Investigation of Scenarios for Flexible Power Generation with a Biogas Plant

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Scope of work

- Process simulation of scenarios for flexible power generation with a biogas plant
- Identification of restrictions and effects on technical units of the biogas plant
- Economic assessment of the simulated scenarios for flexible power generation

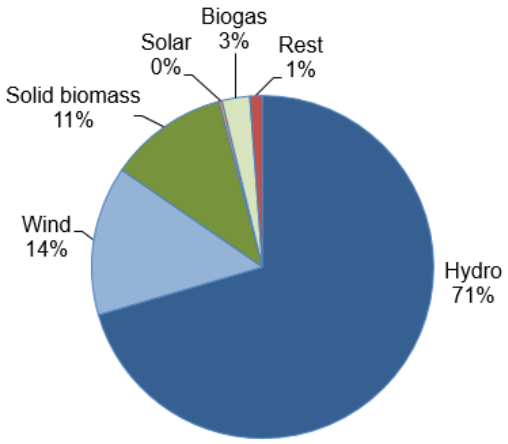
RES in Europe:

- Climate targets of the EU-28 for 2020:
  20% reduction of greenhouse gas emissions and 20% share of energy from renewable energy sources in comparison to the level of 1990
- Increasing integration of renewable energy sources with fluctuating energy generation (wind, solar)

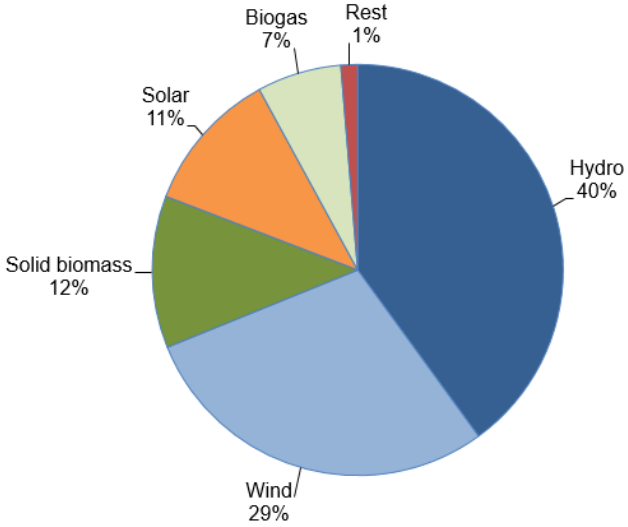
  → additional flexibility in electricity system needed

