IEWT 2021

Das Energiesystem nach Corona: Irreversible Strukturänderungen - Wie?

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Die Corona Pandemie beeinflusst nach wie vor unser aller Leben. Der vollständige Lockdown hat dazu geführt, dass die Art zu arbeiten, die Einstellung zu (Flug-)Reisen und Mobilität und das soziales Leben auf den Kopf gestellt wurde. Digitalisierung wurde schlagartig vorangetrieben, ganze Gewerbe- und Industriezweige stehen nahezu still. Das hat dazu geführt, dass die Energienachfrage bereits im ersten Halbjahr 2020 deutlich zurückgegangen ist und auch die CO2 Emissionen gesunken sind. Gleichzeitig ist der Anteil der Erneuerbaren Energien an der europäischen Stromerzeugung im ersten Halbjahr 2020 bereits rasant gestiegen. Erstmals haben Wind-, Solar-, Bioenergie und Wasserkraft mit einem Anteil von 40 Prozent mehr zur Stromerzeugung der EU beigetragen, als fossile Kraftwerke.

Evaluation of energy autarky-optimal technology portfolio of a local energy system

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Introduction

- Introduction and motivation
- Methodology
  - Model development
  - Use cases
- Preliminary results
- Further work

Idea and motivation

- Sector coupling could be part of a solution to reach GHG emission targets
  - Green hydrogen and green heat
  - Curtailment reduction

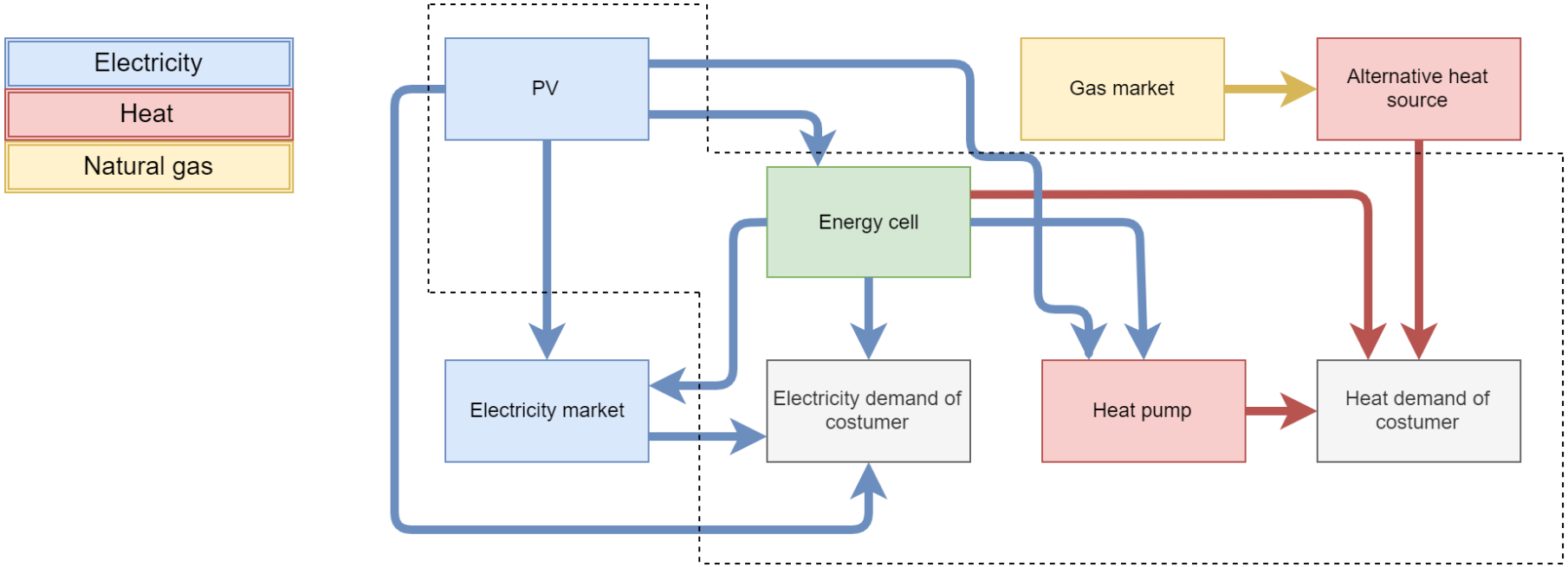
- Energy autarky: “conceptualized as a situation in which the energy services used for sustaining local consumption, local production and the export of goods and services are derived from locally renewable energy resources.” (Müller et al., 2011)

