Solar-CHP - Development of multifunctional systems combining CHP with solar thermal plants

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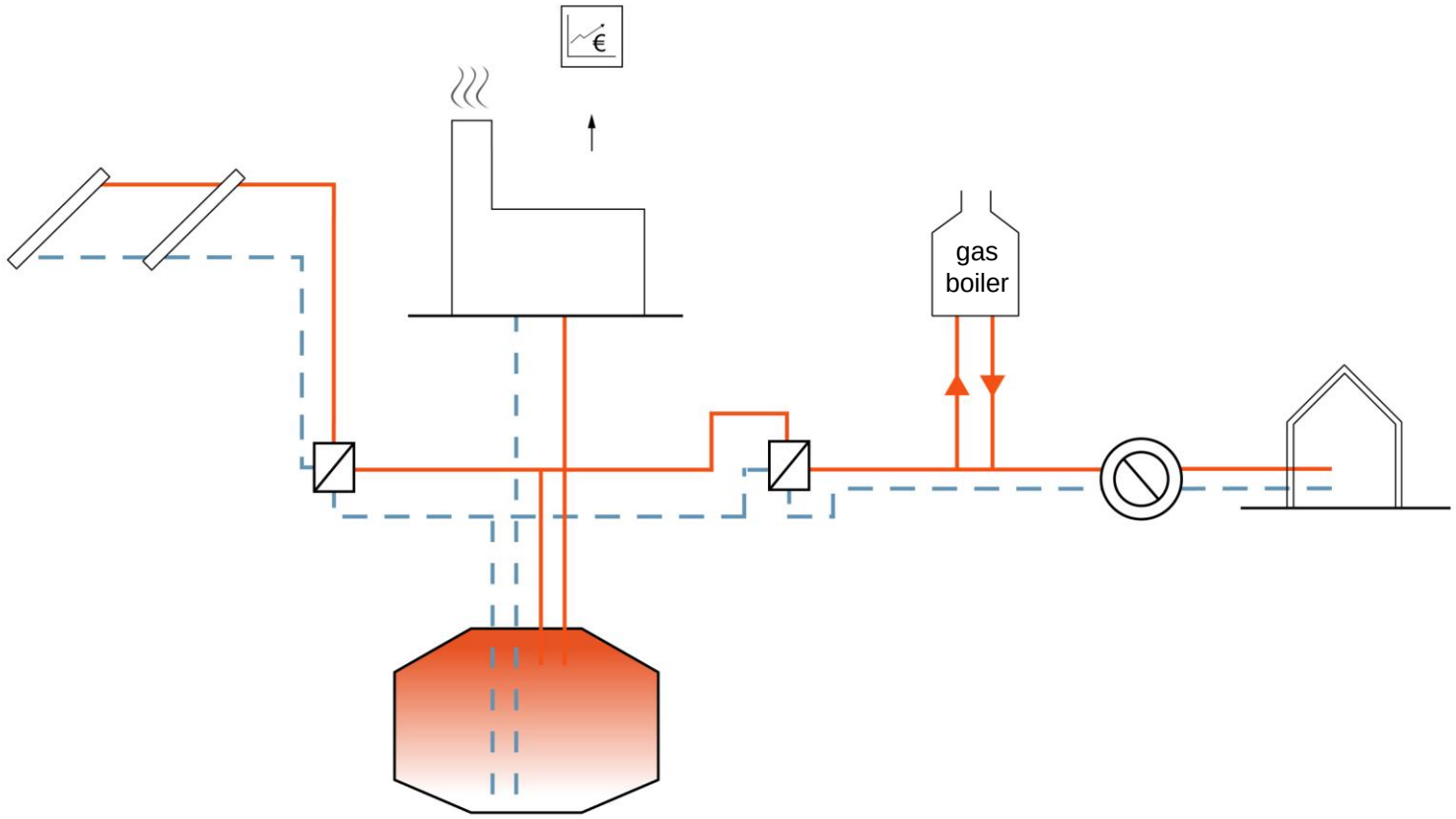
Motivation

- Increasing fluctuating electricity from renewable energy sources
- Decreasing electricity prices
- Decreasing operation hours of fossil CHP plants
- Often increasing heat production in fossil peak load boiler
- Alternative heat supply in district heating systems needed
- Solution: solar thermal and heat storage?
- Research project „Solar-KWK“ (Solar-CHP)
  - Development of simulation models in Trnsys 17
  - Operation of the CHP plant in an economical feasible way