RES-E in EU-28

2005: 489.6 TWh



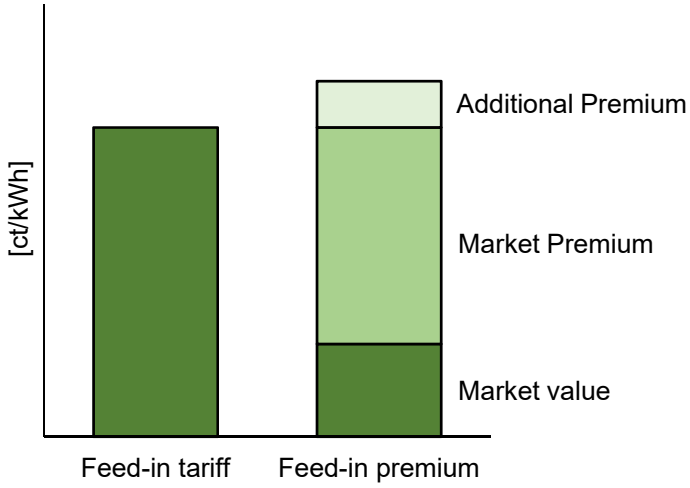
2014: 871.5 TWh

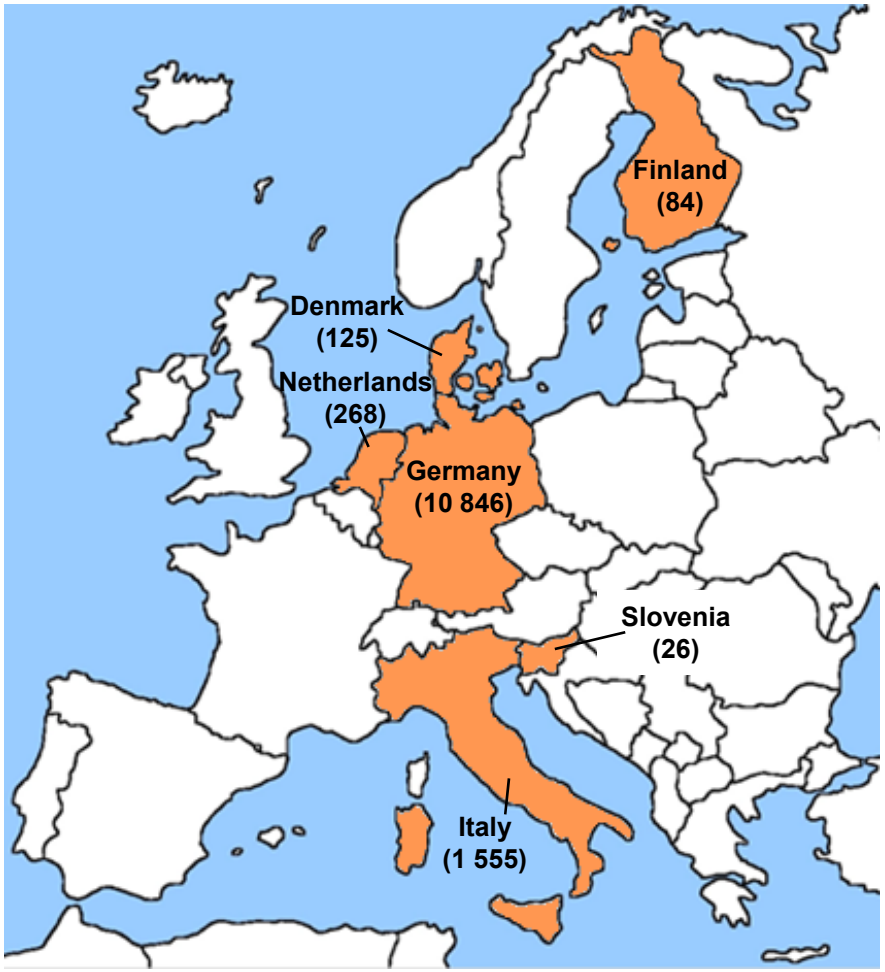


EEA Report No 3/2017, Renewable energy in Europe 2017

Biogas landscape in Europe

- Storability of energy carrier qualifies biogas plants for flexible power generation
- 17 376 plants in EU-28 (8.7 GW, 2015)
- Implementation of Feed-in premiums for promotion of flexible power generation

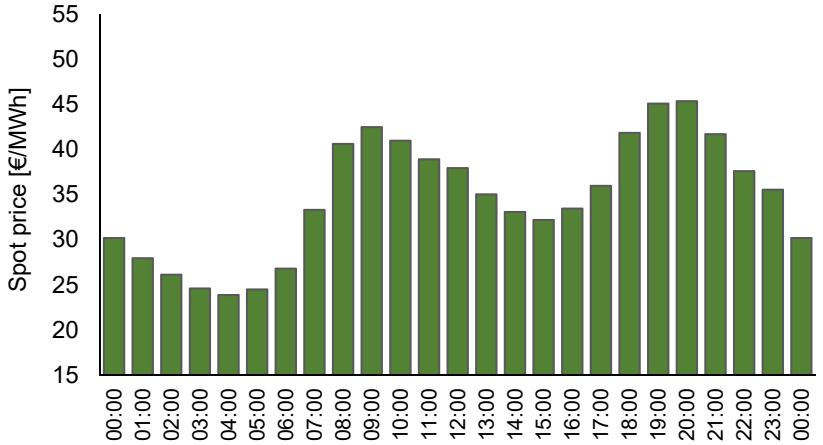




Spot markets

Purpose: Optimization of power generation schedules

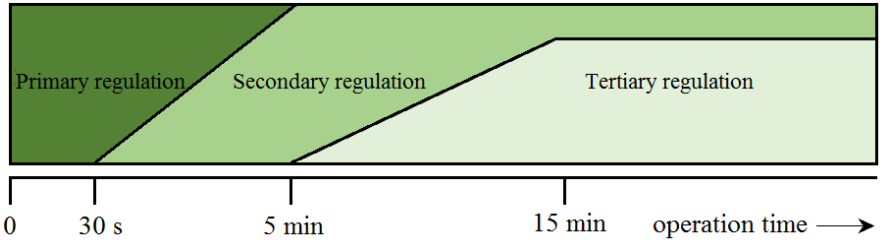
- Day-ahead market: Optimization of power generation schedule for following day
- Intraday market: Trading possible until short (30 min) before actual power supply



Markets for control energy reserves

Purpose: Balancing of the electricity net frequency (50 Hertz)

- Primary reserves: Activation within seconds
- Secondary reserves: Activation within 5 minutes
- Tertiary reserves: Activation within 15 minutes



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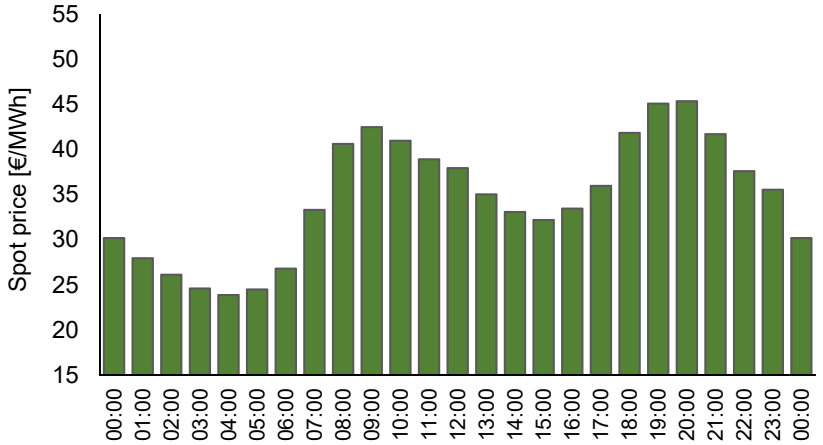