- Autarkic energy systems are able to lower their dependence on external energy systems

- Key motivational factors:
  - Ensure continued implementation and operation of RES
  - Reduce GHG emissions
  - Enable energy autarky

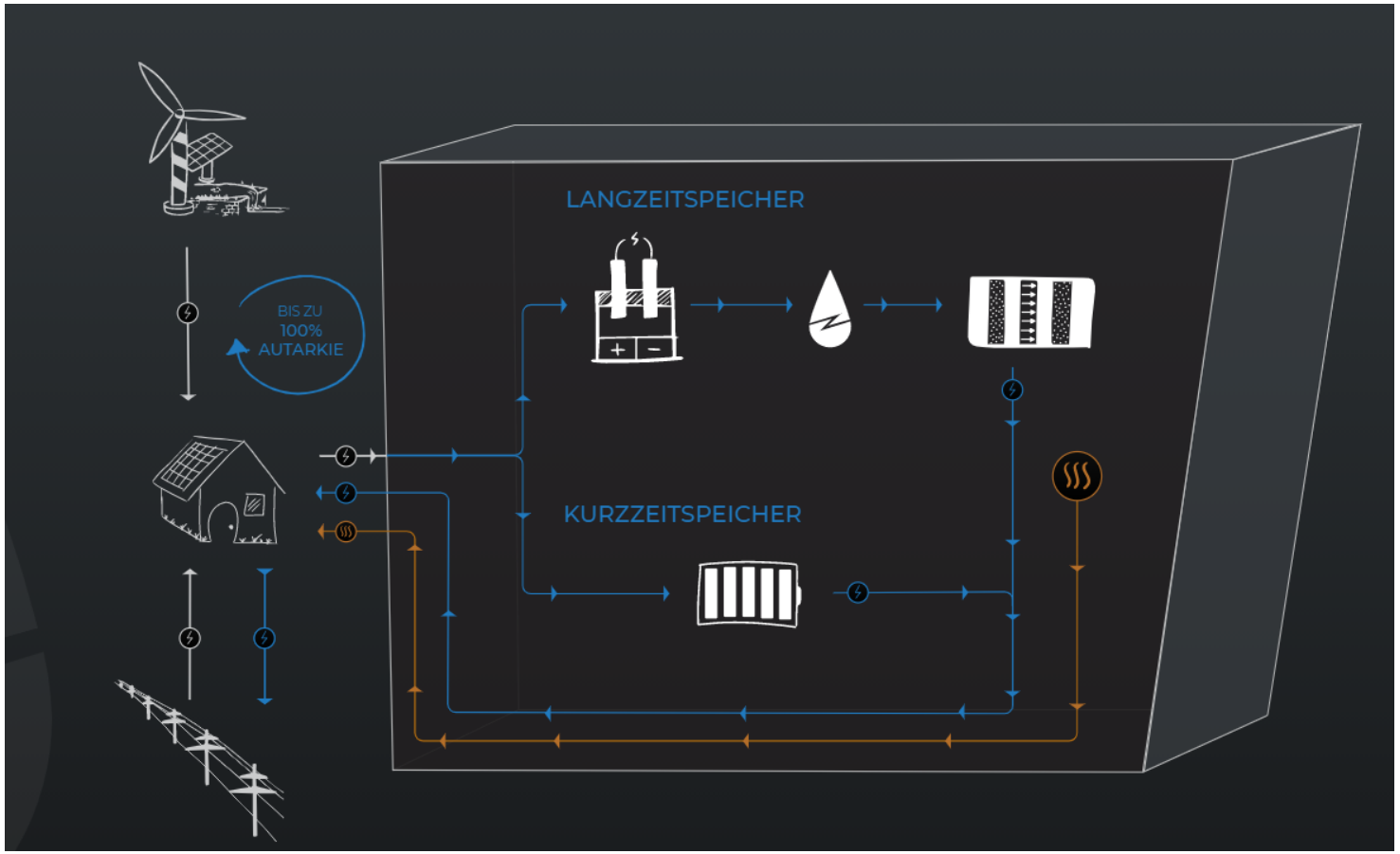
Methodology – model development

- Model development builds on energy cell from Johann project [1] and considers the energy demands of a household
- Investigated system includes both P2H and P2G technology
- Additional heat pump considered in one use case
- Remaining electricity and heat demand are met by heat and electricity bought from external sources



Methodology – model development

- Johann energy cell developed by Elements Energy [2]
  - Battery for short-term electricity storage
  - Conversion to hydrogen for long-term storage by utilizing electrolyzer and H2 storage tanks
  - Fuel cell converts hydrogen back to electricity
  - Electricity is either used by customer or sold to electricity market
  - Excess heat from electrolysis and fuel cell processes are utilized to cover heat demand



Source: Elements Energy, https://www.elements-energy.at/

Methodology – model development

- Optimization model of sector coupled system developed in Julia
- Currently optimizing system operation with regards to autarky – further development to perform portfolio optimization
- Aim: perform a portfolio optimization to evaluate the energy autarky-optimal technology portfolio of an energy system
- Preliminary results are based on current operational optimization model where objective is set to minimize external energy purchase

Methodology – use cases

- Three different use cases investigated
  - Baseline
    - No energy cell
  - Farmhouse
    - Heat pump considered in addition to energy cell
  - Riding stable
    - No heat pump

