Operational Optimization of existing Energy Systems

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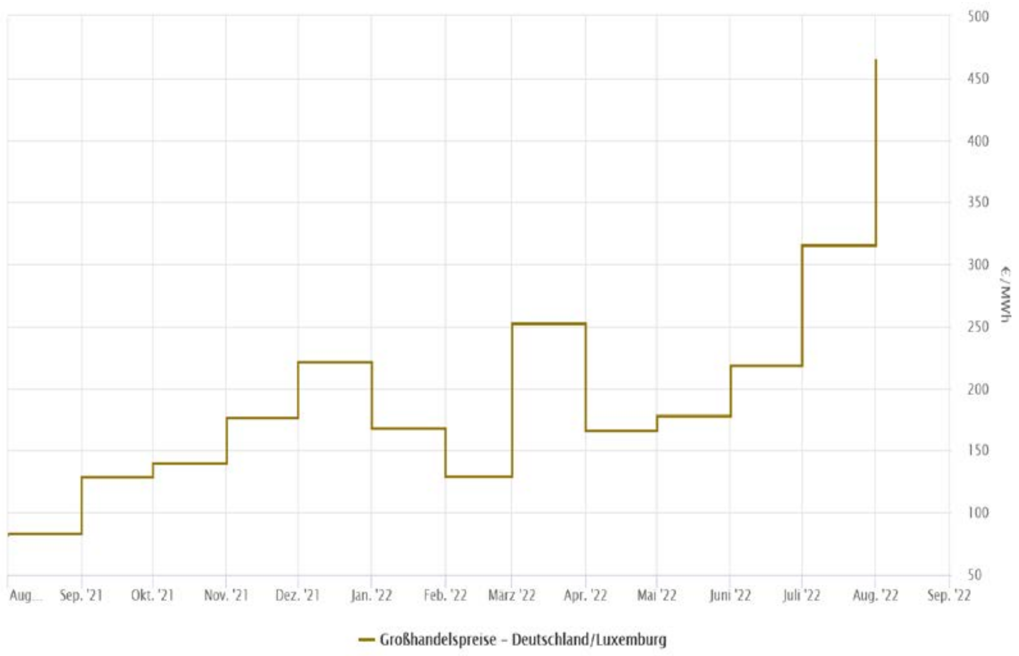
MOTIVATION

- The optimal usage of energy is crucial in current situation.
- The energy prices are continuously rising for about a year.
  - E. g. the electricity prices at the whole sale market are nearly 6 times higher than last August.
  - E. g. natural gas prices are 2 times higher than last August.
- The optimal usage of energy comes along with savings and can be efficiently supported by smart energy management systems.
- The potential shortage of natural gas results in political pressure to reduce its usage.



BNetzA (2022): SMARD | Marktdaten visualisieren.

METHODS

- Mixed integer linear optimization is used to determine optimal asset usage.
- The optimization determines a set of variables maximizing or minimizing an objective.
- The model is restricted by constraints such as availabilities and efficiencies.
- In the context of energy systems: It finds optimal usage of energy assets.
- Optimization models as a component of energy management systems are already used by utility companies.
- Research projects transfer the approach to district energy management.
- The advantages are the optimal usage of the energy and the automated generation of operation plans for the available controllable assets.

Optimization in general:
Minimize f(x) subject to:

$g_i(x) \leq 0, i = 1, \dots m$
(inequality constraint)

$h_j(x) \leq 0, j = 1, \dots p$
(equality constraint)

With $f\colon \mathbb{R}^n \to \mathbb{R}$,
$g_i\colon \mathbb{R}^n \to \mathbb{R}, \mathrm{i} = 1, \dots, \mathrm{m}$
and $h_j\colon \mathbb{R}^n \to \mathbb{R}, \mathrm{j} = 1, \dots, \mathrm{p}$

Use Case - MOTIVATION

- The stop of Russian gas supply on short notice, either on supply or on import side, did hit energy suppliers hard, since Russian gas made up 55% of the gas consumption in Germany in 2021.
- According to the BDEW power plants made up 31% of the gas consumption in Germany in the year 2020.
- The BDEW estimated in a study that was published in March 2022 that the reduction- and substitution potential of the gas consumption of power plants could be as high as 36%.*
- The studies used to estimate this potential were based on analysis of German statistics and assumptions from expert regarding the reduction- and substitution potential.
- For the Use Case 4 Utility Companies have been chosen, that already use an optimization model for their operation management.

* Bdew (2022): Kurzfristige Substitutions- und Einsparpotenziale Erdgas in Deutschland.