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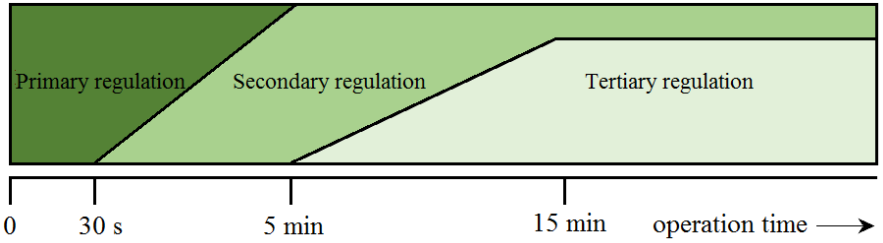


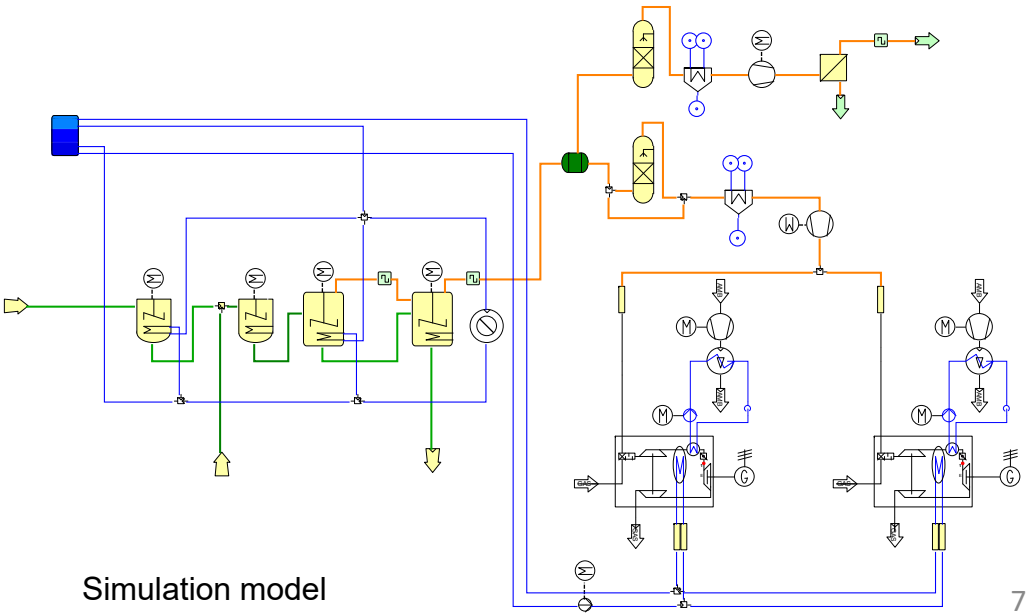
Investigated biogas plant

Biogas plant „Bruck an der Leitha“

- Waste recycling plant (about 4.4 Mio. m³ biogas/year)
- Main focus on gas upgrading of biogas to biomethane (gas permeation)
- Excess CHP–unit capacity (1.36 MW)
- Gas storage capacity of 4 800 m³

Process simulation

- Simulation programm „IPSEpro 7.0“
- Flow sheet bases on monitoring at plant
- Integrated mass and energy balances

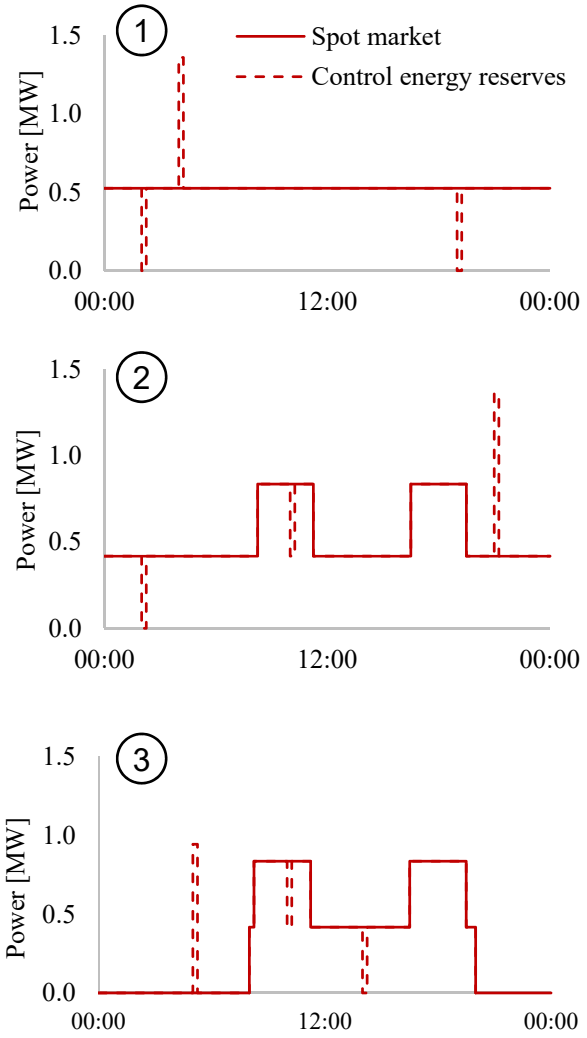


Simulation model

Scenarios of flexible power generation

Power generation while continously upgrading biogas to biomethane and providing control energy reserves was assumed