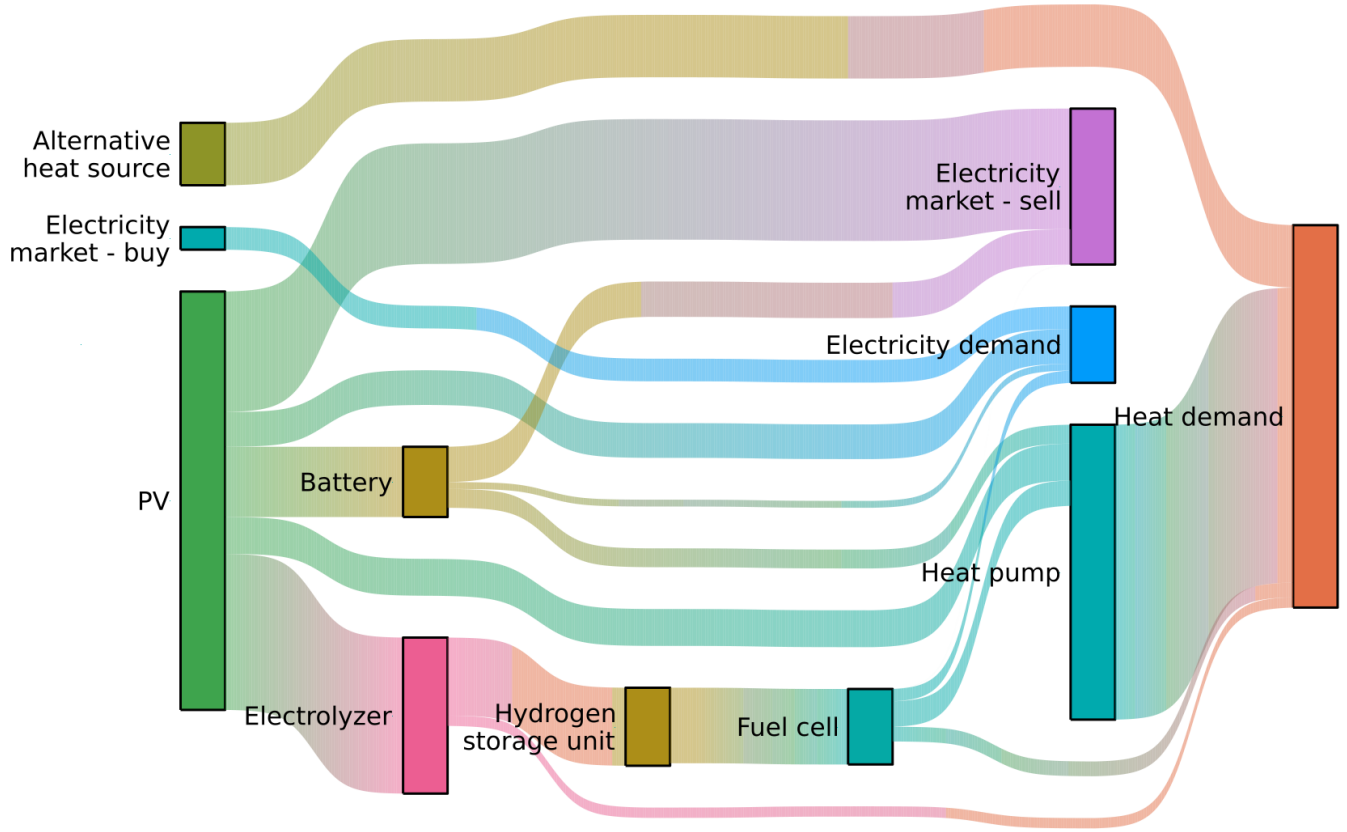
Baseline
- No energy cell

Farmhouse
- $D_{el} < D_{heat}$
- Additional heat pump

Riding stable
