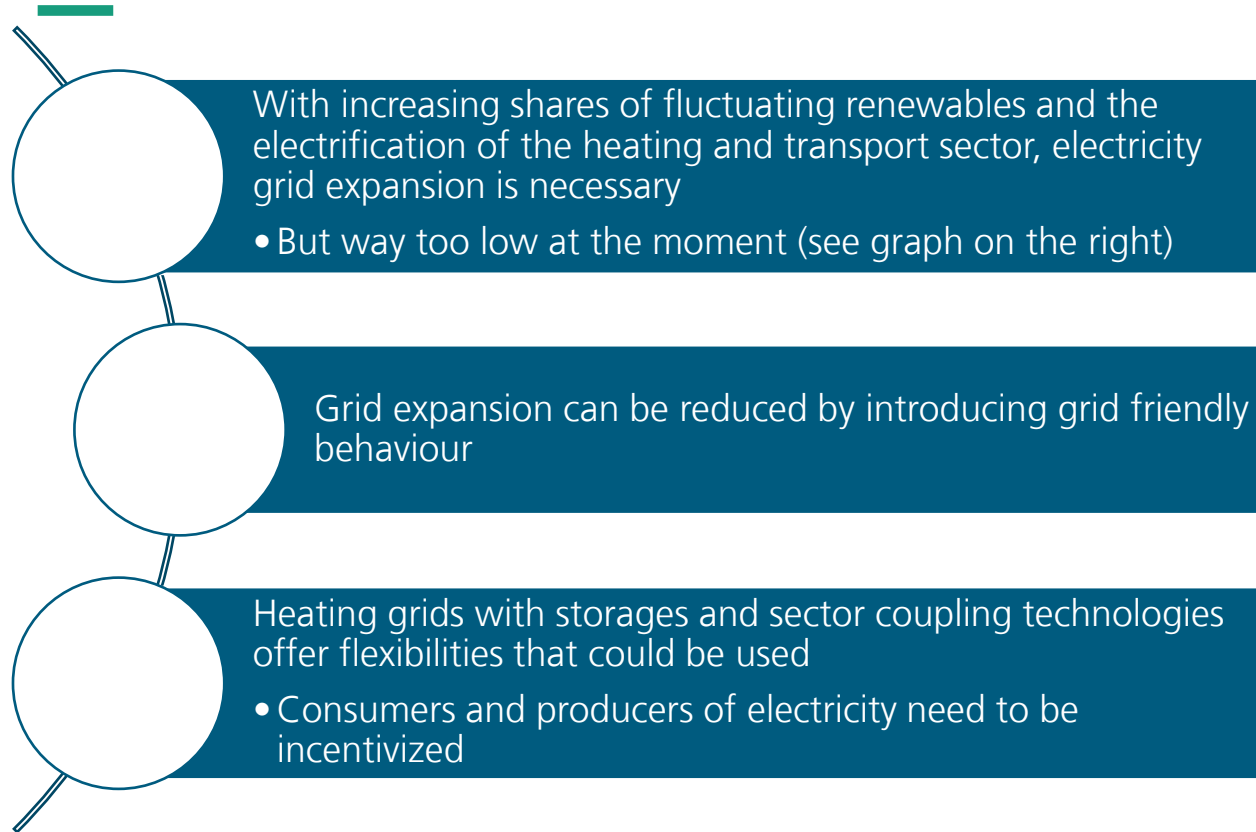


Flexibility potentials in low temperature heating grids – exploring business models under current regulations

Enerday Conference, Dresden
27.03.2026

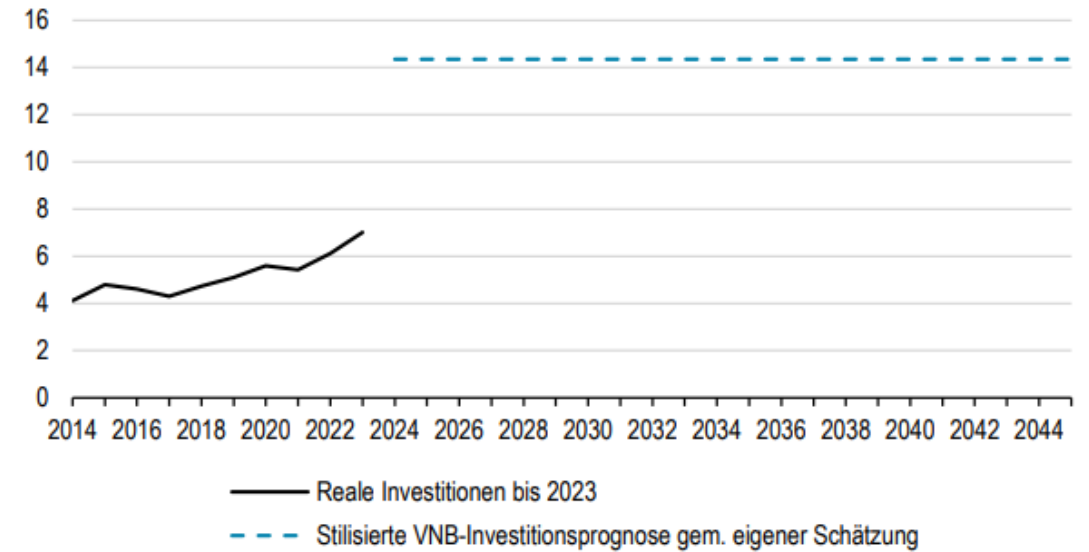
Dr. Annette Steingrube, Erik Fröhlich, Fraunhofer Institute for Solar Energy Systems ISE
Annette.Steingrube@ise.fraunhofer.de

Motivation



Source: Institut für Makroökonomie und Konjunkturforschung – yearly needed investments in distribution grids

Abbildung 3: Jährliches Investitionsvolumen in die Verteilnetze in Mrd. Euro, reale Preise von 2023



Quellen: Eigene Berechnungen und BNetzA (2023b).



Analyzed business models in the Transurban.NRW project

1. Optimization of self-consumption

2. Dynamic electricity prices

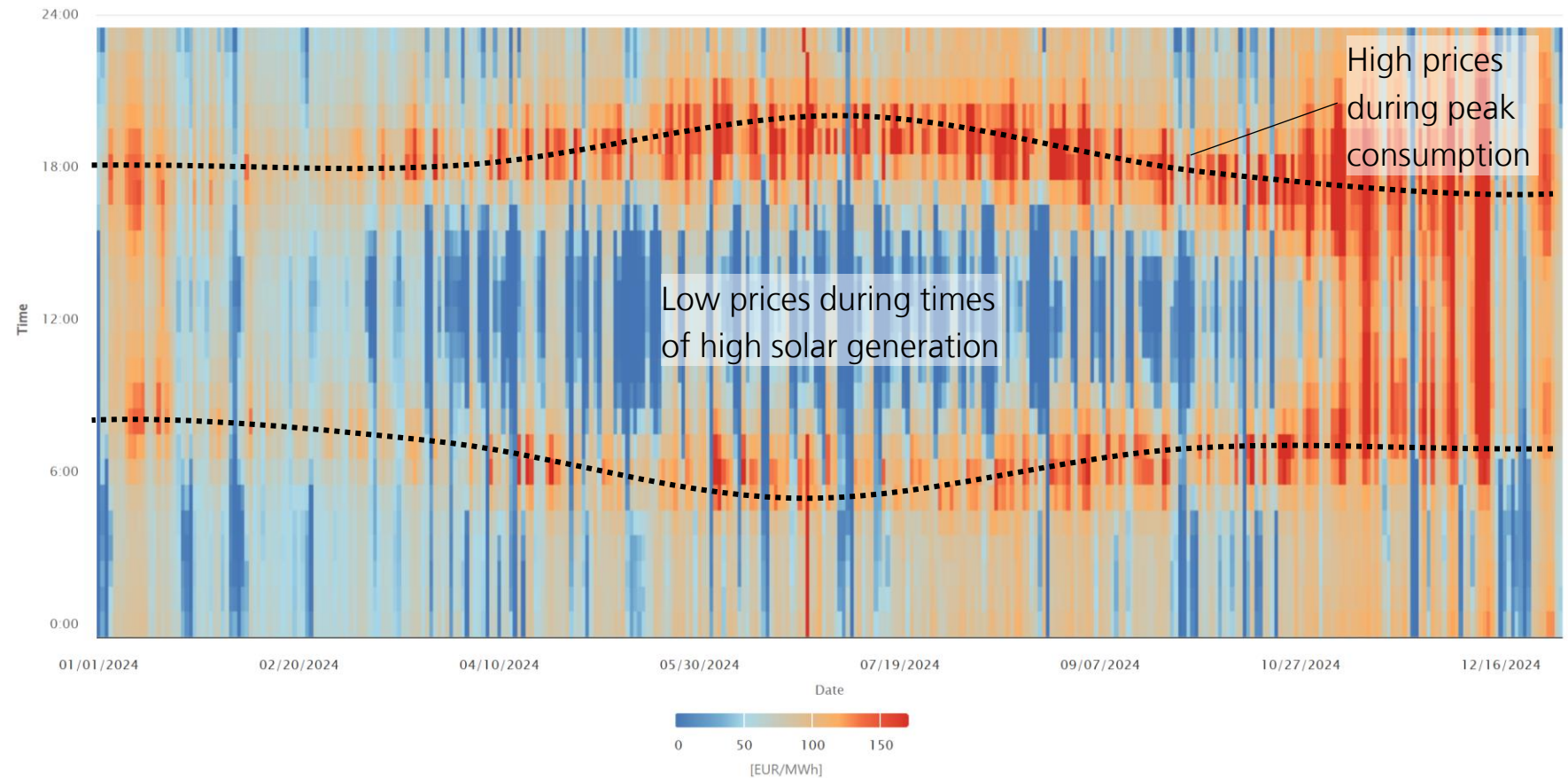
2. Grid-oriented control (ENWG §14a)

