Optimization based planning of energy systems

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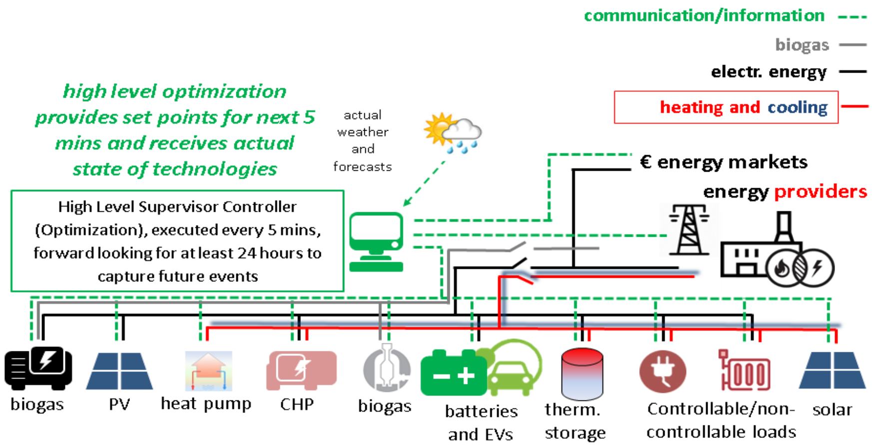
Regional Energy: Electricity, Heating, Cooling

Change of energy system:

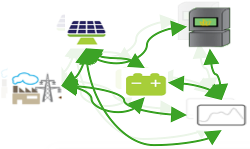
- Microgrids
- Cellular Energy Systems
- Local Energy Communities

Local energy systems:

- high efficiency since generation and loads are close to each other,
- excellent integration of volatile renewables since loads and generation can be controlled as on entity,
- less need for intense “energy transit”,
- increased reliability,
- reduced CO_2 emissions…

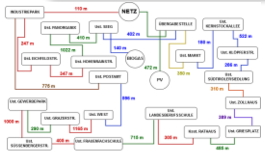


Successful application



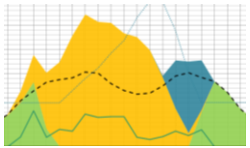
Conceptual Planning

Detailed Planning



Implementation

Operation & Monitoring



- Economic and environmental concerns
- Optimal combination of DERs and their technology size
- Cost objectives
  - Annual energy costs
  - CAPEX
  - OPEX
- Emission objectives
  - Total emission volume
- Consideration of
  - Investments
  - Operational costs
  - Maintenance costs
- Different modeling approaches exists
  - Simulation
  - Optimization

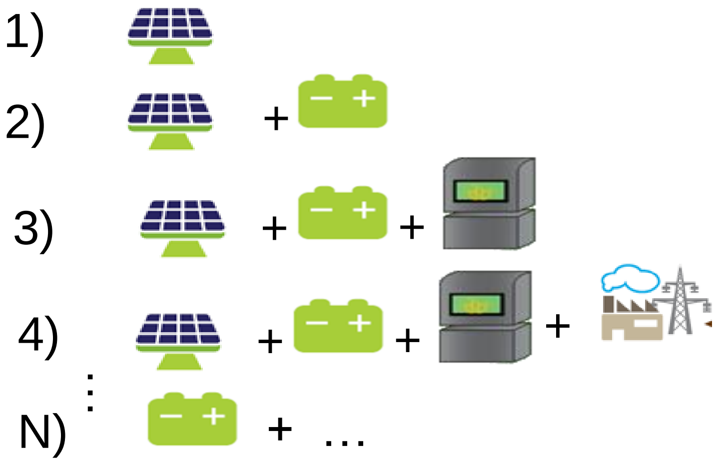
} Minimization (cost objectives and emission objectives)

Conceptual Planning

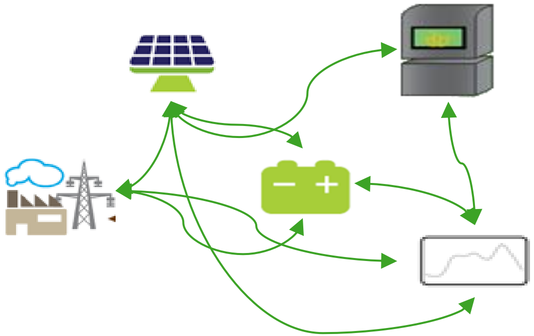
Conceptual Design Method: Simulation

- Simulation of different technology interaction
- Input changed → check how changes impact output
- No built in mechanism to find the best solution