- $D_{el} > D_{heat}$
- No heat pump considered

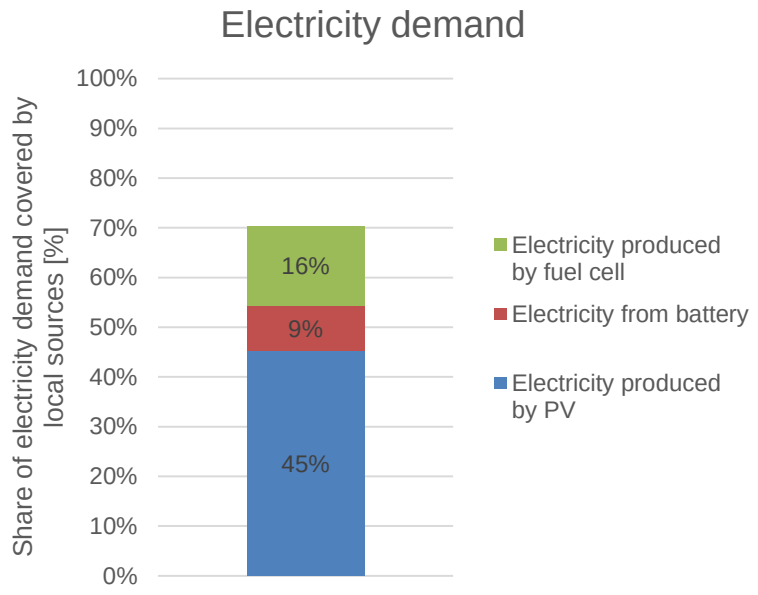
Preliminary results – farmhouse use case