Use Case – Assumptions and Advantages

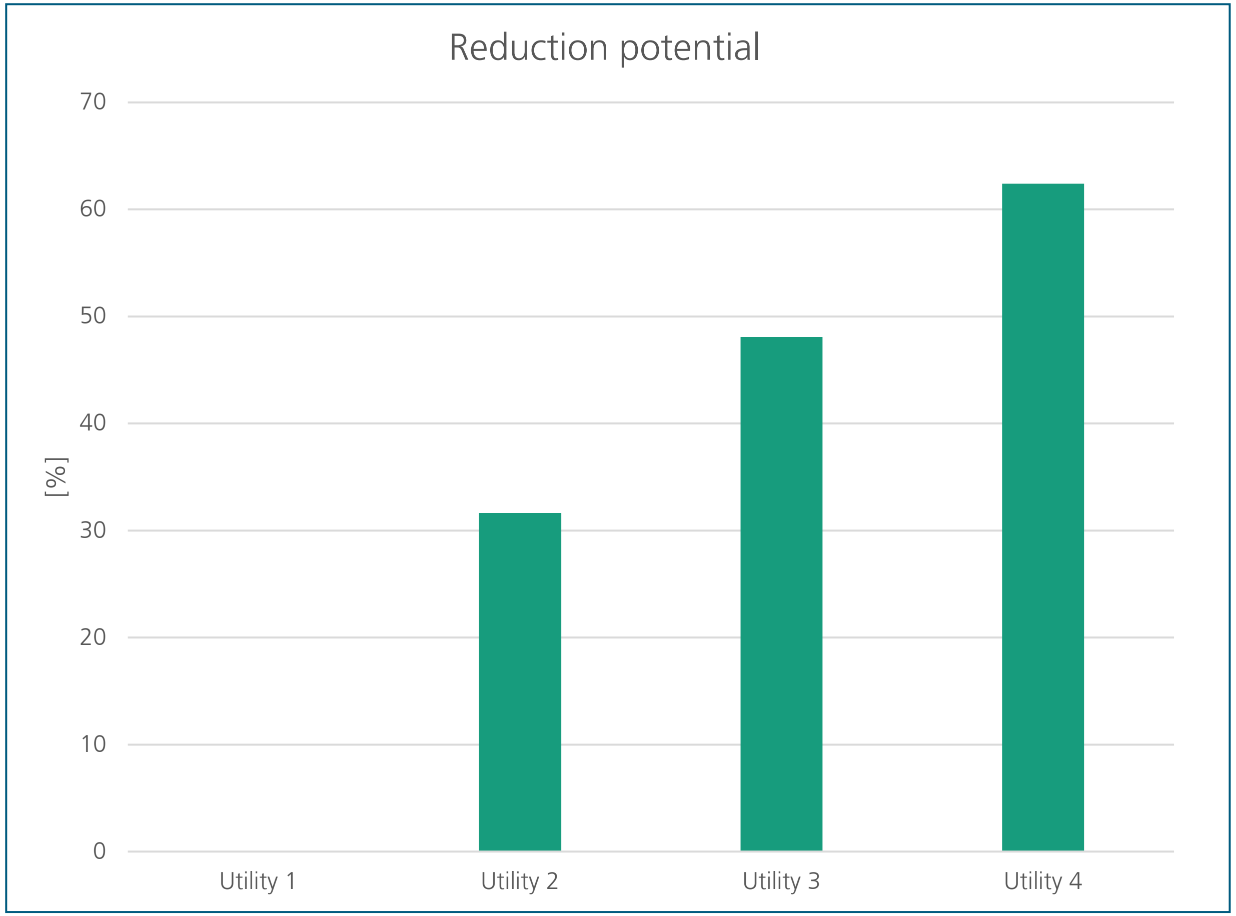
- Chosen time horizon is the November 2021.
- The comparison is between a scenario with all parameters as in the real month, and one with increased prices.
- Long time contracts not considered, could impact the results
- Only available substitution potential was used
- Consumption profiles were not changed

- **Advantages:**
  - **No new model necessary**
    - Only the objective function has to be adapted
    - Transition can be made within a few minutes
    - No integral changes to the model are necessary
    - Lower possibilities for errors
  - **Optimization still prefers more efficient solutions**
    - Results also consider the economical side
  - **Optimization is still restricted by technical restrictions**