- Scenario 1: Continuous, constant power generation with one engine
- Scenario 2: Continuous power generation (demand-oriented power profile) with one engine
- Scenario 3: Demand-oriented power generation during peak times with one engine



Key parameters for simulation

- Ex-post simulations (July 2016 – May 2017)
- Participation at intraday market and market for secondary control energy reserves was assumed
- Gas storage volume 4 800 m³ (3 800 m³ effective)

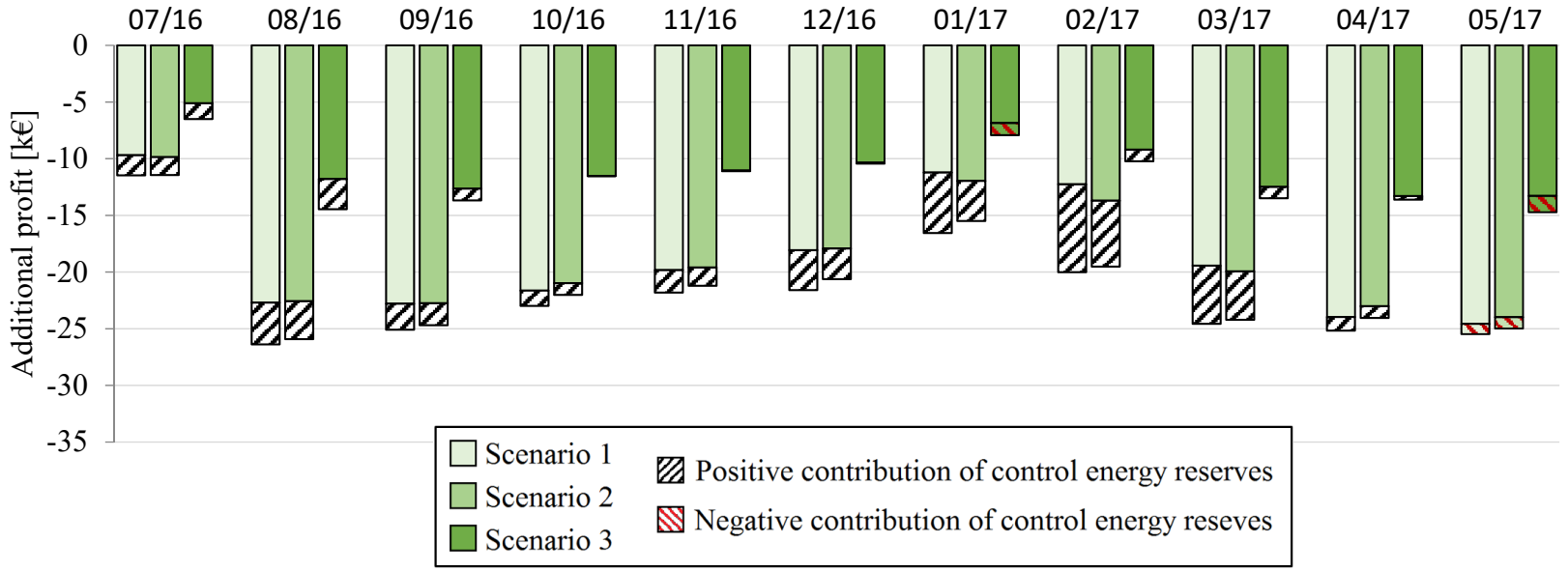
Key parameters of economic assessment

Parameter	Value	Unit
Power price (control energy reserves)	200 (positive), 45 (negative)	€/MWh
Electricity cost	60	€/MWh
Heat cost	55	€/MWh
Heat revenue	40	€/MWh
CHP-unit start-up cost	10	€
CHP-unit maintenance cost	16.5	€/h
Electricity grid utilization cost	1.76	€/MWh