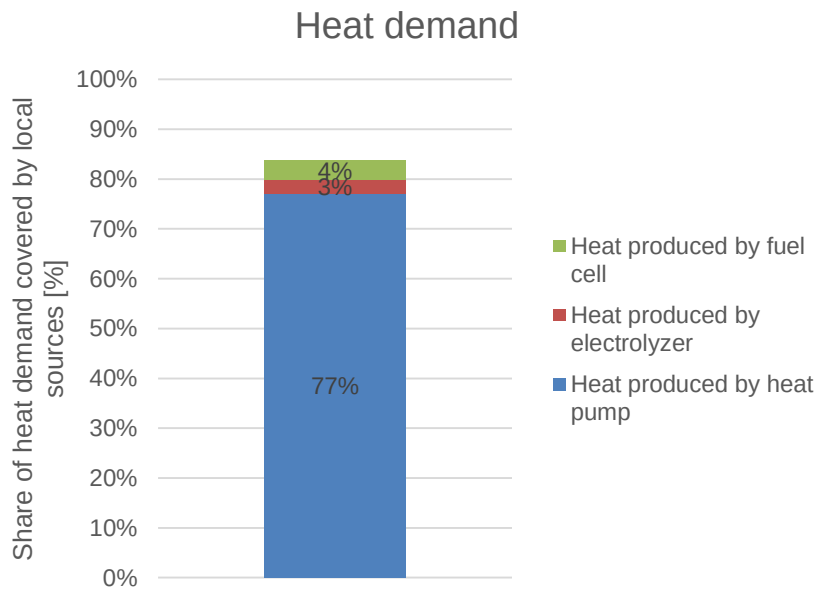
- Overview of technology utilization in farmhouse use case
- Majority of generated electricity is either fed into energy cell (electrolyzer + battery) or sold to the electricity market
- Heat pump covers around 77 % of assumed heat demand



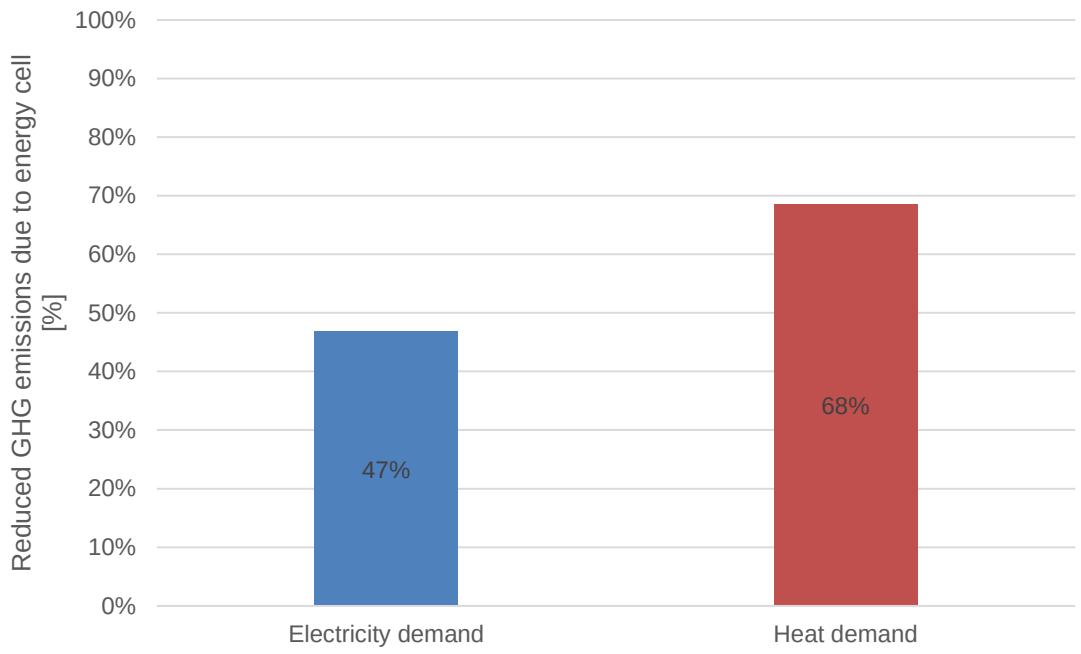
Preliminary results – farmhouse use case

- Degree of energy autarky increases under current assumptions
  - 70 % energy self-reliance achieved for electricity demand
    - Majority of electricity demand met by electricity produced by PV
    - Both short-term and seasonal storage utilized when needed
  - 84 % energy self-reliance achieved for heat demand
    - Implementation of heat pump increases the degree of energy autarky related to meeting the heat demand