Results - I

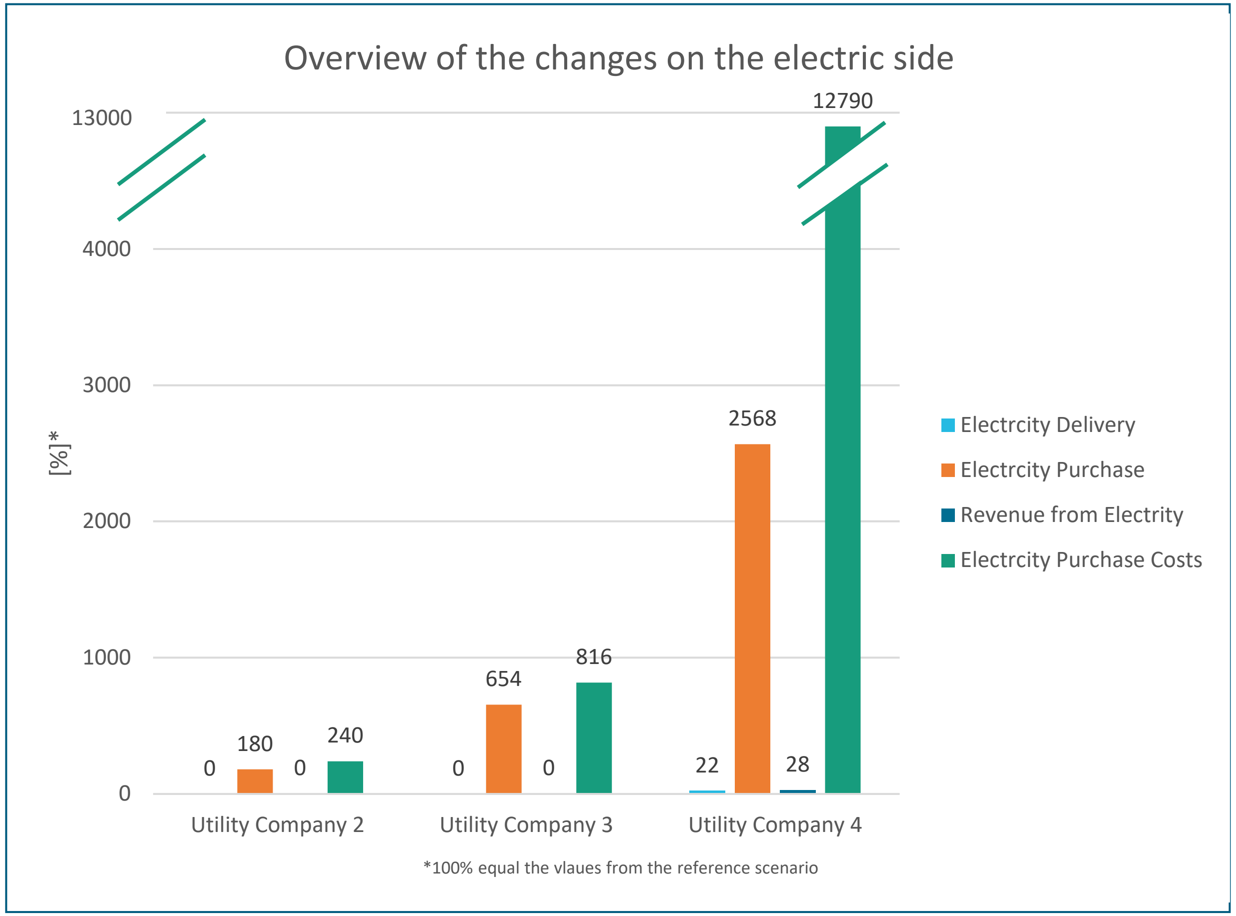
- The reduction potential for the natural gas consumption is between 0% and 62% in the conducted simulative investigation for the utilities looked at in the month of November 2021.

- Utility 1:
  - Utility company 1 already uses the full potential of all its not gas driven technologies for the supply of heat.
  - The gas fueled assets are only used for the supply of heat or hot water.
  - No reduction potential could be found
  - Therefore, not look into in the further consideration.