Economic Assessment

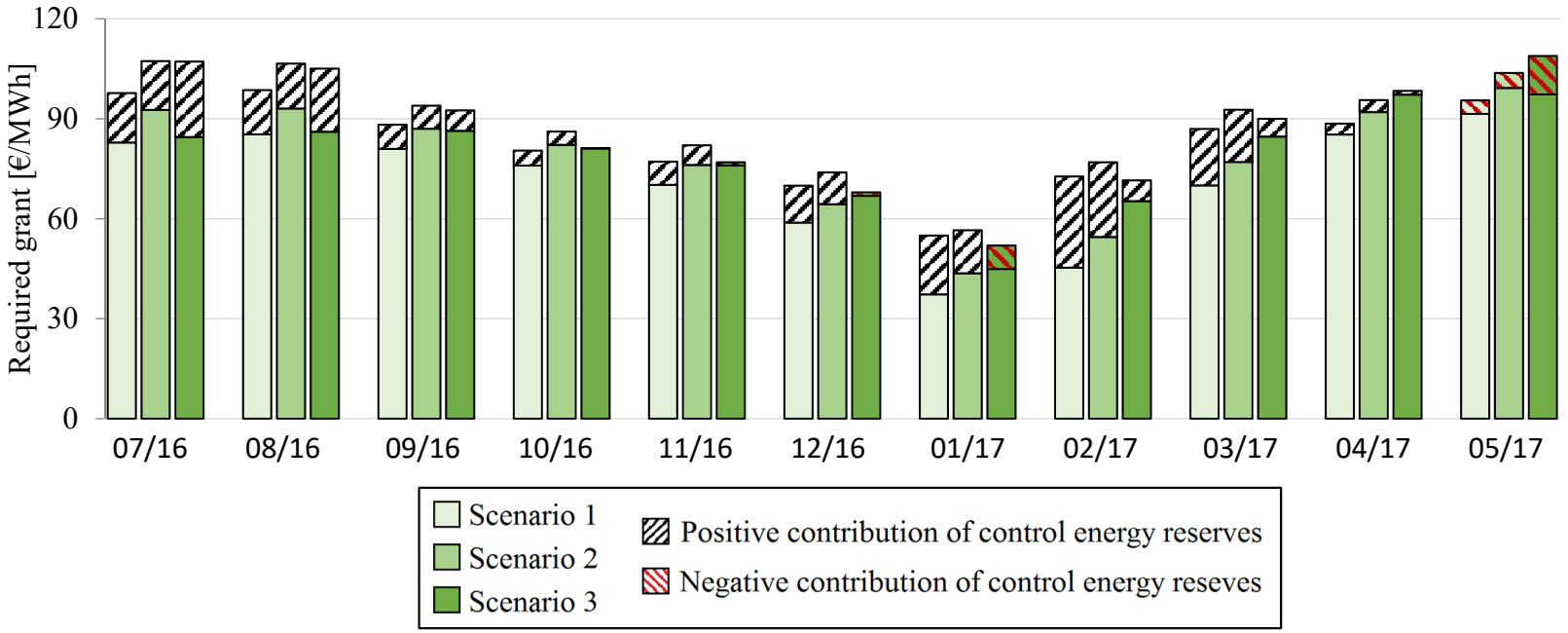
- 3 simulated scenarios (power generation + gas upgrading) were compared to a reference scenario (status quo – gas upgrading only)
- Simulated scenarios are uneconomic without proper support scheme

  (Average electricity price 35.2 €/MWh; Feed-in tariff 125.1 - 186.7 €/MWh)