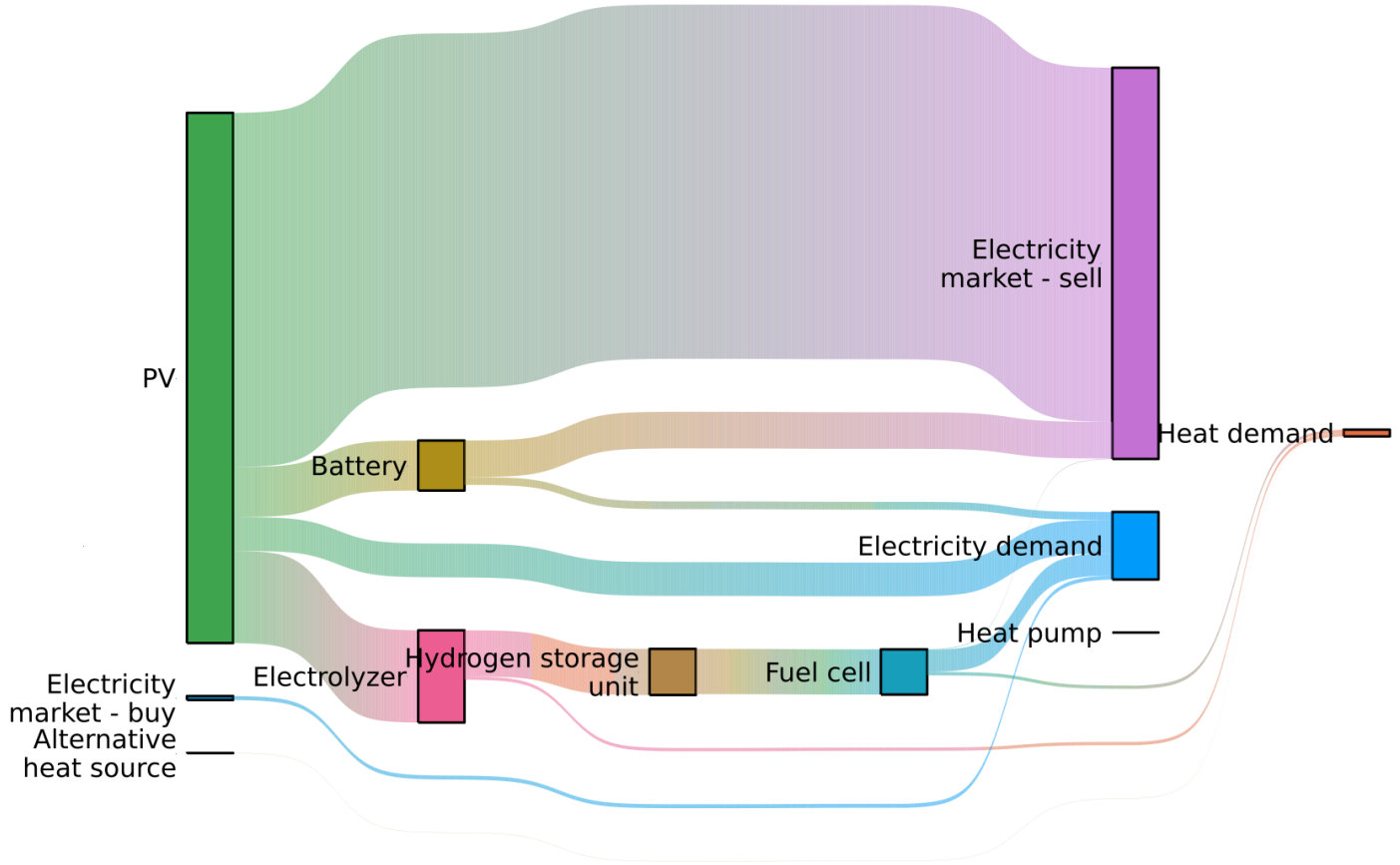
Preliminary results – farmhouse use case



- Significant GHG emission reduction potential
- Implementing Johann energy cell results in
  - 47 % reduction of emissions related to covering the electricity demand
  - 68 % reduction of emissions related to covering the heat demand
- Reduction potential depends on
  - Size of technology utilized
  - Emission factor of electricity mix
  - Alternative fuel considered (natural gas)