CHP: Combined Heat and Power

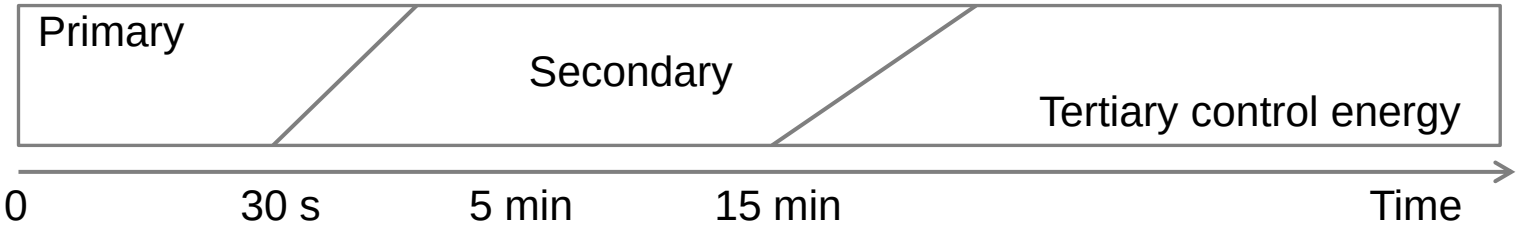
Solar-CHP system



The electricity market in Germany

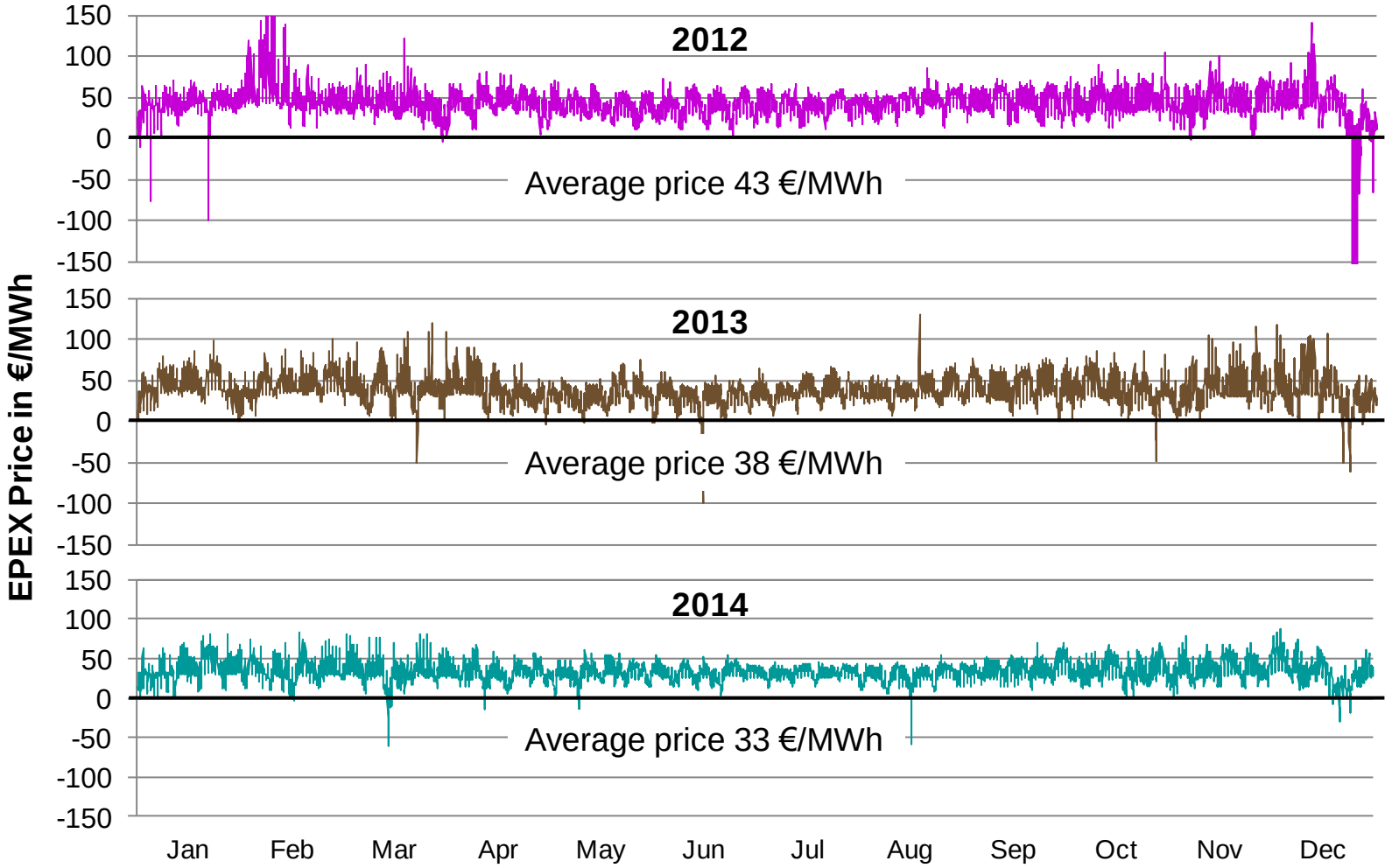
- European Energy Exchange EPEX
  - Different auctions
  - Physical Electricity Index (Phelix)
  - Hourly data