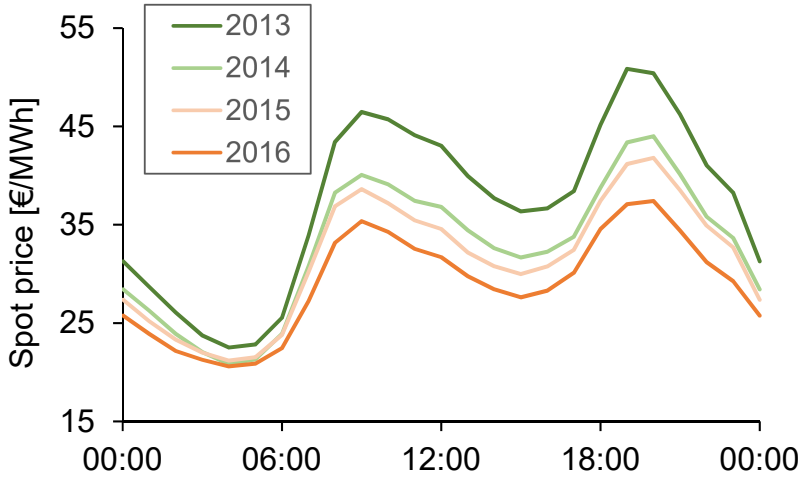
Economic Assessment

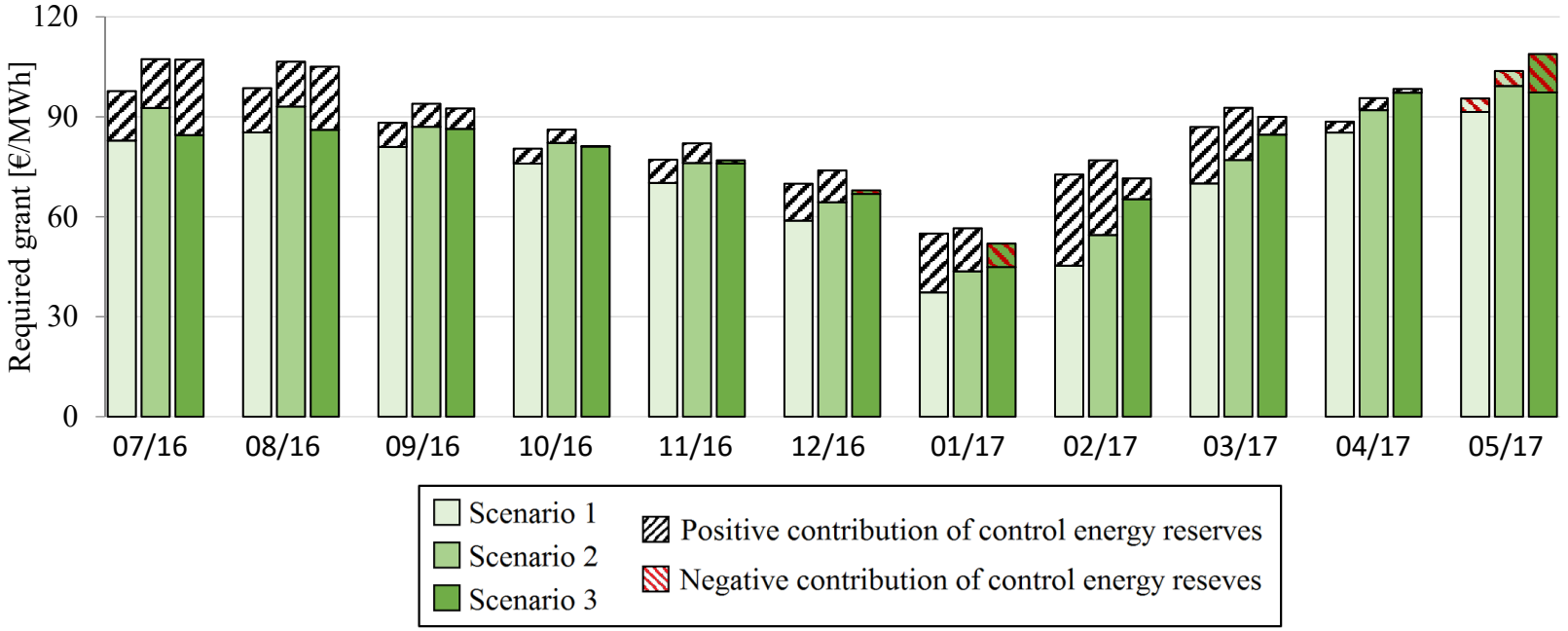
- Needed additional grant for electricity traded at spot market 37.3 – 99.3 €/MWh
  (Feed-in premium in Germany 58.5 - 277.3 €/MWh)
- Profitability increases during colder months of the year



Economic Assessment

- Scenarios with demand-oriented power generation profile (2+3) economically not superior to scenario 1 with constant power generation profile
- Additional revenues can be obtained through participation at control energy market in most cases





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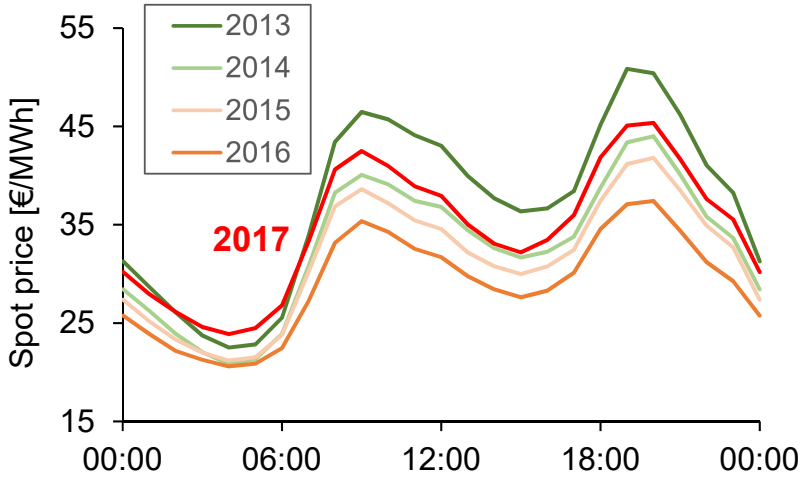