Simulation of different combinations



Millions of combinations exists



Conceptual Design Method: Optimization

- Usage of mathematical optimization techniques to find true optimal combination
- Size, Location, Dispatch
- Multi Objective
  - Costs
  - Emissions

Minimization of cost function	$f(x) = \sum_k c_k \cdot x_k$ x_k ...Decision variable
Restrictions	$\sum_k a_{ik} \cdot x_k \leq b_i$
Non- negative Variables	$\forall k \;\; x_k \geq 0$

Optimization with OptEnGrid based on DER-CAM+

DER-CAM+ DECISION SUPPORT TOOL FOR DECENTRALIZED ENERGY SYSTEMS

TOPOLOGY | ANALYTICS | PLANNING | OPERATIONS

Industrial and Government Partners

Universities and National Labs

*https://building-microgrid.lbl.gov/projects/der-cam

Powerful decision support tool

Developed in the USA

>1500 User/ Institution in more than 24 countries

*Source Berkeley Lab

Optimization with OptEnGrid based on DER-CAM$^+$

DER-CAM$^+$ developed for the US market → Focus on electricity

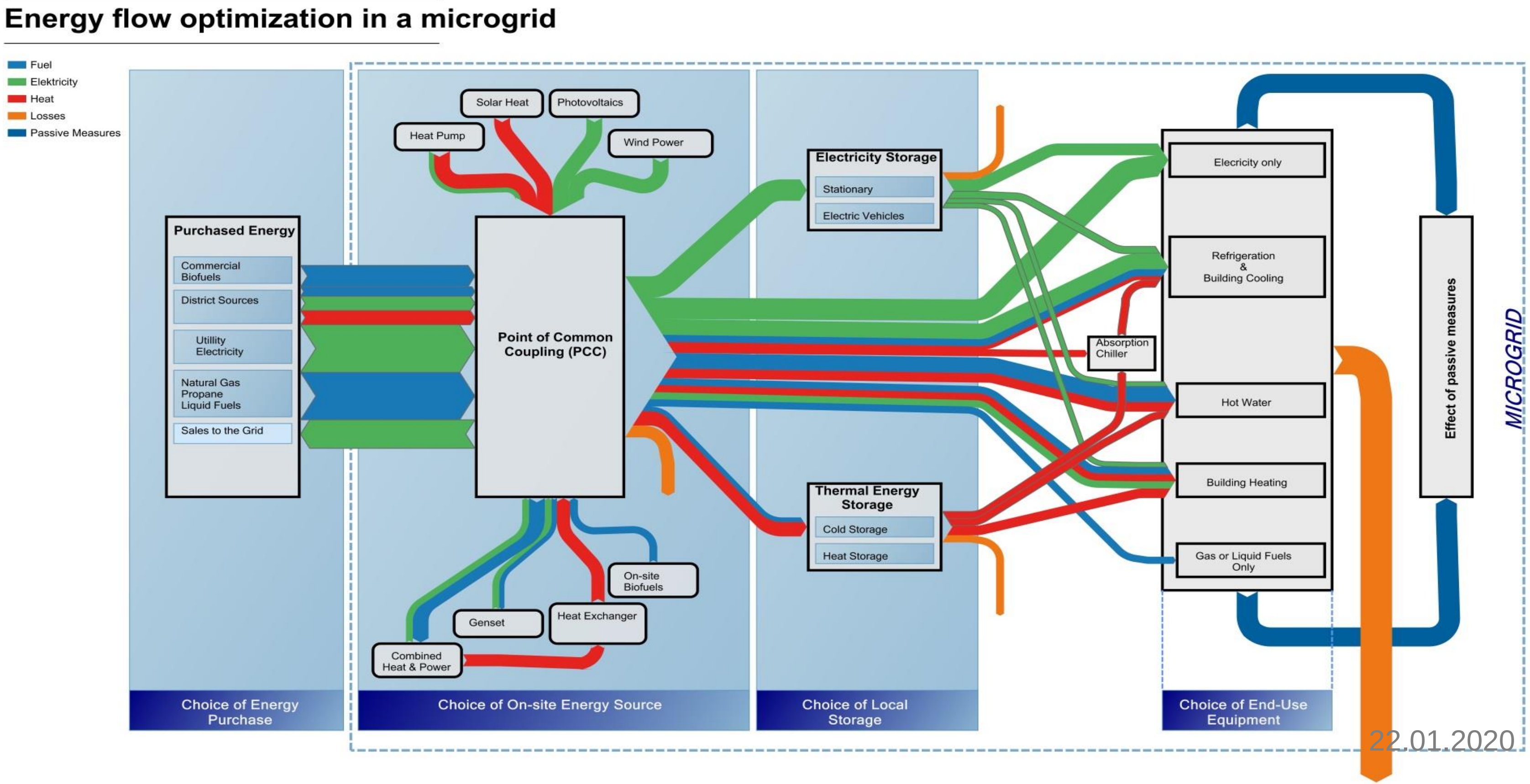
OptEnGrid → Further development and adaption on European market