3. Provision of control reserve

2. Dynamic electricity tariffs

- Dynamic electricity tariffs follow market prices, **procurement costs are volatile**
- Due to high shares of renewable generation in Germany **price patterns** can be observed in spot prices, flexible users can respond

Day Ahead Auction (DE-LU) in Germany in 2024

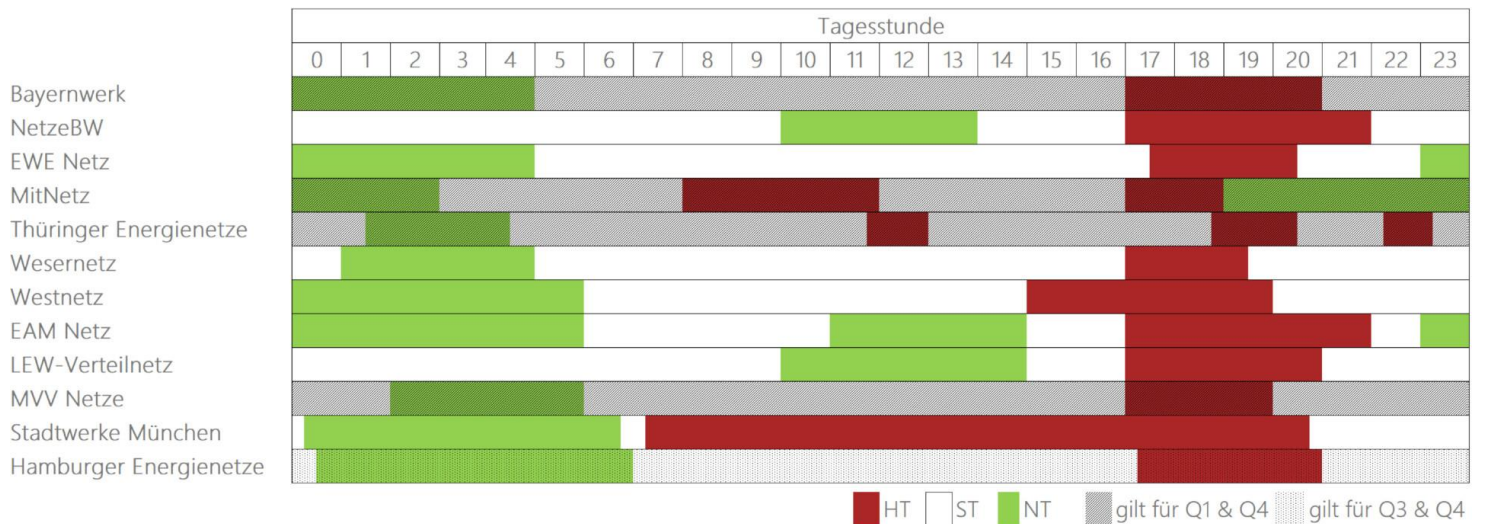
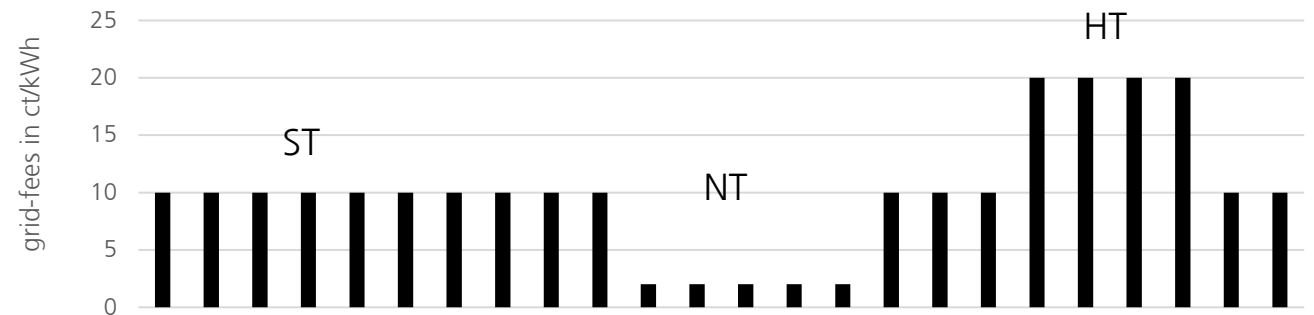


Energy-Charts.info - last update: 05/03/2025, 12:11 AM GMT+2

2. Variable grid fees and EnWG14a

- In Germany since 2024 a **new legislation enables time-variable grid fees** (EnWG §14a) on a local level
- ... but **only for controllable loads** (e.g. heat pumps, EV, battery storage)
- For load dimming different remuneration schemes exist
 - Module 1: yearly compensation for load shedding (110 – 190€/a)
 - Module 2: reduction of grid fees by 60%
 - **Module 3:** in addition to module 1, **application of time-variable grid fees**
- Time-variable grid fees are applied as 3 different price levels (NT, ST, HT)

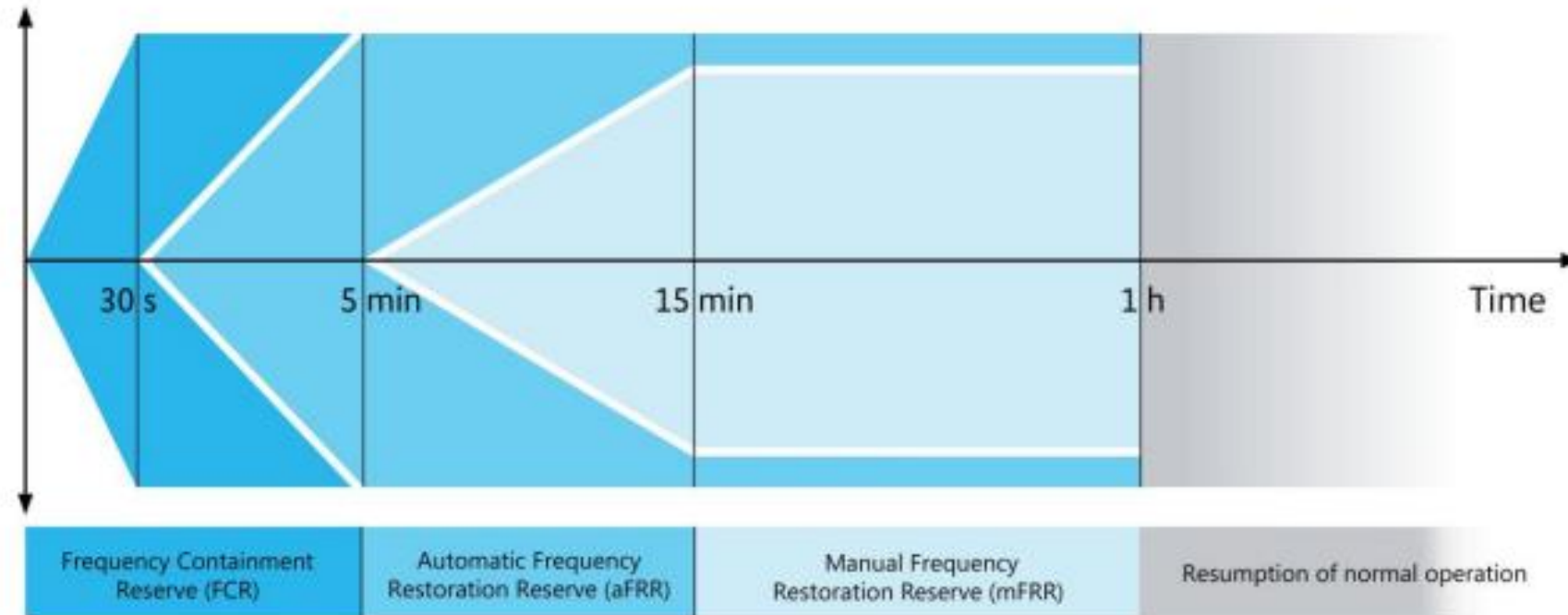
Examples for time-variable grid fee tariff according to EnWG14a



Source: FfE

3. Provision of control reserve

- To compensate for frequency fluctuations in the power grid, the mechanism of **control reserve** comes into play
- For the districts under consideration, providing automatic frequency restoration reserve (aFRR) is particularly attractive because the compensation is higher than for mFRR, and the required response times can be achieved even with heat pumps