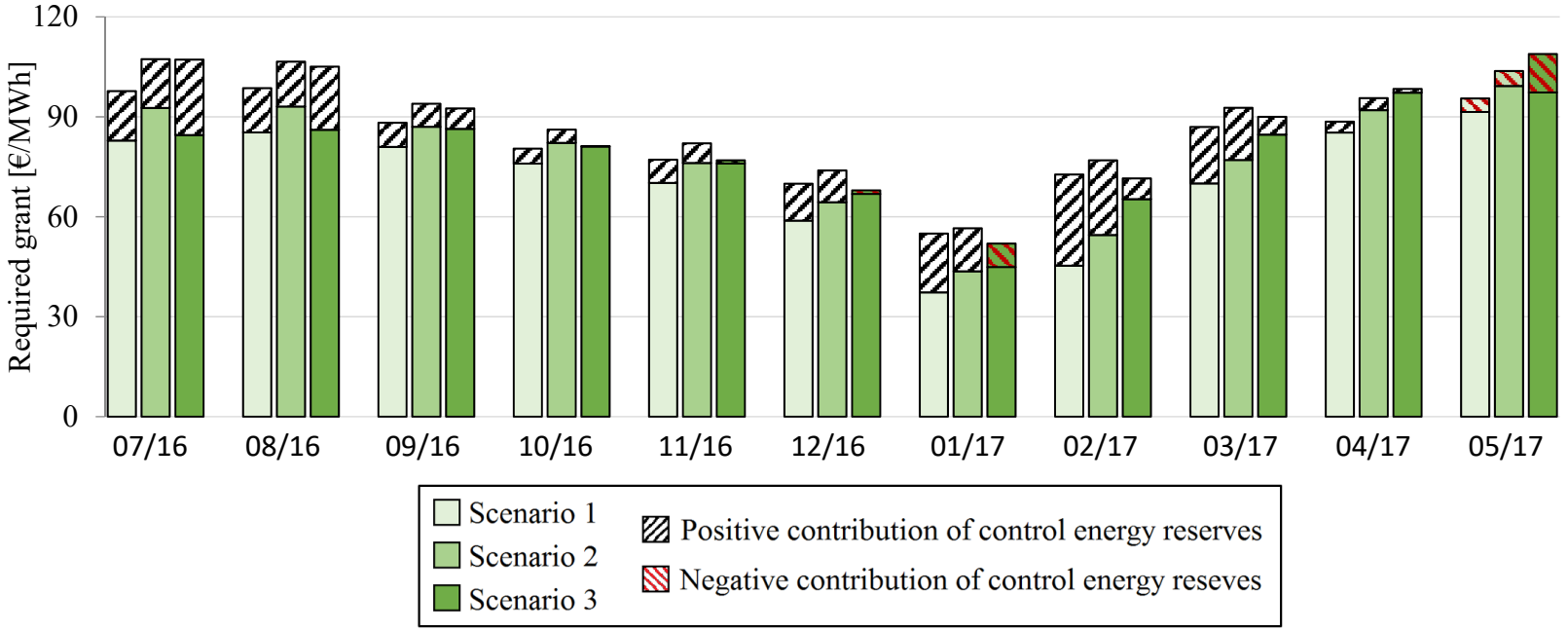

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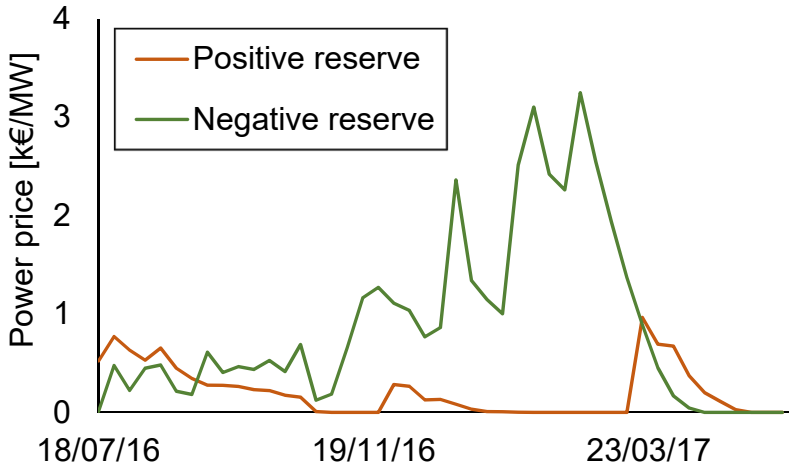