- Thermal sector
- Power2Gas
- European energy market (Pricing, Regulatory,…)
- 8760 optimization

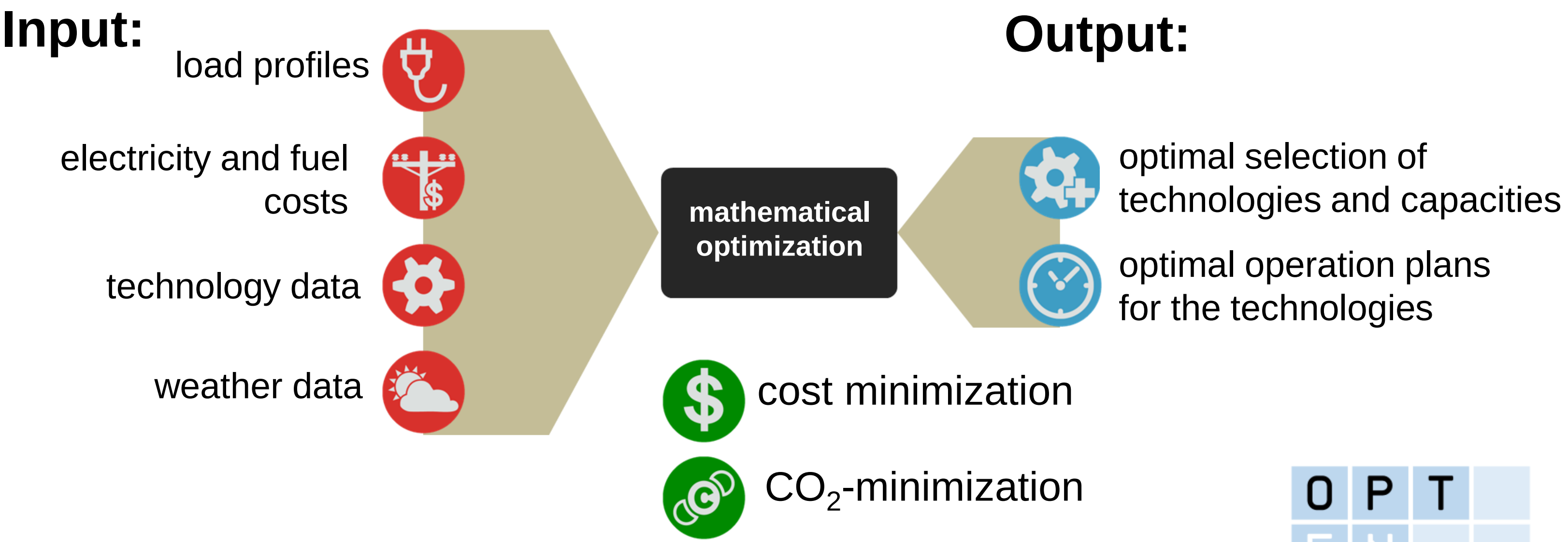
- Biomass
- Seasonal storage

powered by klima+ energie fonds

Optimization with OptEnGrid: Energy flow optimization – basic modeling problem



Planning based on Mixed Integer Linear Programming (MILP)

