond to a high feed-in of renewable energies at the power exchange. However, the purely market-related integration of the flexibilities can be restricted by the different self-interests of the customers. Raising customer awareness of the environmental and financial challenges of Flex+ is necessary to attract mass segments. Based on an evaluation of the customer benefit, the supplier can make an offer and, through a contractual agreement for the energy supply and flexibility marketing, assign the customers to the component pools. An important source of income for the supplier is the sale of electricity to the energy and balancing markets. Furthermore, they are able to improve their forecasting of the prosumer behaviour and reduce their imbalance settlement costs.



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57

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6. Results of the project

According to the simulation results, the total variable energy costs of the heat pump pool could be reduced by up to 12%. The most profitable use case was when the heat pumps participated on the day-ahead spot market, and additionally provided balancing energy (automatic frequency restoration reserve (aFRR)). Per heat pump and year, this amounted to a cost reduction between 65-117 € for the combination of day-ahead spot market and aFRR and between 8-23€ for only day-ahead spot market participation. The biggest share of cost reduction was due to reduced grid tariffs for frequency restoration reserve. The participation in the electricity markets resulted in up to 3% increased electricity consumption.

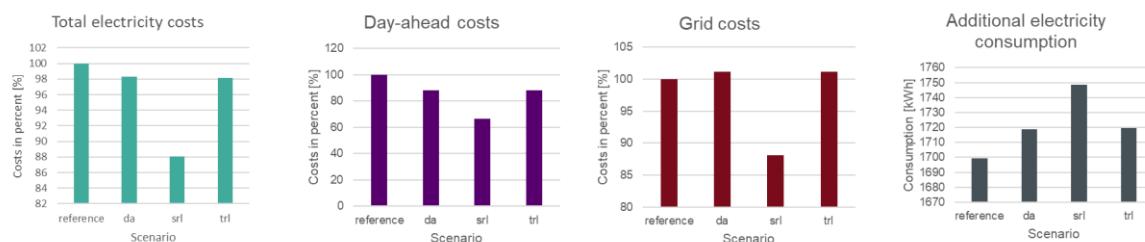


Figure 3: Simulation results for the heat pump pool in Flex+

7. Challenges / socio economical barriers and opportunities

- Business case becomes more interesting, the simpler the processes and the lower the implementation costs
- Prequalification for aFRR provision of the pool is complex
- Prediction of user behaviour is challenging (hot water, heating demand, electrical load)
- Difficulty to find the right modelling depth for technical components (duration of the solution time of the MILP (mixed integer linear programming) increases strongly with model depth)



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