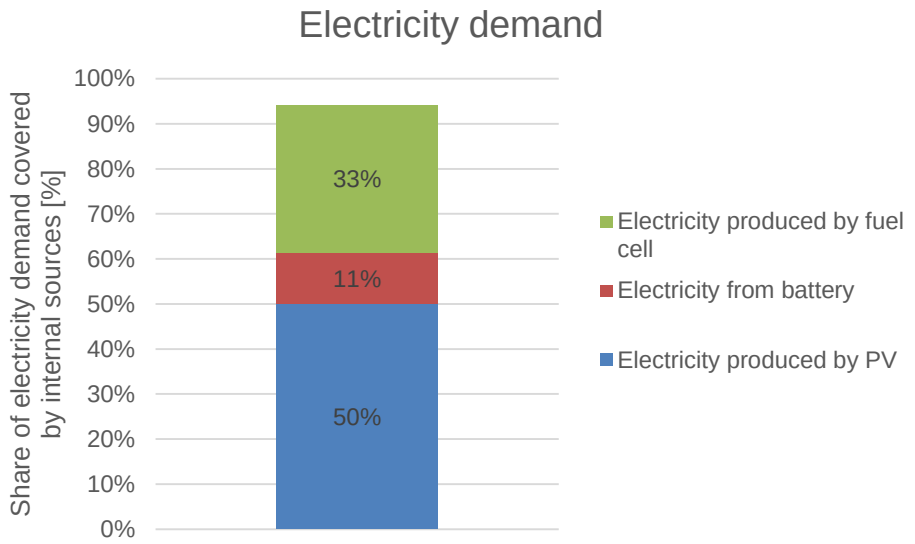
Preliminary results – stable use case

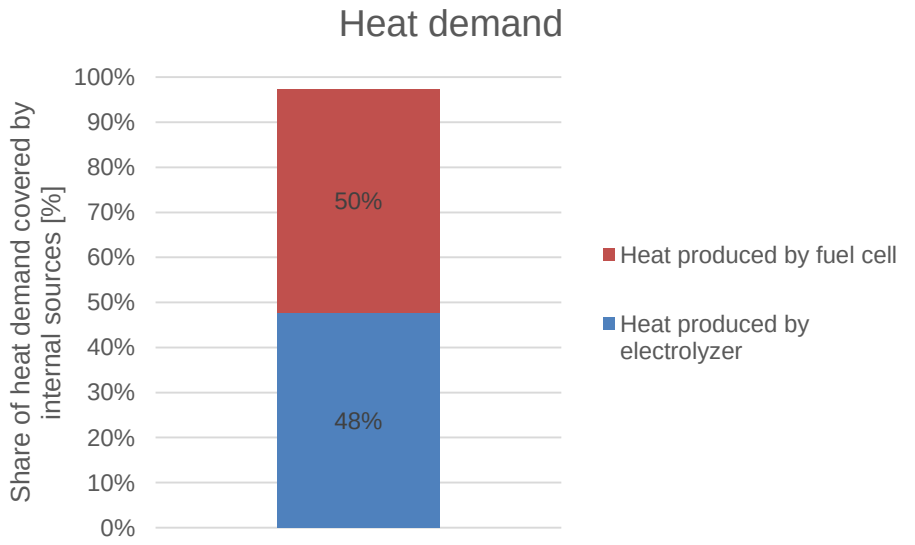
- Overview of technology utilization in riding stable use case
- Utilizing the energy cell combined with PV significantly reduces the amount of external electricity bought
- No heat pump implemented → majority of heat demand is met by excess heat from internal processes