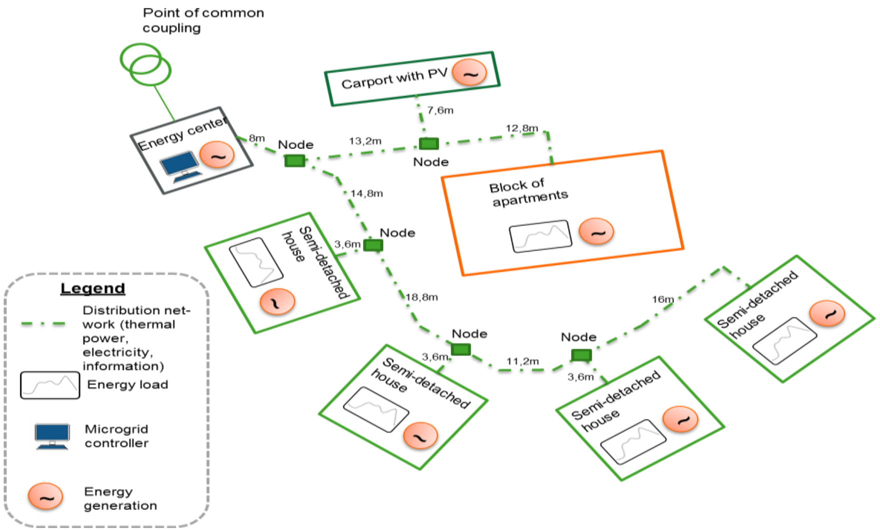


OptEnGrid
Energieoptimierung mit System

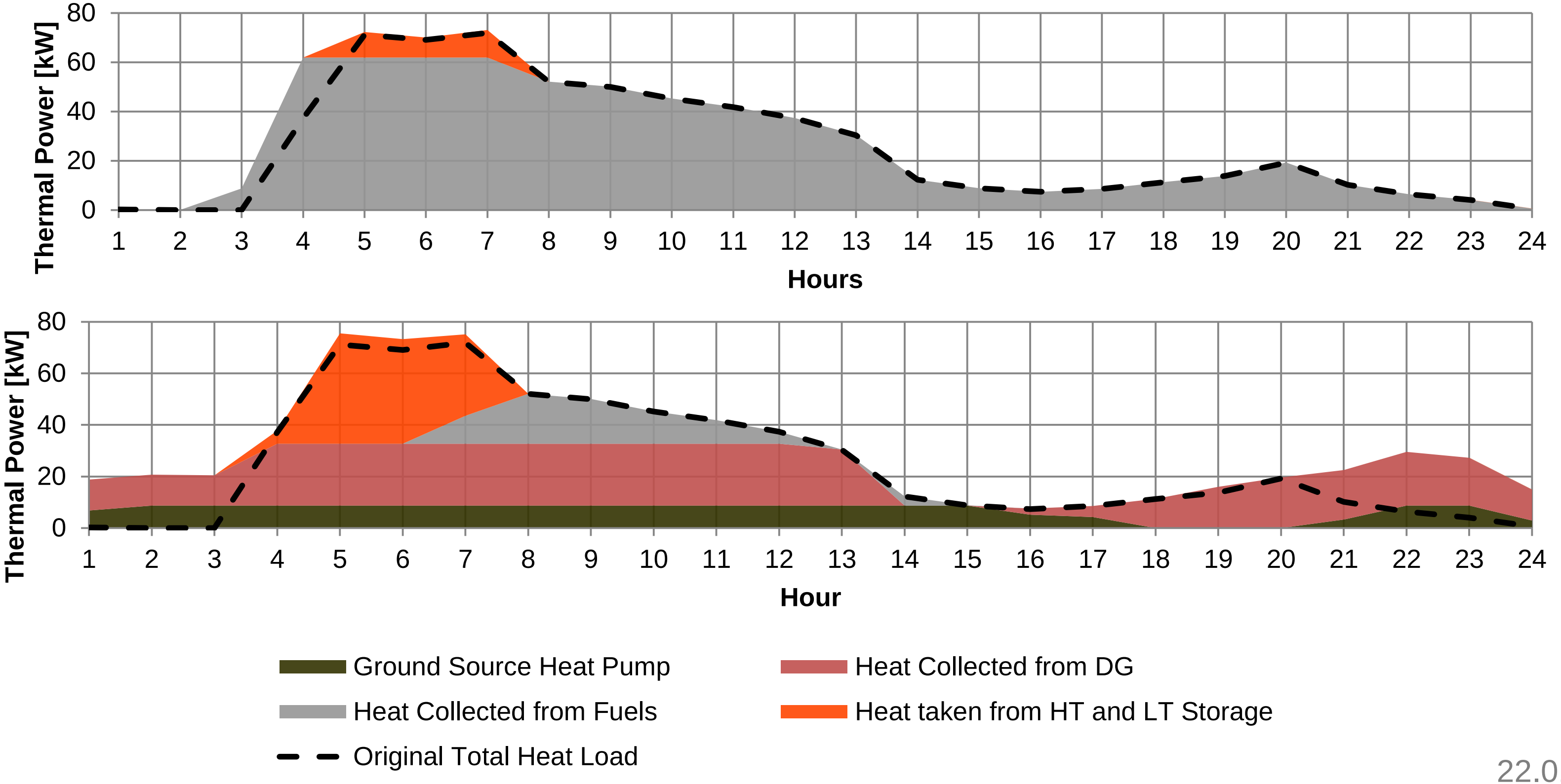
OPT EN GRID

Case Study – Planned Smart Village