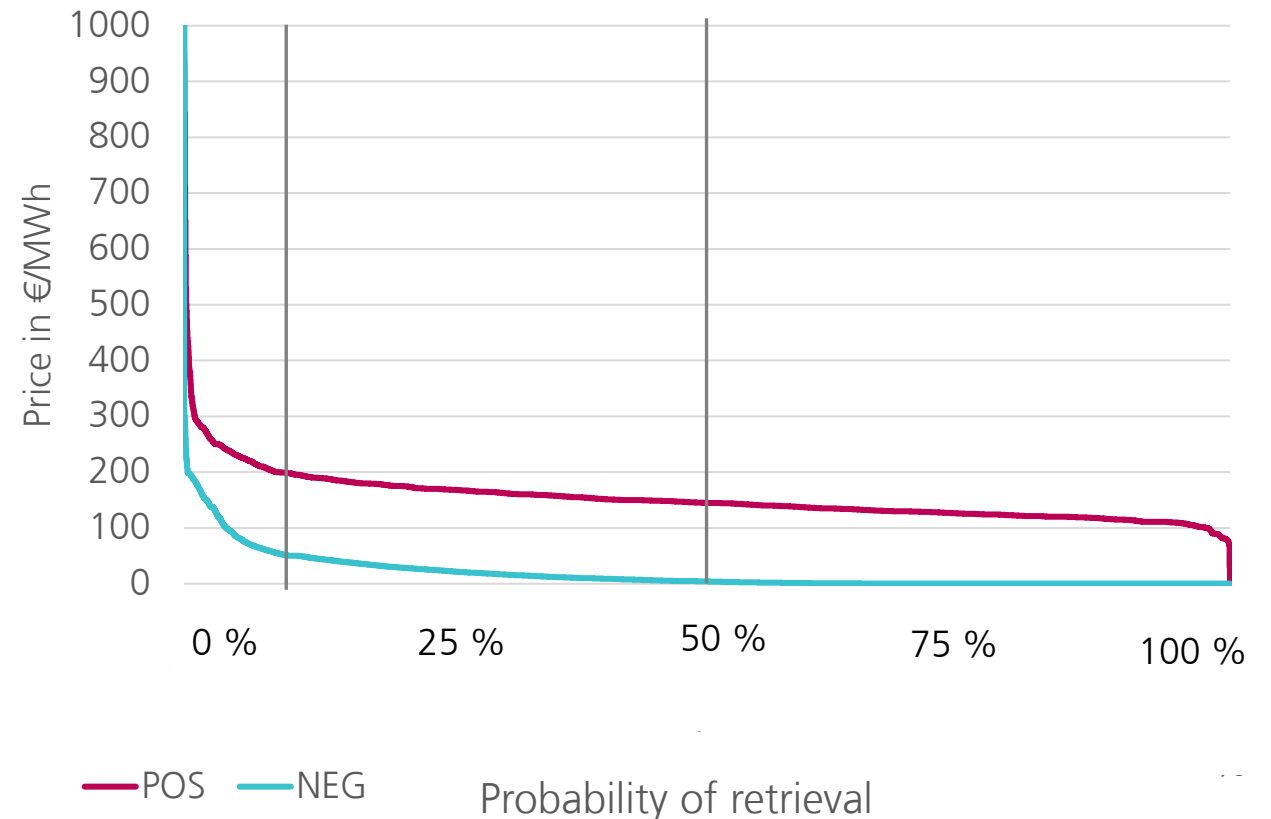
3. Provision of control reserve

- The calculations reflect the participation of the districts in the **aFRR control reserve capacity market** and **aFRR control reserve energy market**.
 - “Pay as bid” applies in both markets
 - The higher the price bid, the lower the probability that bid is retrieved
 - Two different probabilities have been modelled
- It should be noted that, in practice, a **minimum bid size of 1 MW applies**. In some of the case study districts, this minimum cannot be met.
 - To still be able to utilize the business model, it is possible to **aggregate multiple plants into a virtual power plant**

aFRR energy market "clearing price" 2023

10 % Probability of retrieval
POS: 198 €/MWh
NEG: 50 €/MWh

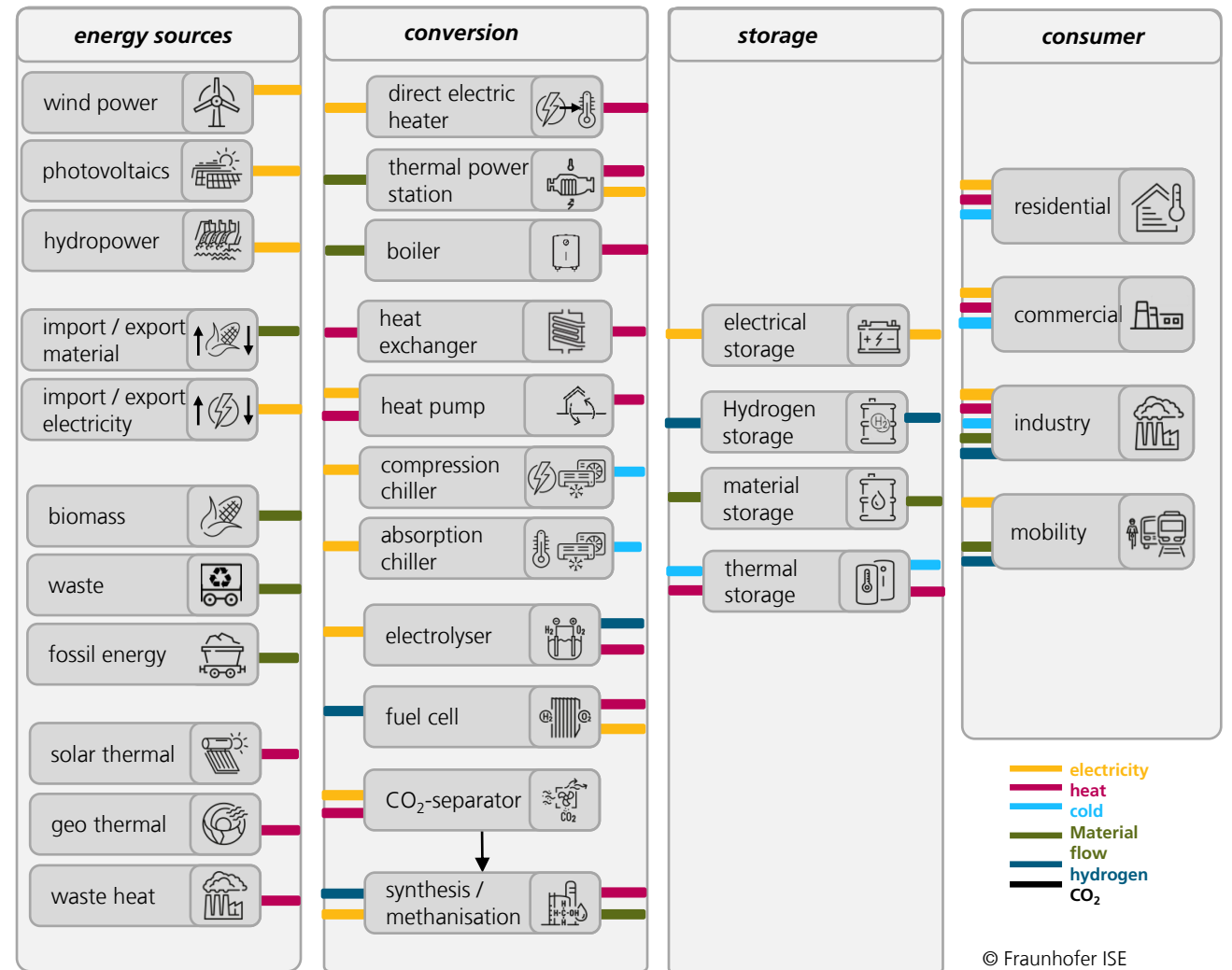
50 % Probability of retrieval
POS: 145 €/MWh
NEG: 4 €/MWh



Energy system model to study economic attractiveness of flexibility options

Method

- The energy system **optimization** tool KomMod¹ is used **to study the effects of different flexibility options** on the total energy system costs
 - bottom-up techno-economic model for local sector-coupled energy systems
 - linear programming optimization problem with the target of minimizing total energy system costs
 - Simultaneous optimization of expansion and operation



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The three case studies

- Three neighborhoods in Germany are examined
 - Glückaufpark **Hassel**, Gelsenkirchen
 - **Seestadt**, Mönchengladbach
 - **Shamrockpark**, Herne
- Each features a decarbonized 5th. gen. District heating network with electrical heat generation
- Modelled as energy-community: Can be equipped with shared PV Systems and battery storages