- Control energy (Germany)
  - Power system stability in four zones
  - Positive and negative control energy
  - Three qualities
  - Data of 15 minutes periods



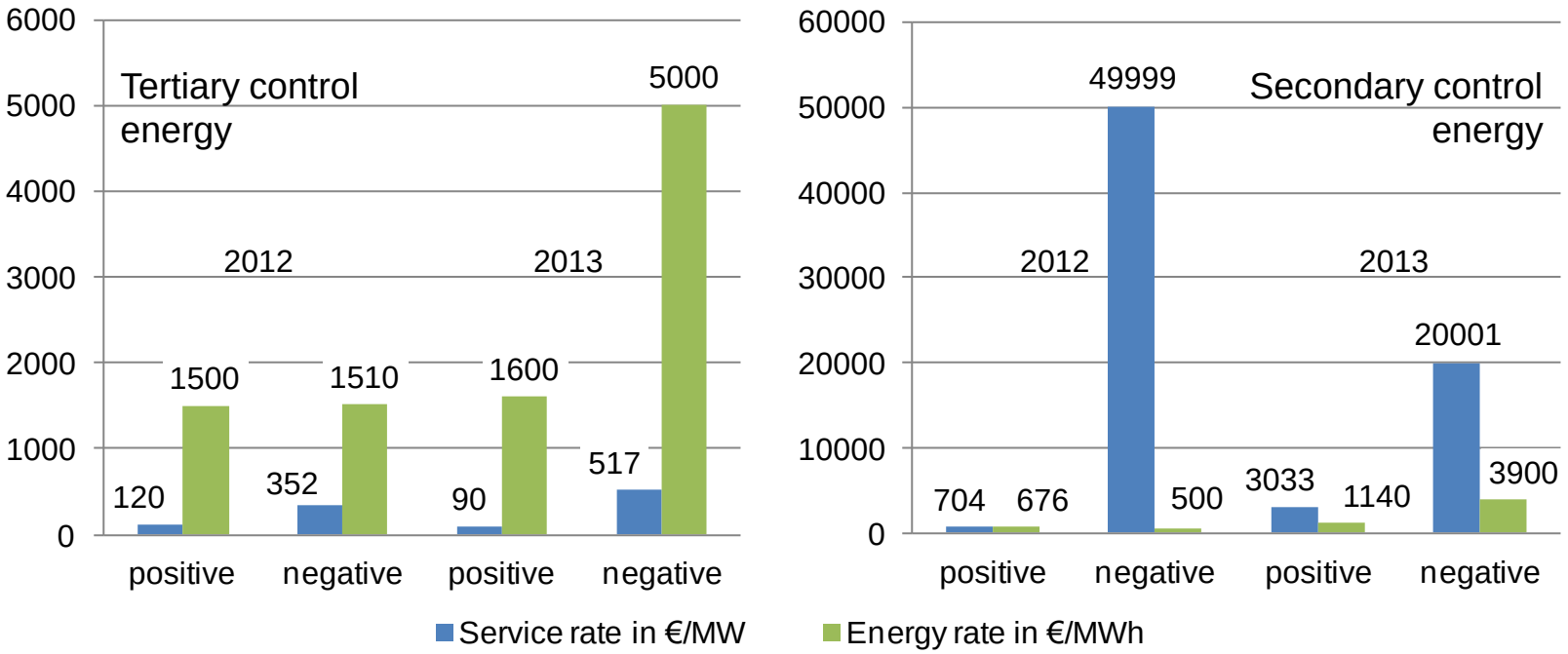
www.eex.com, www.regelleistung.net

Data analysis - European Power Exchange EPEX



Data-Analysis - market of control energy

Paid service and energy rates

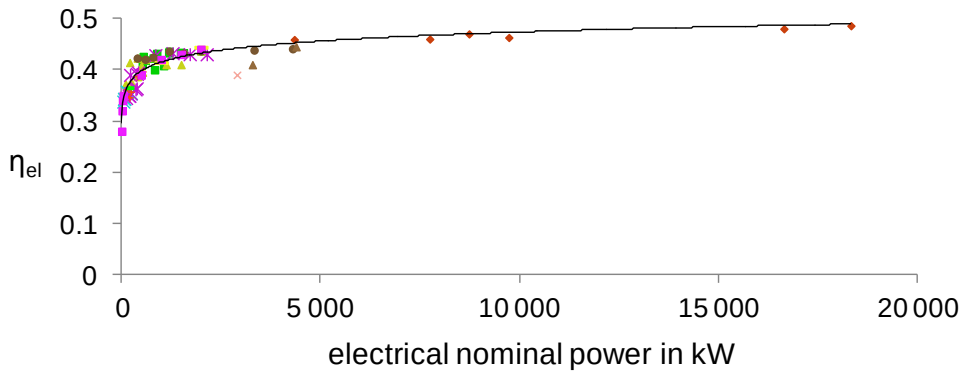


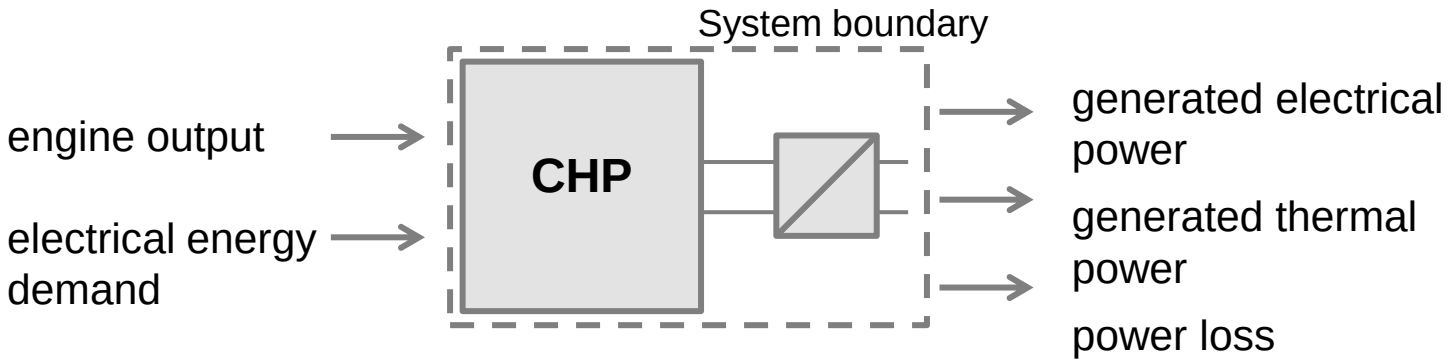
Tertiary control energy: access in 9 % of the 15 min periods

Secondary control energy: access in 99 % of the 15 min periods

Development of a CHP simulation model

- Empirical model based on characteristic curves
  - efficiencies and power
  - time-based behaviour
- Technical boundary conditions
- Data from literature, operators, and manufacturers





Development of a control model

- Power-led control of the CHP model
- Operation if EPEX price > marginal costs of cogenerated electricity
- Provision of tertiary control energy
- Price data for the years 2012, 2013 and 2014