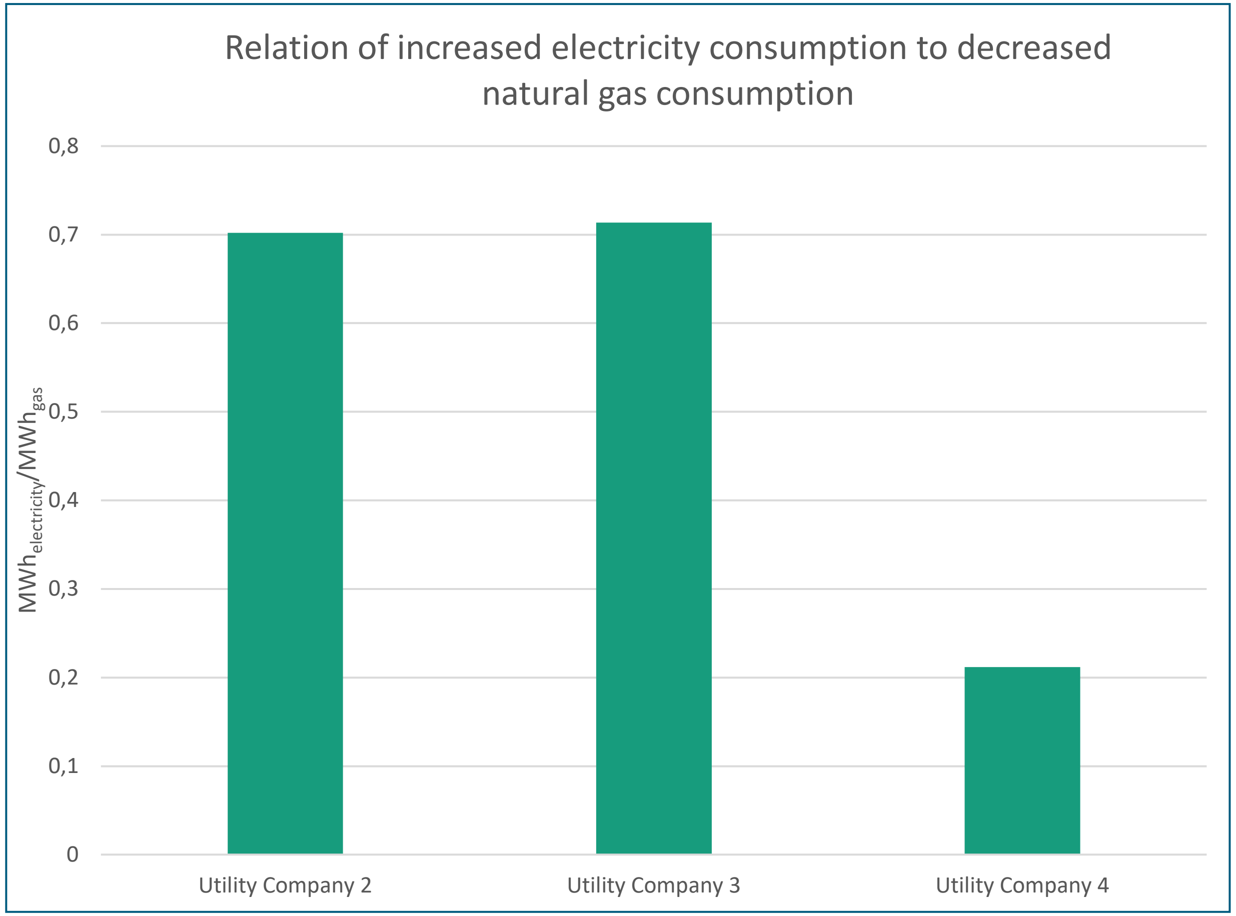
Results - II

- The electricity purchase for all three utilities increased significantly.
- Biggest increase, relative to the electricity consumption in the reference scenario is for utility 4 (25-times), also the biggest increase in electricity cost (128-times).
- This disproportionate increase, is mainly due to increased need to purchase electricity from the spot market during times when it is particularly expensive.
- Utility 2 and 3 stopped selling electricity at the spot market to 0%.
- Utility 4 still provides electricity to the market, even though it is just 25% of the amount compared to the reference scenario.



Results - III

- For utility 4 the natural gas demand could be decreased drastically, with only a small absolute increase in the electricity demand. This is mainly done by utilizing an alternative power plant.
- Therefore, every saved MWh natural gas results in an increased electricity demand, which differs between 0,2 and 0,7 $\frac{MWh_{Strom}}{MWh_{Gas}}$.
- It also results in higher costs. Utility 3 has the highest costs, per saved MWh of natural gas with 62 €/MWh.
- Overall, the optimization tries to utilize assets which can generate heat from other sources then gas first, then only tries to use the most efficient assets and lastly reduces the generation of electricity through gas.



Summary – Limitations of the significance of the results

- The considered utilities that were looked at were chosen on a spot check basis, the spot check is static and not representative.
- The simulations were only done for one reference month in the heating season.
- Interdependencies to the natural gas and electricity market were not considered.
- The determined increases in costs and decreases in earnings were calculated on the basis of the prices from the reference month (November 2021). Current and future price development were not considered.
- The question of how the increased demand for electricity is satisfied, without the use of gas power plants was not part of this consideration.
- The simulations did not consider restrictions in the distribution grid.

Summary - Key Messanges

- The reduction potential of the utilities considered in the use case is between 0% and 62%.
- There is a non-negligible potential for reducing gas consumption at utility companies, even while ensuring district heating and warm water supply.
- The identified reduction potentials are not limited in time and can be implemented in the short term, i.e. without structural adjustments (i.e. technical extensions) to the existing generation plants.
- If the gas reduction potentials at utility companies are to be raised, on the one hand the additionally required electricity demand must be secured, and on the other hand a monetary compensation must be discussed.
- **Therefore, it was shown that an optimization and its respective target function can be adapted from a pure economical perspective to others such as the minimal usage of natural gas or CO_2-Minimizing with little afford.**

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http://s.fhg.de/aEE

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