Glückaufpark Gelsenkirchen
Hassel



Seestadt, Mönchengladbach



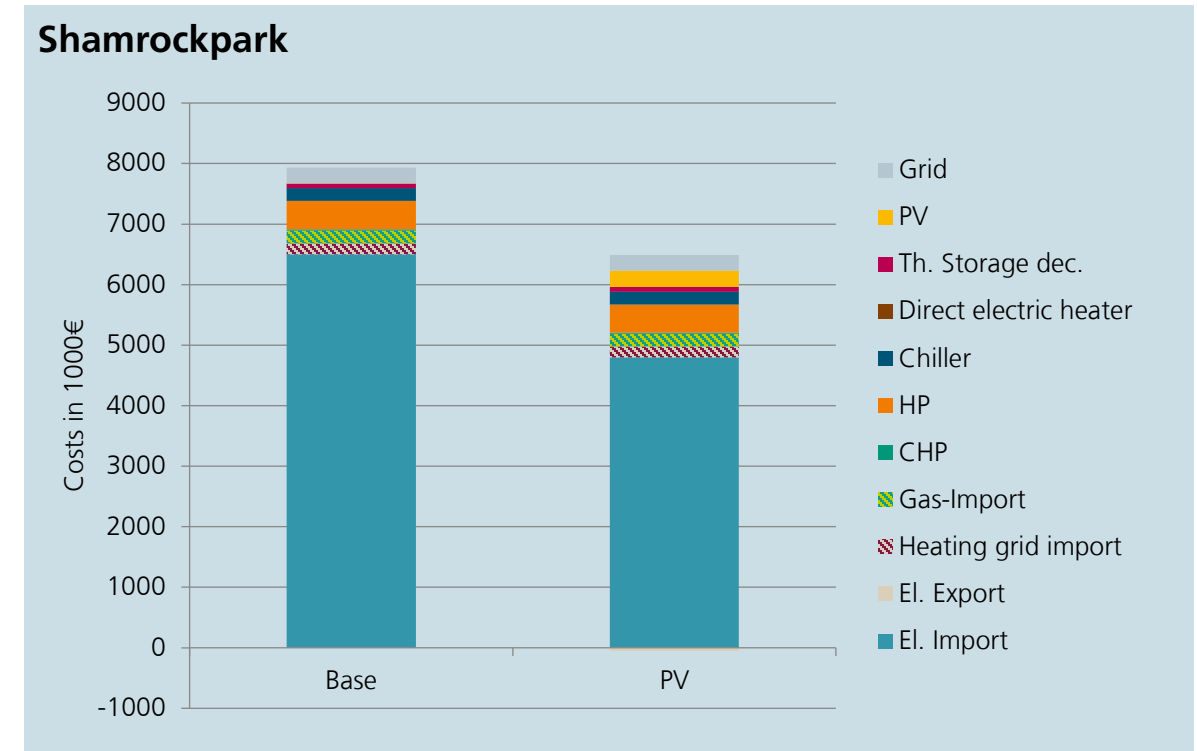
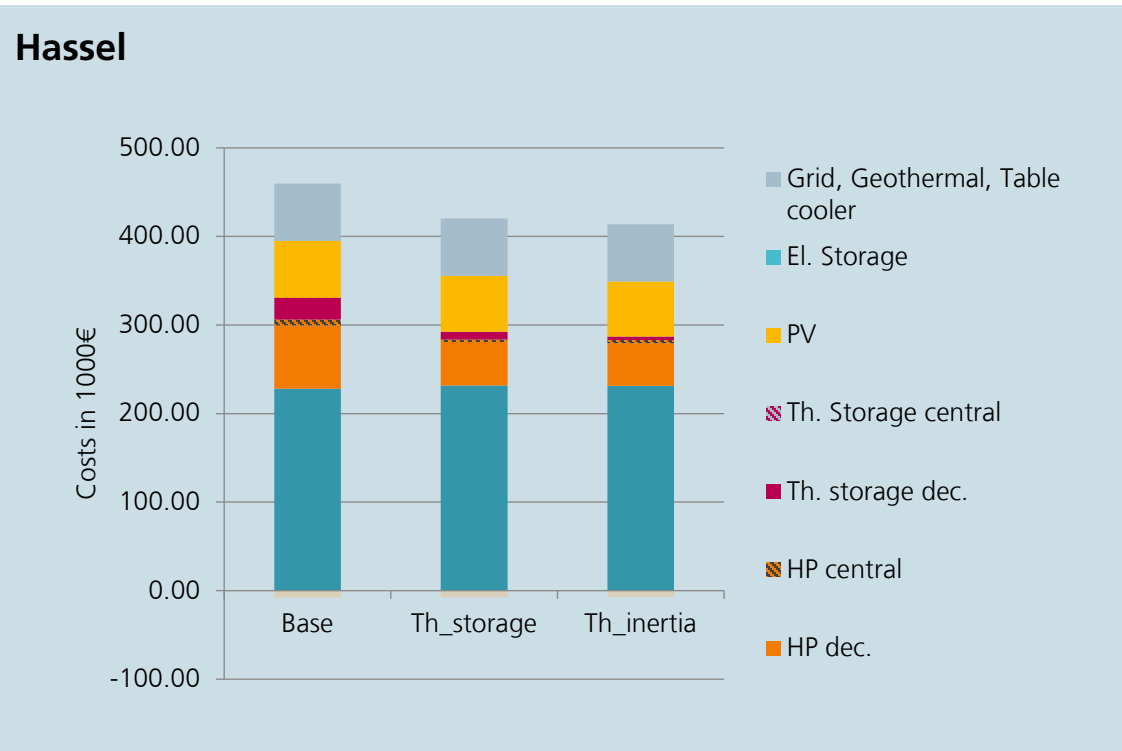
Shamrockpark, Herne



The three case studies

| | Hassel | Seestadt | Shamrockpark |
|---|--|---|--|
| General description | Residential neighborhood, SFH and MFH | Residential neighborhood, only MFH | Mixed use neighborhood: MFH, office buildings, computation center |
| Heating system characteristics | Cold heat network (2 – 15°C), decentral heatpumps (over-dimensioned) | Low temperature heat network (39°C), central heatpumps, decentral flow heaters, backup gas boiler | Combined heating and cooling network (22°C/12°C), decentral heatpumps and compression chillers |
| Solar own generation | Large PV capacities: 31% solar coverage | Large PV capacities: 25% solar coverage | Small PV capacities: 1% solar coverage |
| El. Import costs | 50% of total energy system costs | 67 % of total energy system costs | 82% of total energy system costs |
| El. load profile: in % of max. possible load — avg. Load - - - max. load ····· min. load - - - - - dyn. el. price | | | |

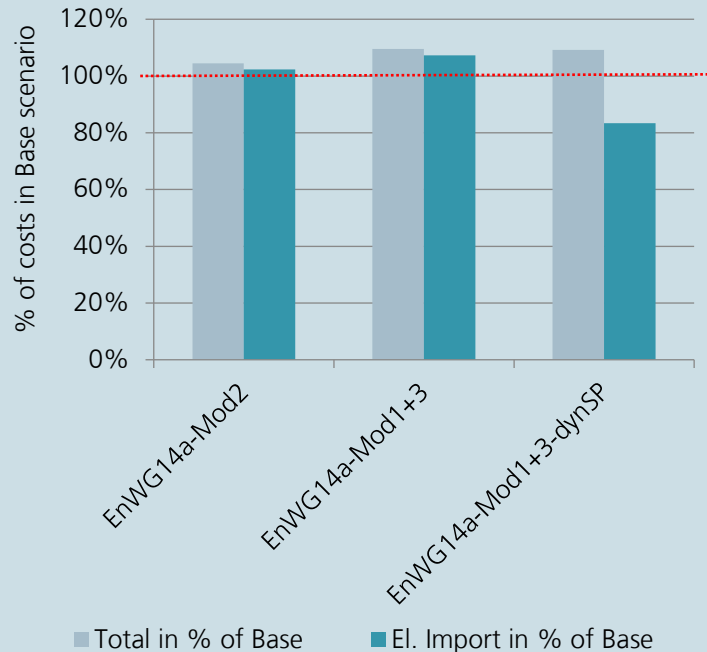
Results: 1. Optimization of self-consumption



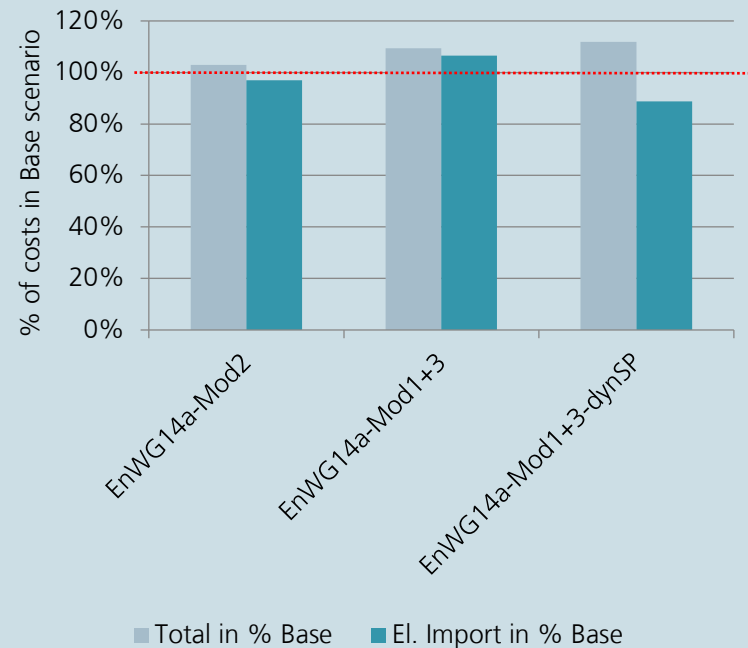
- Optimization results show that optimized system configurations (in comparison to the planned/ implemented ones) can lower the system costs
 - By 9-10 % in Hassel by installing higher storage capacities or using thermal inertia
 - By 20 % in Shamrockpark by installing higher PV capacity

Results: 2. ENWG 14a and dynamic electricity prices

Hassel



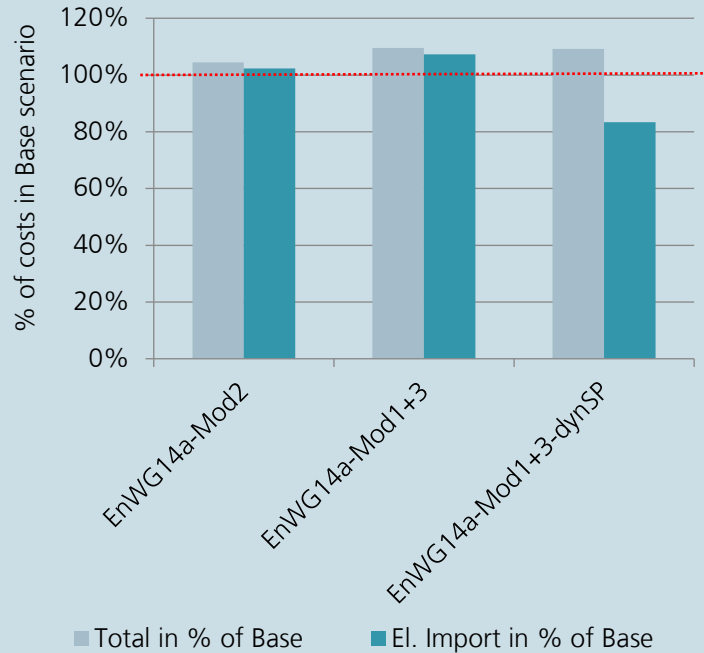
Seestadt



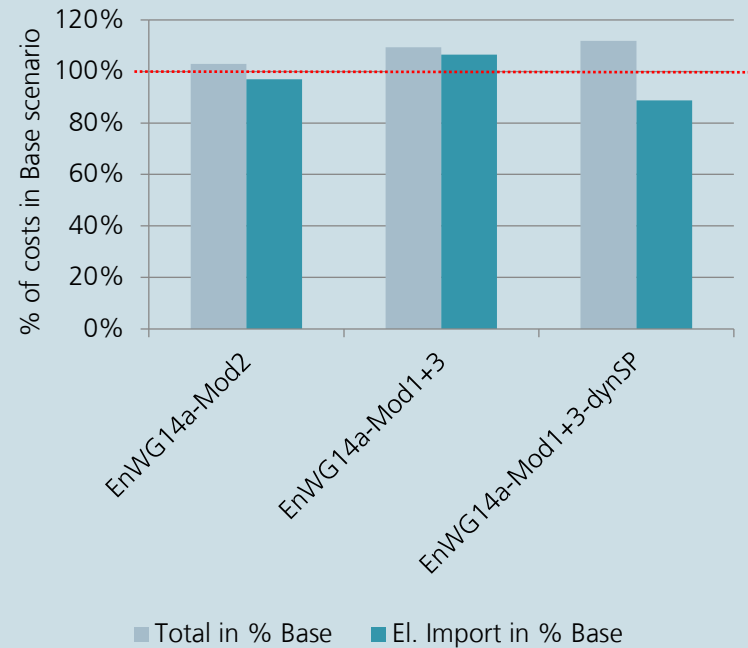
- In Hassel and Seestadt **ENWG 14a** options **rise total costs compared to base scenario**
 - Module 2 (reduced grid fees): Higher installed HP capacities necessary
 - Module 3: This is because **the variable grid tariffs are unfavorable for the neighborhood's load profile**; the high prices during the evening hours result in higher costs, and the reduced grid tariffs during the midday hours cannot be fully utilized due to on-site generation