- Calculation of marginal costs (€/MWh)
  - \+ Variable operation costs
  - \+ Fuel
  - \+ Electricity demand of the CHP plant
  - \- Reimburse of energy tax
  - \- Heat credit
  - \- Legal CHP reimbursement („Kraft-Wärme-Kopplungsgesetz KWKG“)

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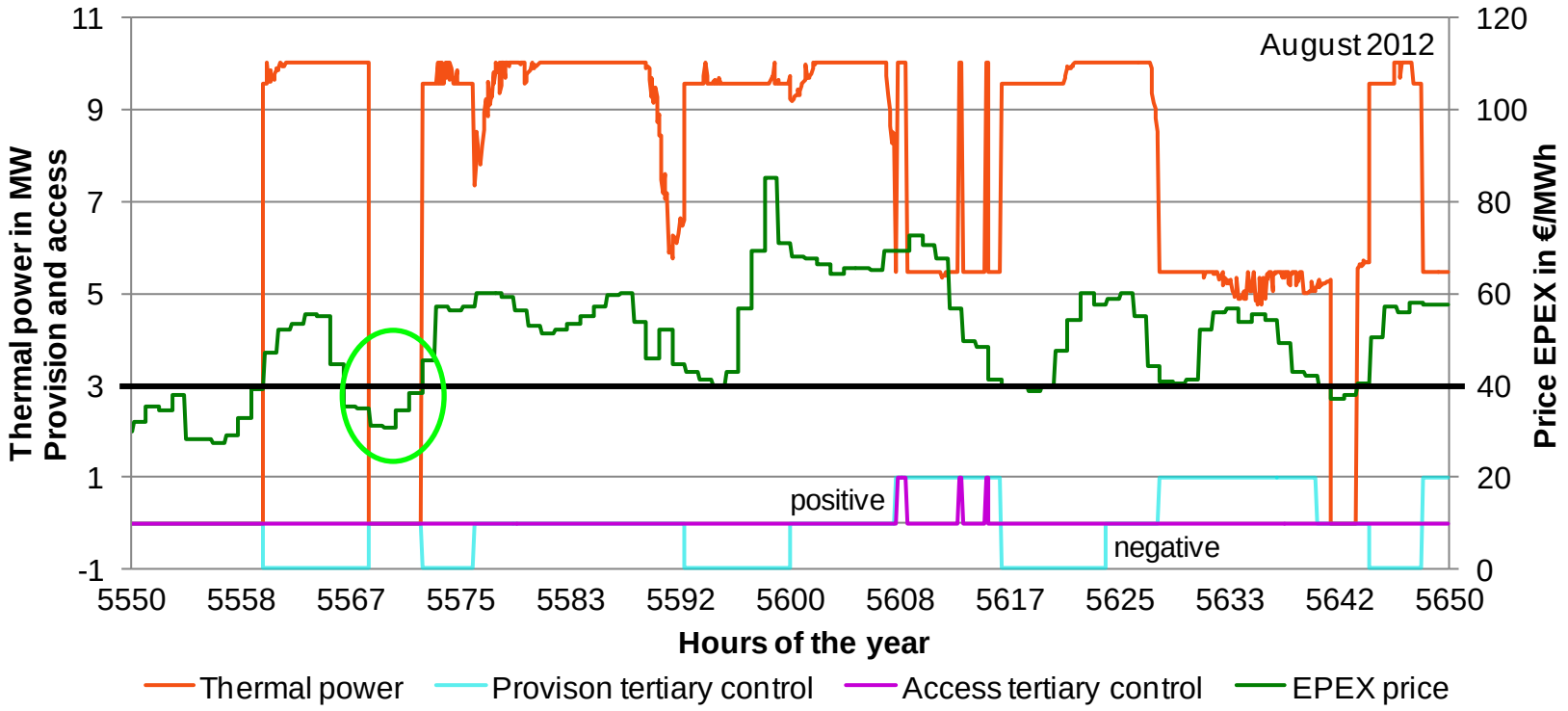
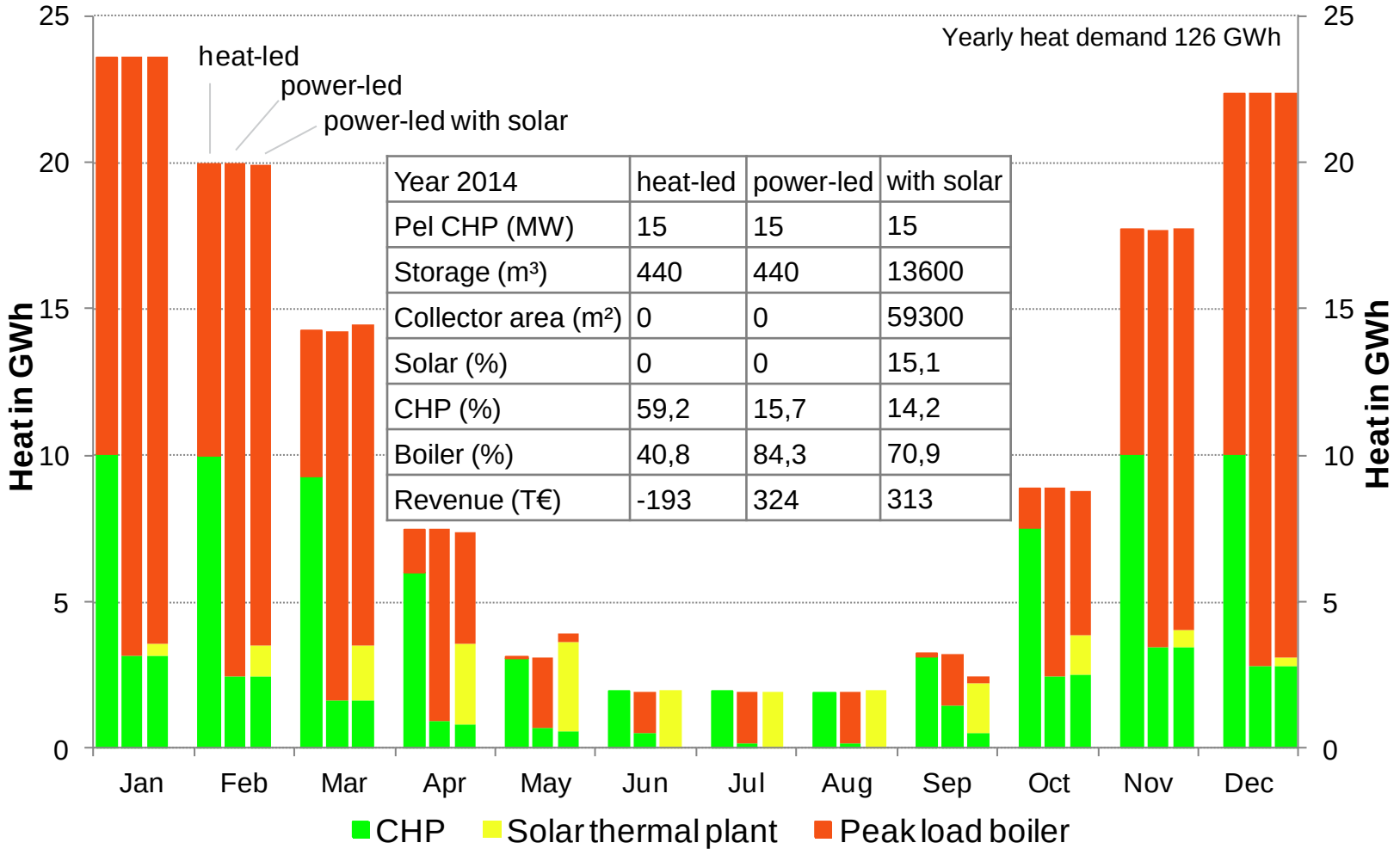
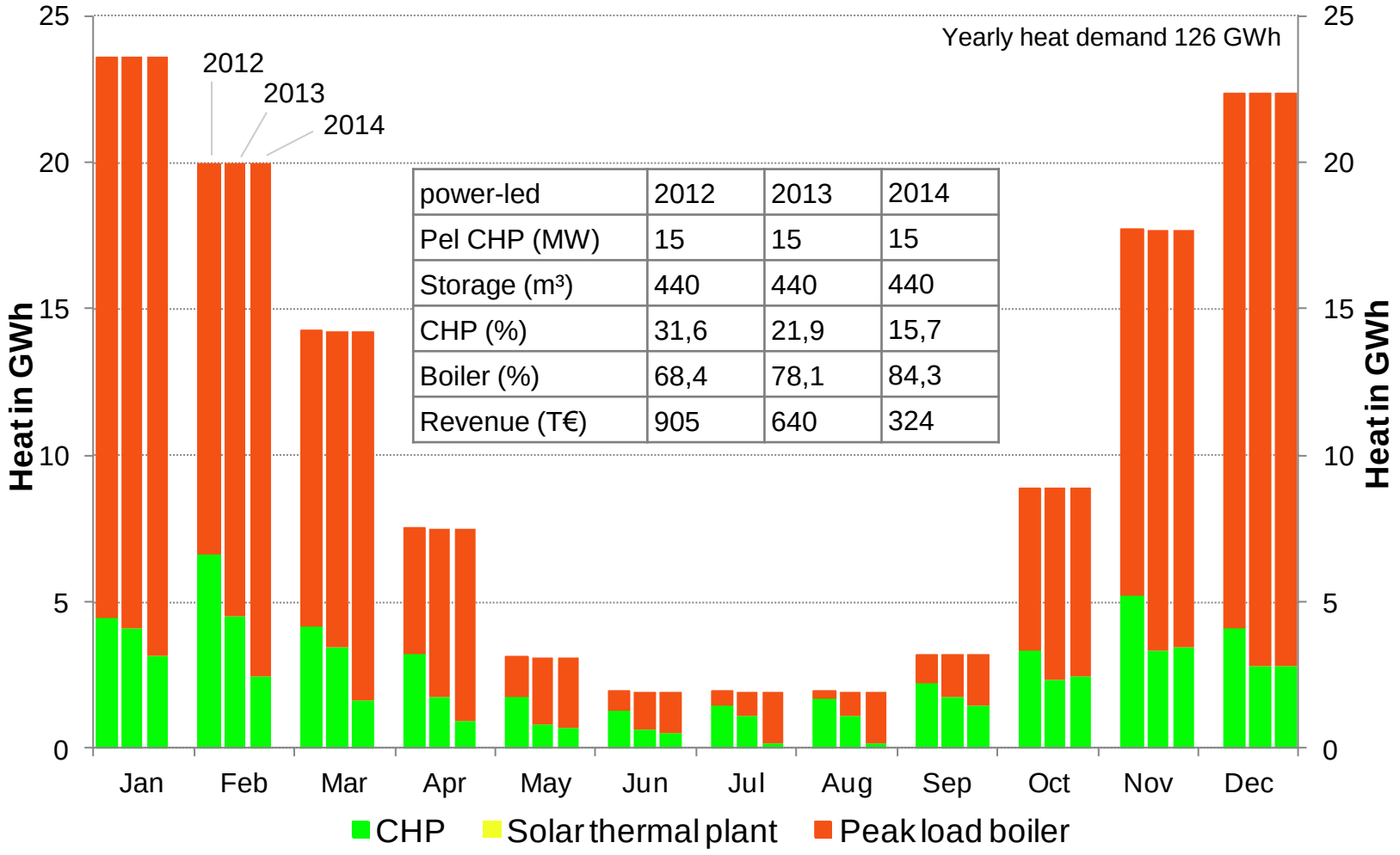


System simulation results



Year 2014	heat-led	power-led	with solar
Pel CHP (MW)	15	15	15
Storage (m³)	440	440	13600
Collector area (m²)	0	0	59300
Solar (%)	0	0	15,1
CHP (%)	59,2	15,7	14,2
Boiler (%)	40,8	84,3	70,9
Revenue (T€)	-193	324	313

System simulation results



power-led	2012	2013	2014
Pel CHP (MW)	15	15	15
Storage (m³)	440	440	440
CHP (%)	31,6	21,9	15,7
Boiler (%)	68,4	78,1	84,3
Revenue (T€)	905	640	324

Conclusion

- Simulations confirmed the anticipation

  CHP plants are getting more and more uneconomic with the developing electricity market in Germany

- Solution: solar thermal and heat storage!
  - Heat share from gas boiler reduced
  - Heat production and economical feasibility of CHP preserved

- ➢ Further optimisation of the developed simulation system
- ➢ Simulations of existing CHP plants
- ➢ Sensitivity analysis and risk estimates for investments enabled

Thank you for your attention

www.solar-district-heating.eu

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Picture: Solar thermal plant Ulsted, DK; Source: Arcon Solar