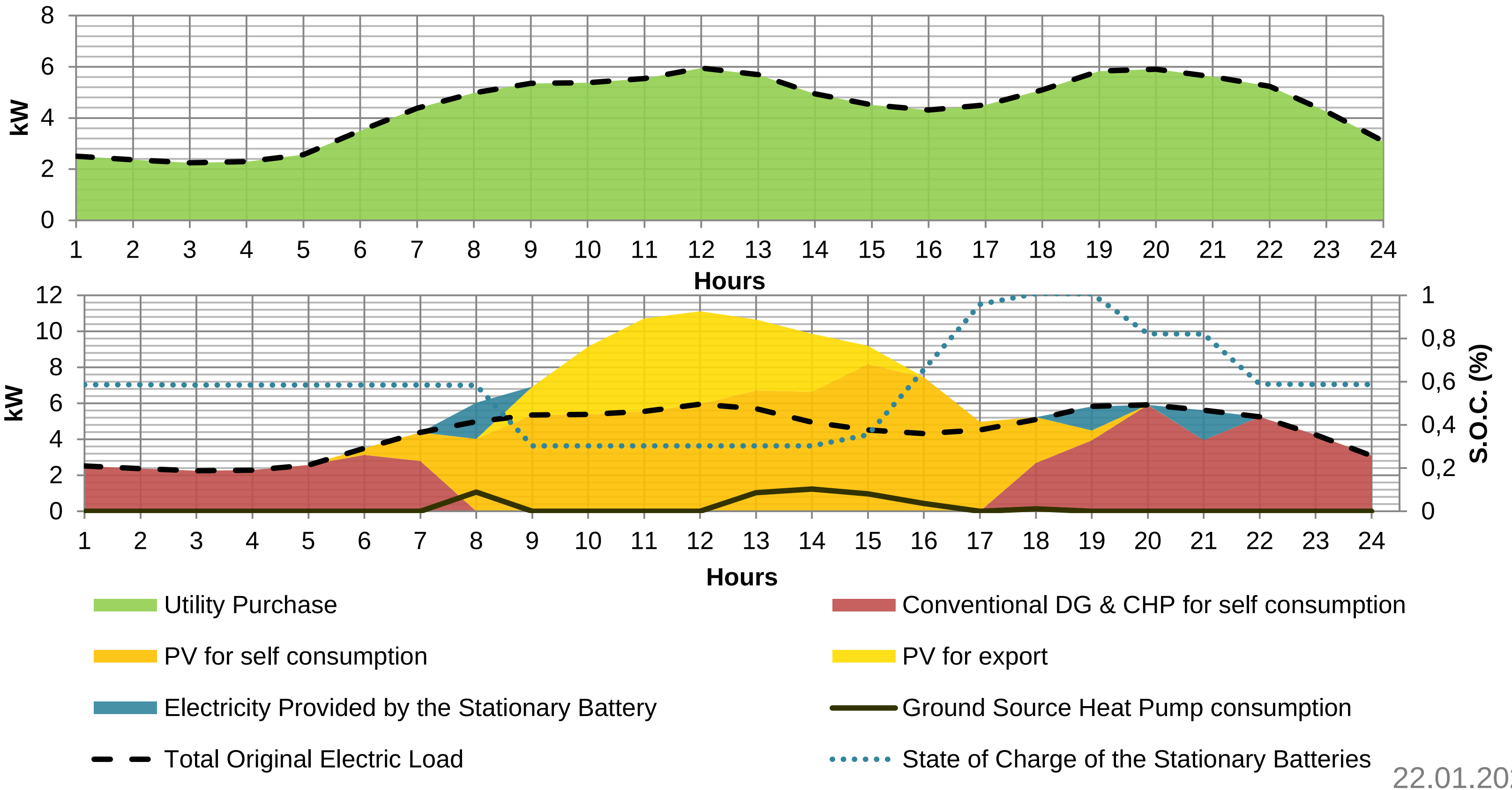
- Four semi-detached houses, a apartment house with 8 apartments, a technical center and a Carport
- Microgrid concept based on OptEnGrid