Results: ENWG 14a

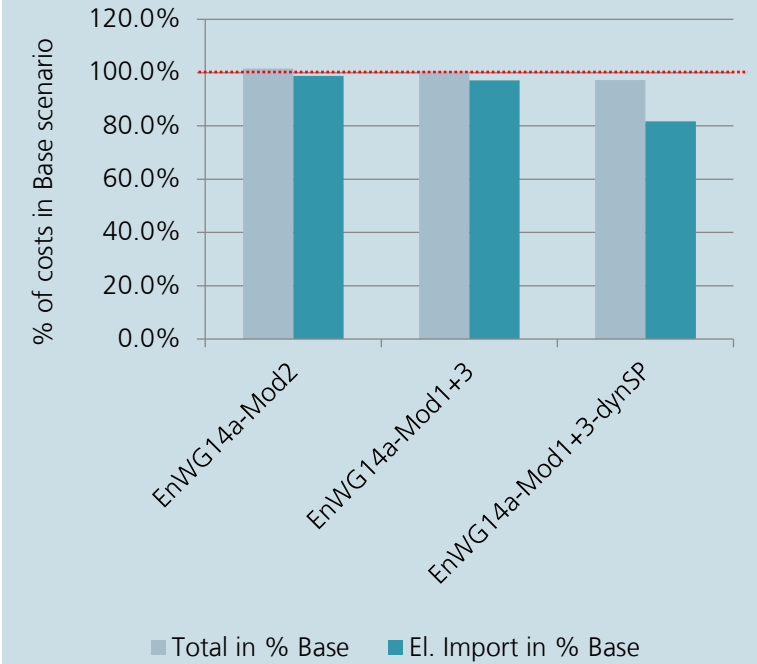
Hassel



Seestadt



Shamrockpark

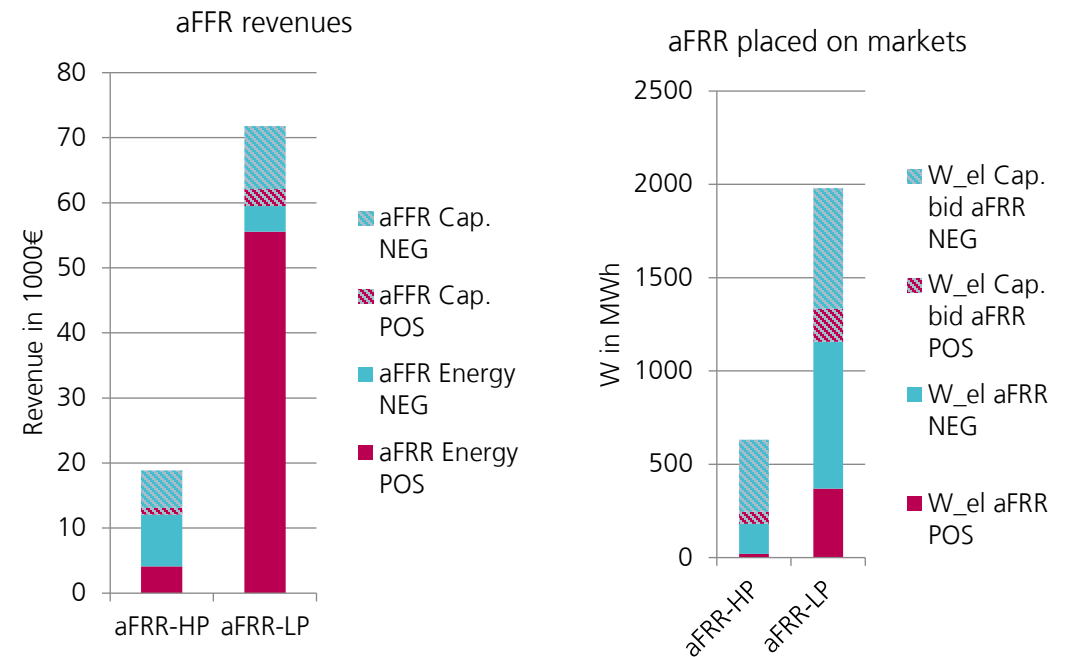
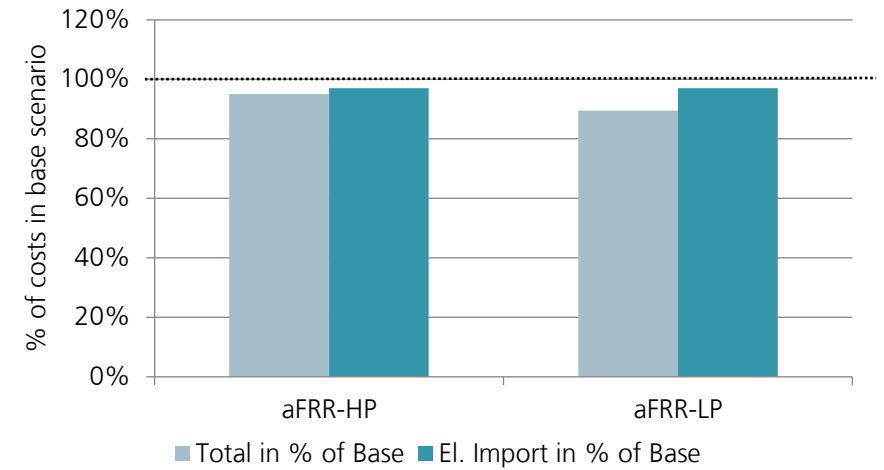


- Only in Shamrockpark cost can be decreased
 - Load profile more favorable because of high share of commercially used buildings

Results: 3. Provision of control reserve (aFRR)

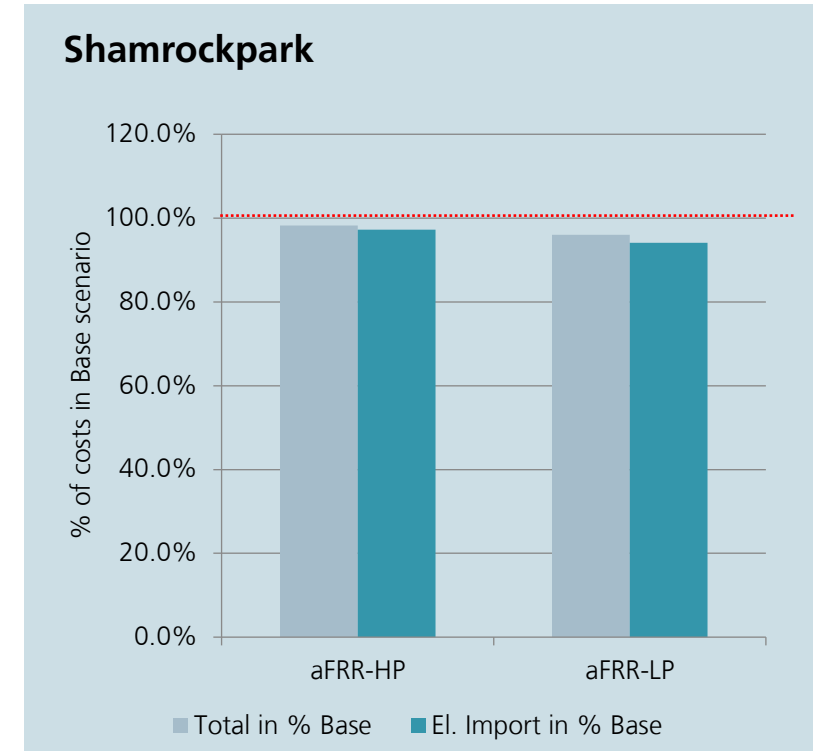
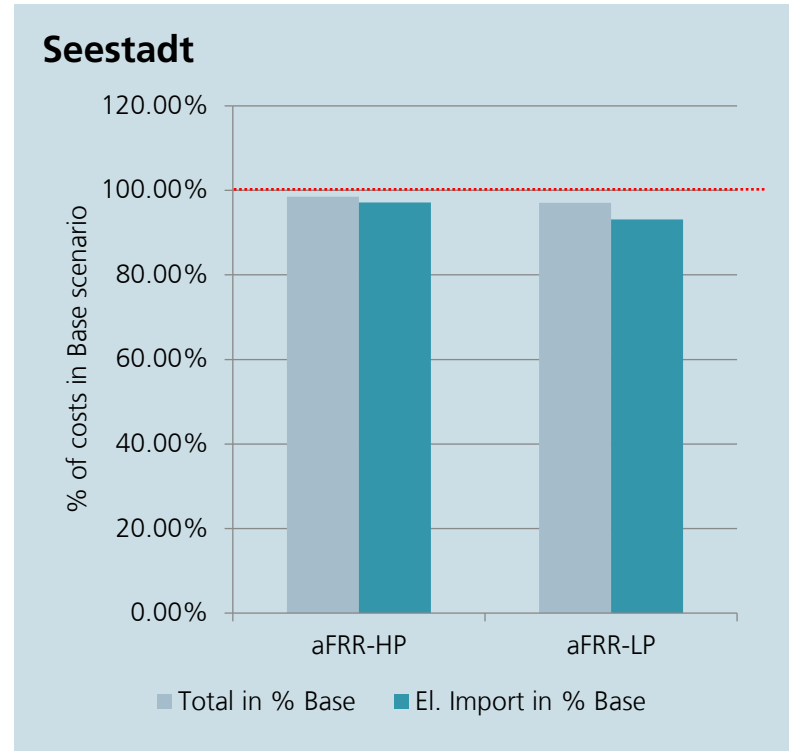
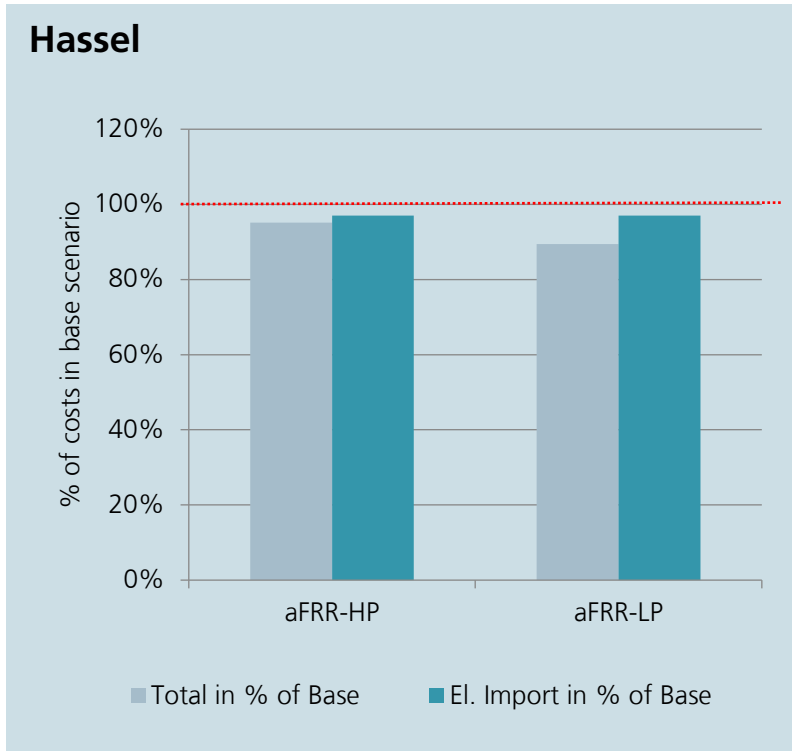
Example of Hassel:

- The provision of **aFRR is the only flexibility option that provides savings**. In the example of Hassel the total system costs are between 89-95 %
- Higher savings can be achieved with high bidding prices at low probability (LP) compared to low bidding prices at higher probability (HP)
- For low probability: the revenues are much higher for positive aFRR energy than for negative energy, although the energy placed on the markets is even lower



Results: Provision of control reserve (aFRR)

Comparison of the three districts



- By providing control reserve savings can be achieved in all three districts between 3 and 11%

Conclusion

Financial incentives for flexibility too small under current market conditions

- The only flexibility business models that can achieve savings is offering control reserve

Future developments can change market conditions

- Decreasing battery costs
- Increasing price volatility

Attractiveness dependent on districts energy system configuration

- **With significant share of self-generated solar energy, time-variable tariffs tend to be less attractive**, as low prices coincide with peak generation periods. Maximizing solar coverage is more attractive than using time-variable tariffs.
- The **remuneration for controllable loads does not always compensate for higher energy system costs** caused by the need for higher heat generation or storage capacities

Thank you for your attention!

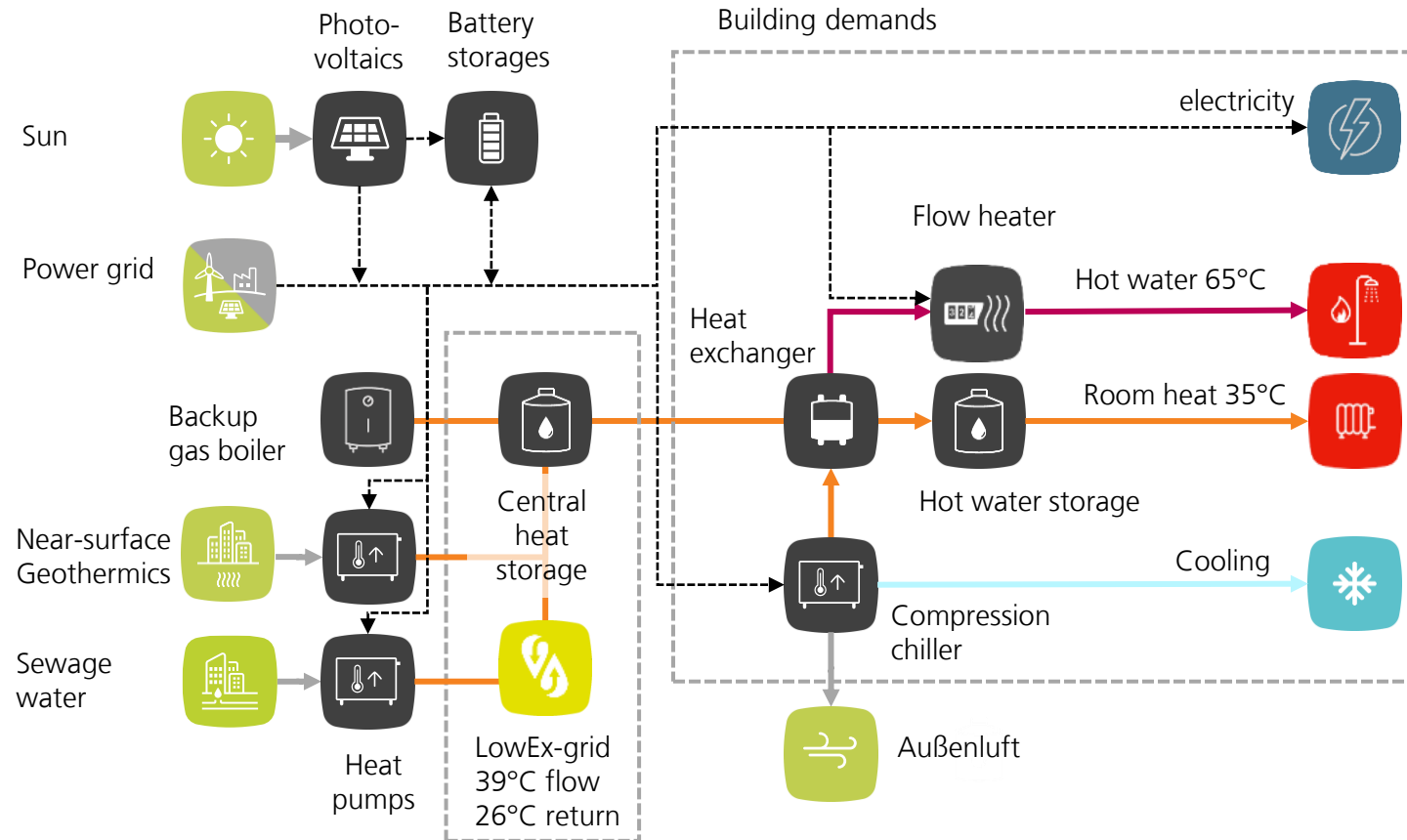
16.06.2025

Erik Fröhlich, Fraunhofer Institute for Solar Energy Systems ISE

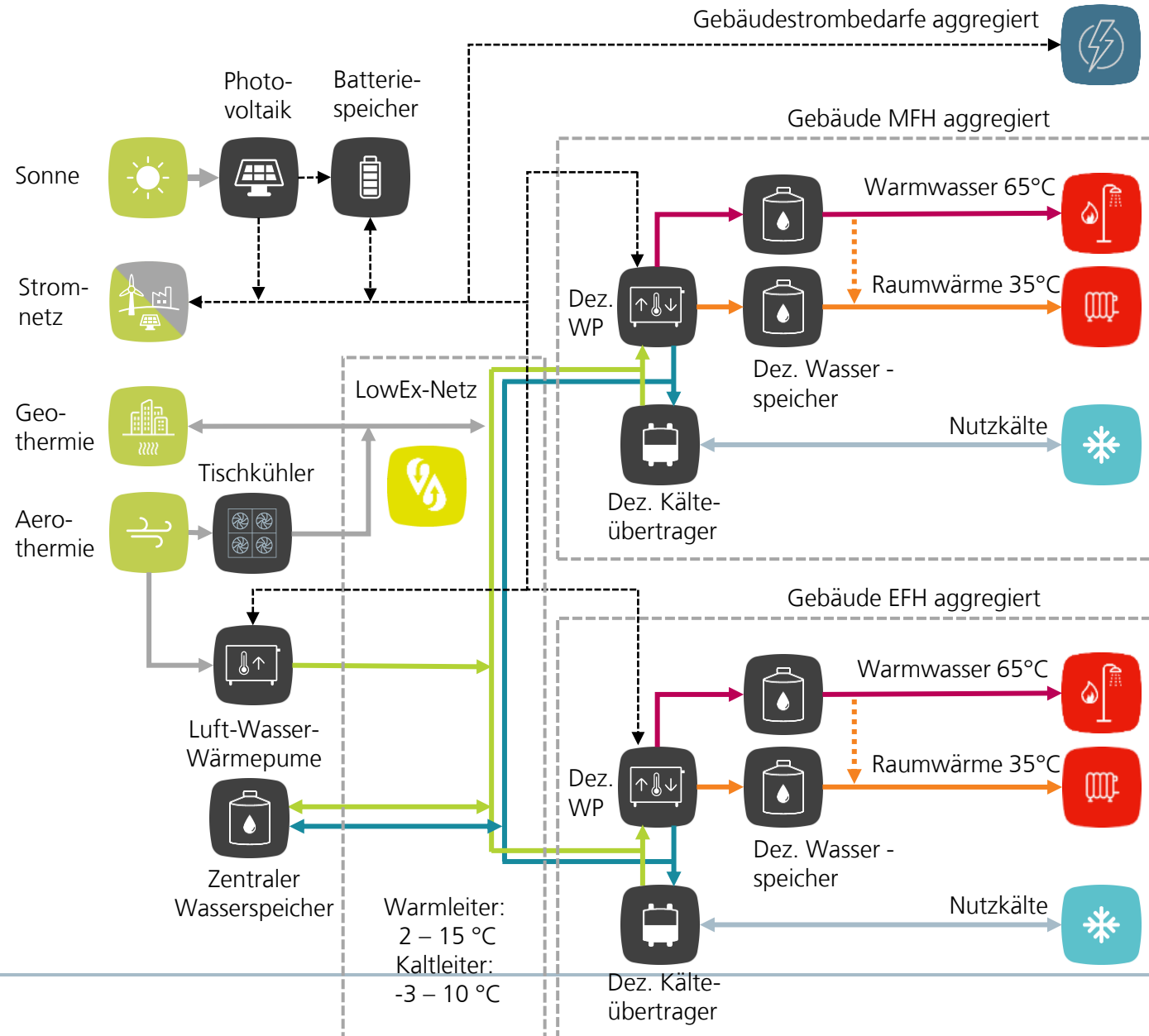
erik.froehlich@ise.fraunhofer.de

The three case studies

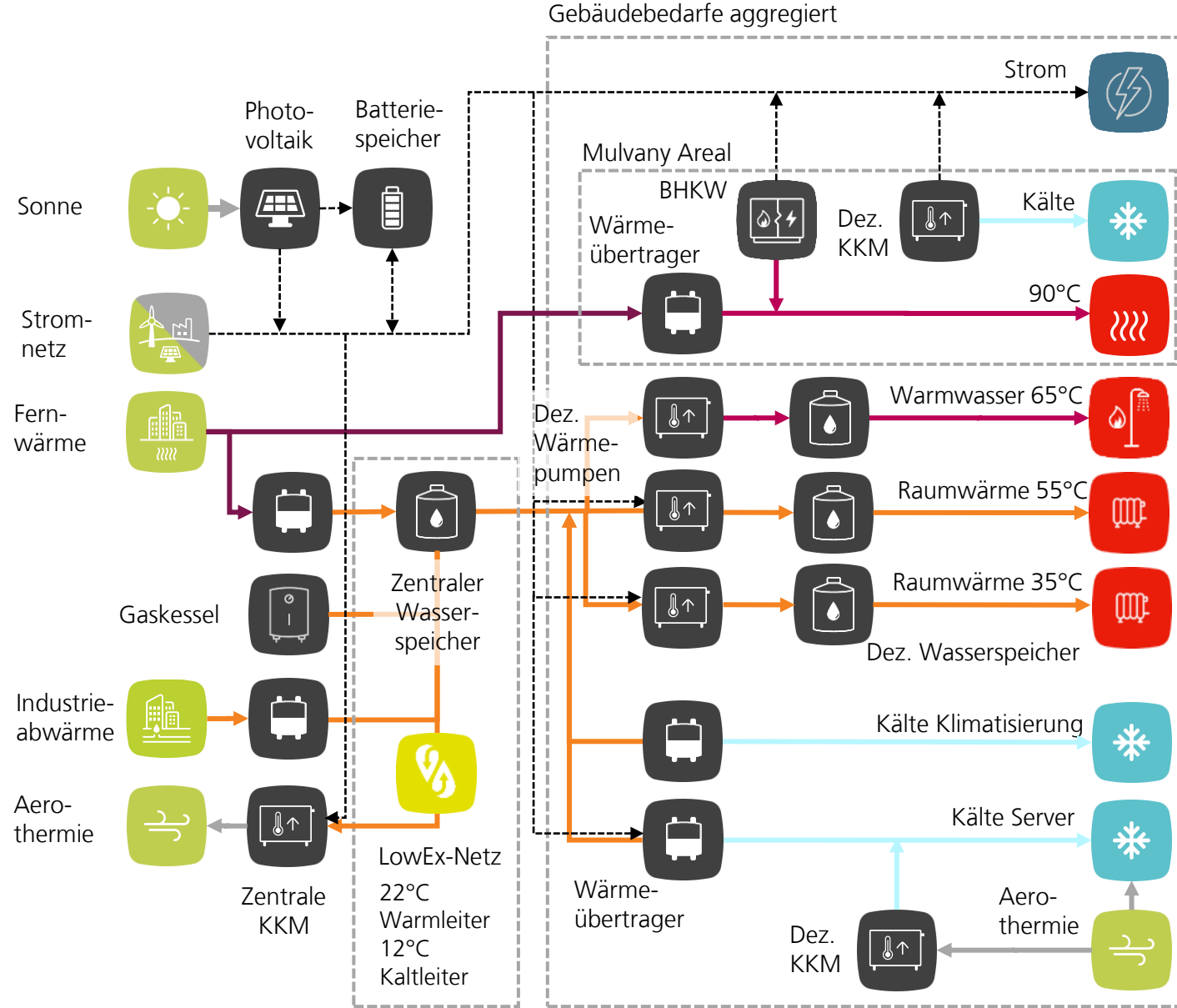
Schematic diagram for the energy system in Seestadt