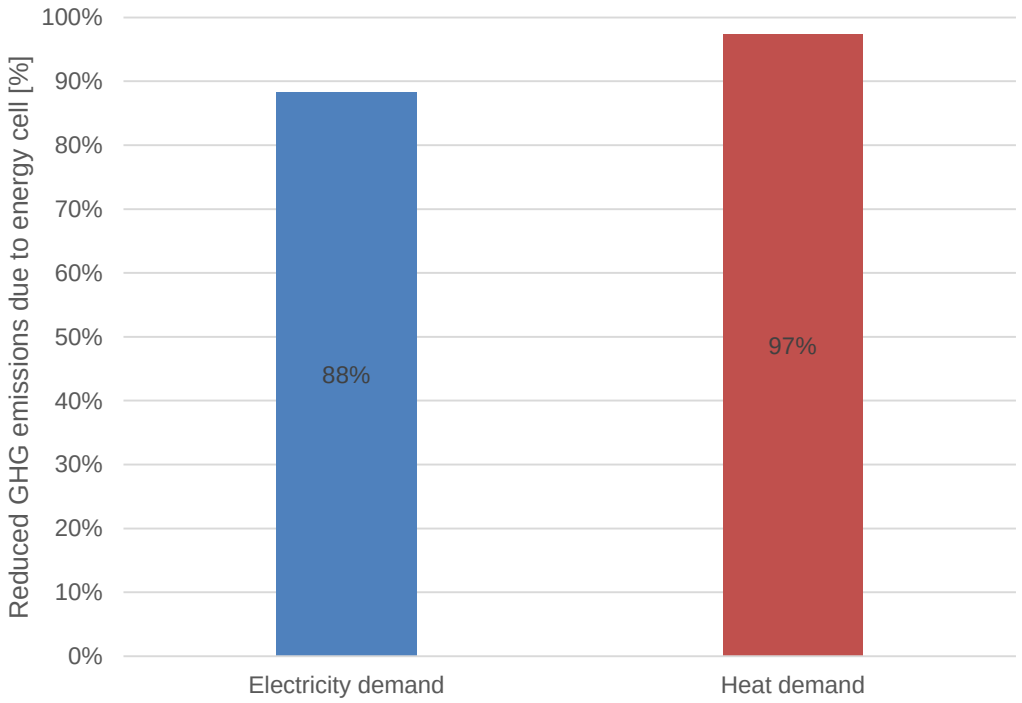
Preliminary results – stable use case

- Degree of energy autarky increases under current assumptions
  - 94 % energy self-reliance achieved for electricity demand
    - Majority of electricity demand met by electricity produced by PV
    - Both short-term and seasonal storage utilized when needed
  - 97 % energy self-reliance achieved for heat demand
    - No heat pump implemented in this use case
    - Relatively low heat demand → excess heat from internal processes sufficient to meet heat demand





Preliminary results – stable use case



- Significant GHG emission reduction potential
- Implementing Johann energy cell results in
  - 88 % reduction of emissions related to covering the electricity demand
  - 97 % reduction of emissions related to covering the heat demand
- Reduction potential depends on
  - Size of technology utilized
  - Emission factor of electricity mix
  - Alternative fuel considered (natural gas)

Concluding remarks and further work

- Utilization of sector coupling concepts combined with short-term and seasonal electricity storage has the potential to
  - reduce GHG emissions
  - increase the degree of energy autarky
- Portfolio optimization is yet to be performed
- Further work
  - Evaluate optimal system topology under consideration of different degrees of autarky
  - Consider the possibility of having green hydrogen as output from the energy cell – as well as possible ways of utilization

References and acknowledgements

This work is done in the “Energy cell “JOHANN”” project [1] and is supported with the funds from the Climate and Energy Fund and implemented in the framework of the RTI-initiative “Flagship region Energy” within Green Energy Lab.

[1] Energiezelle „JOHANN“, Green Energy Lab, https://greenenergylab.at/projects/energiezelle-johann/

[2] Der Hybrid-Energiespeicher der Zukunft - JOHANN, Elements Energy, https://www.elements-energy.at/

[3] Matthias Otto Müller, Adrian Stämpfli, Ursula Dold, Thomas Hammer (2011). Energy autarky: A conceptual framework for sustainable regional development. *Energy Policy, 39*(10), 5800-5810. https://www.sciencedirect.com/science/article/pii/S0301421511003028

Thank you!

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