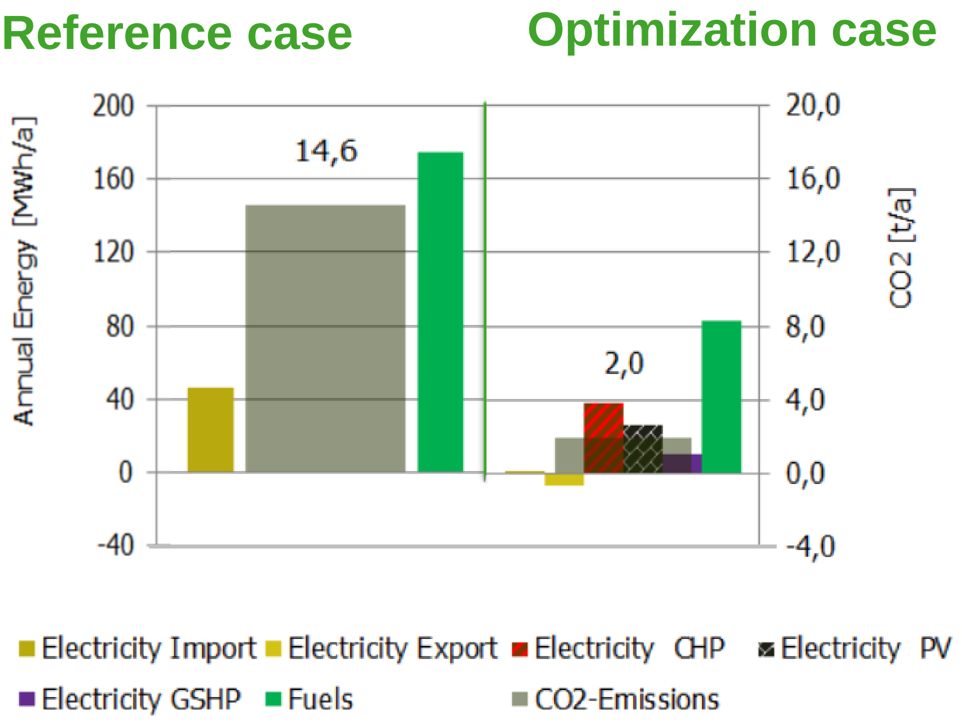
Optimal dispatch for heating technologies (April – week)



Optimal dispatch for electricity technologies (August-week)



Comparison basecase and optimization



→Life cycle cost reduction of more than 20 %

→CO_2 reduction of roughly 85 % in the case study

Conclusion

- Local energy grids (microgrids) have huge positive potential, but can reach a very high level of complexity
- A variety of different ways to cover energy consumption with DERs
- Mathematical optimization is able to deal with the complexity
- Planning tool for technology providers, energy suppliers, energy planners and regulatory authorities

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OptEnGrid
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