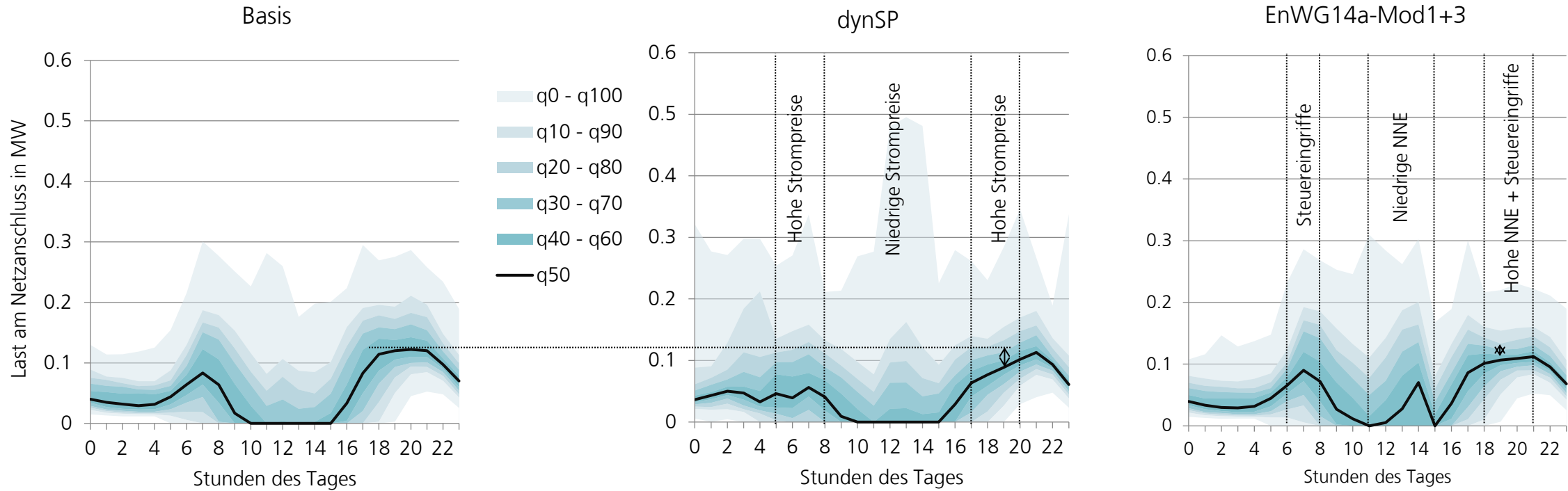
Glückaufpark



Shamrockpark



Daily load profiles Glückaufpark

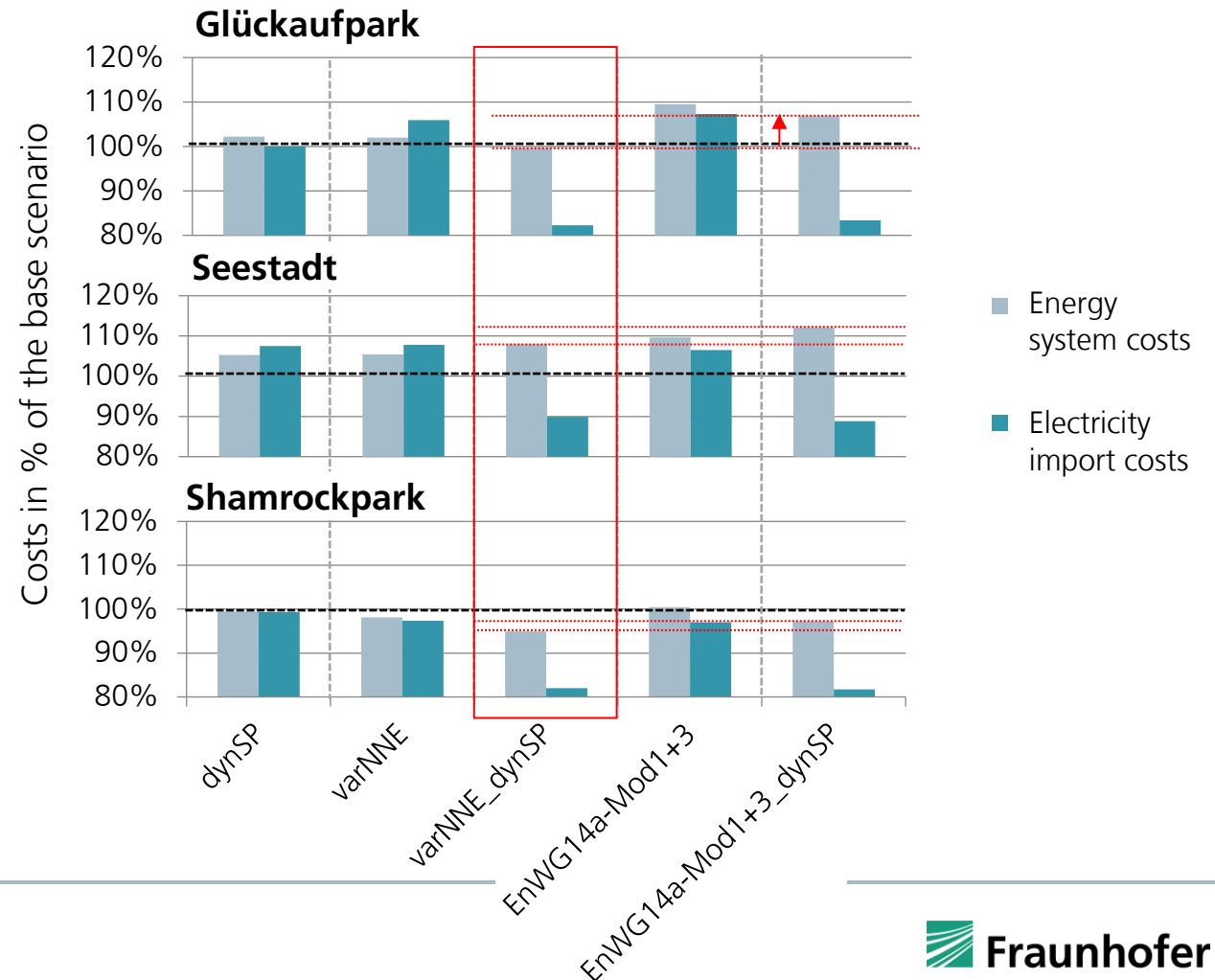


Cost savings

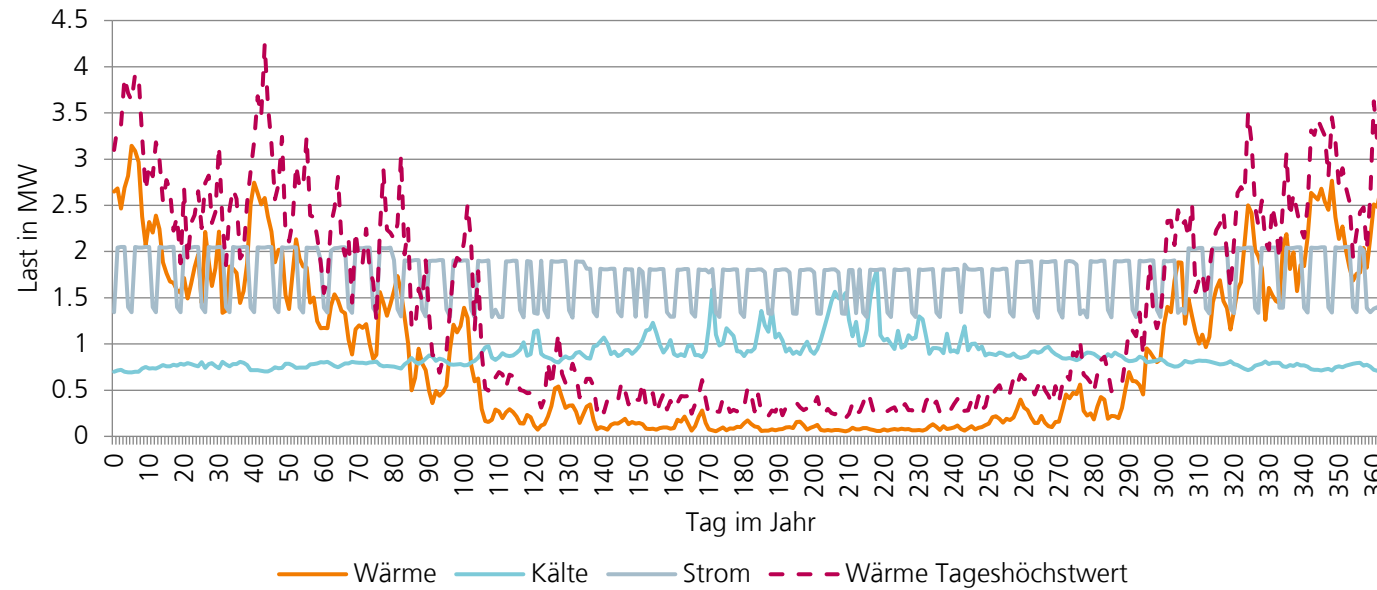
Results

- Application of **dynamic tariffs does not lead to significant cost savings in any of the considered systems**
- Only for Shamrockpark cost savings** w.r.t total energy system costs can be achieved through variable electricity prices. This is **due to its beneficial load profile** with peaks during low price periods
- The **combination of variable grid fees and dynamic procurement** tariff leads to **investments in battery storage**. Operational **expenses decrease** in all neighborhoods. Total energy costs, however, can still be higher.
- Load **dimming causes additional costs**, due to increased heat generation capacities. The existing remuneration schemes do not compensation for these additional expenses.

Possible cost savings for the different time-variable tariffs compared to static tariff

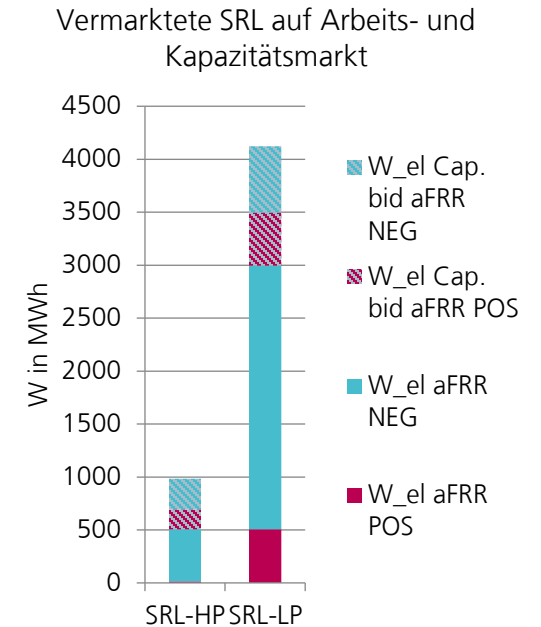
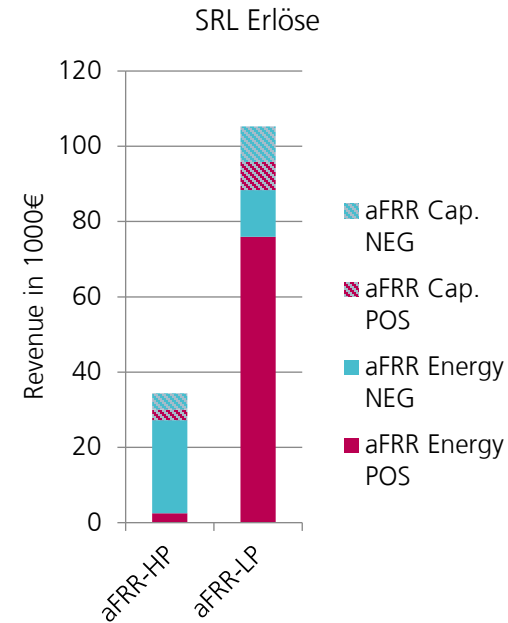
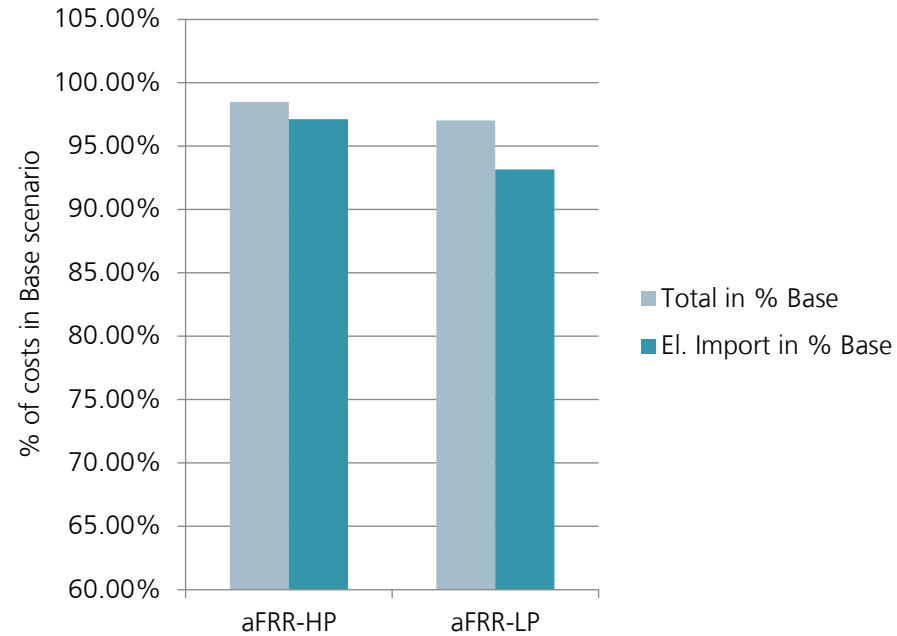


Bedarfe im Jahresverlauf im Quartier Shamrockpark (Tagesmittelwerte)



Provision of balancing energy

Seestadt



Provision of balancing energy

Shamrockpark