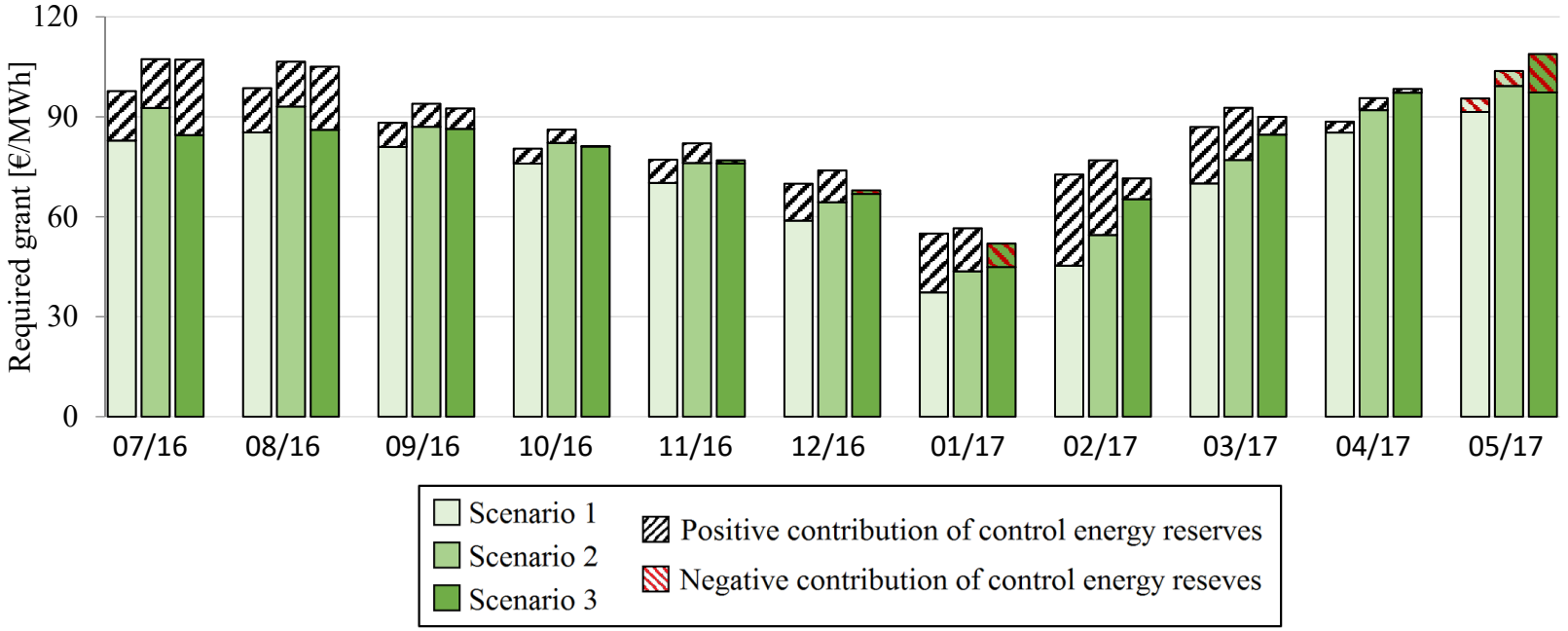

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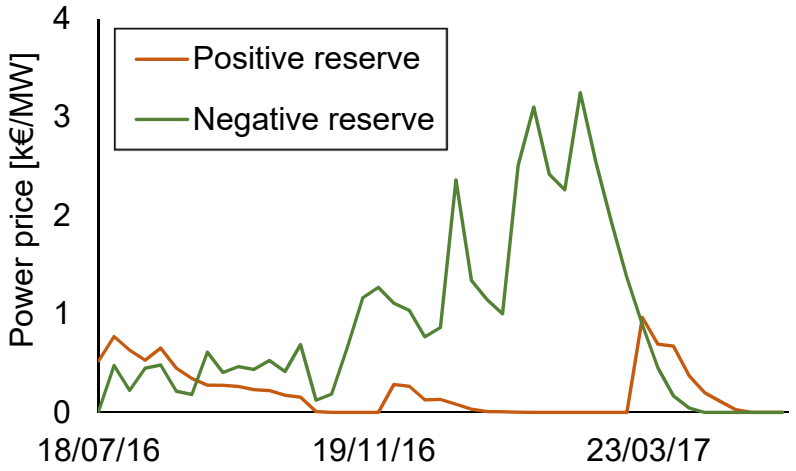
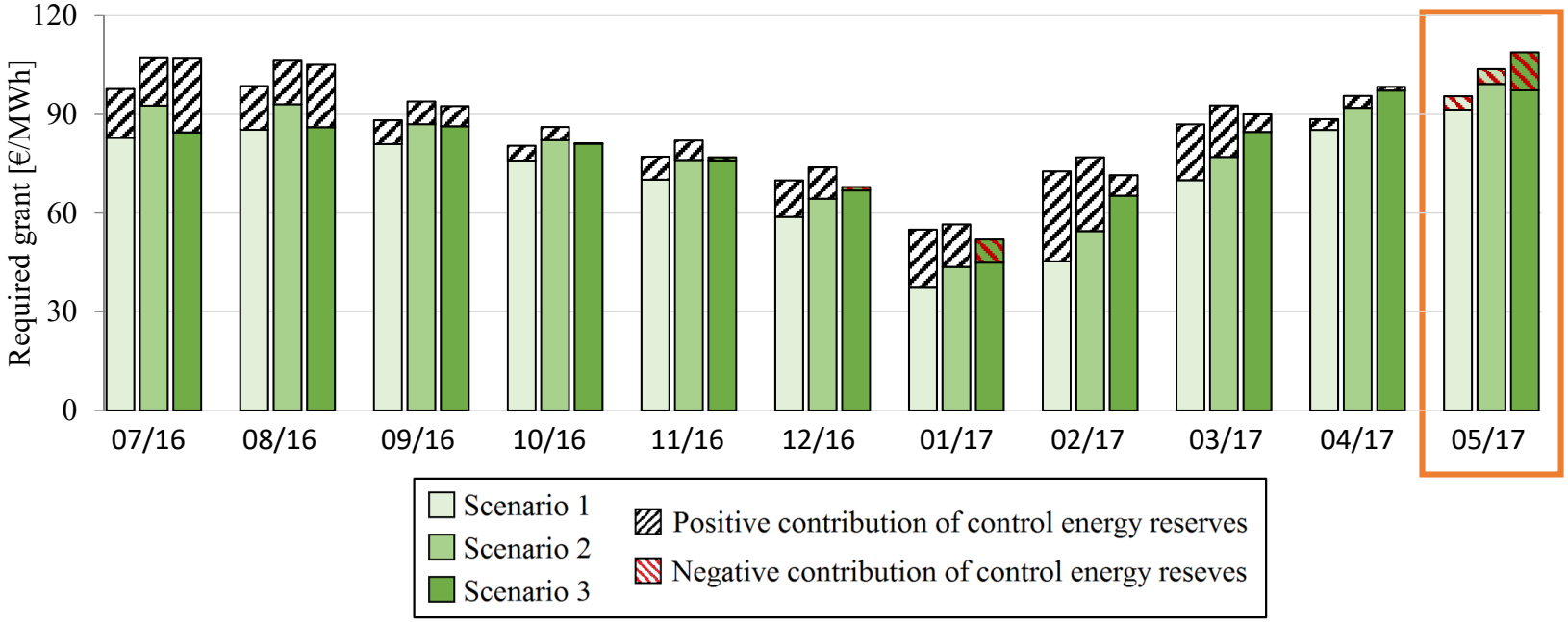


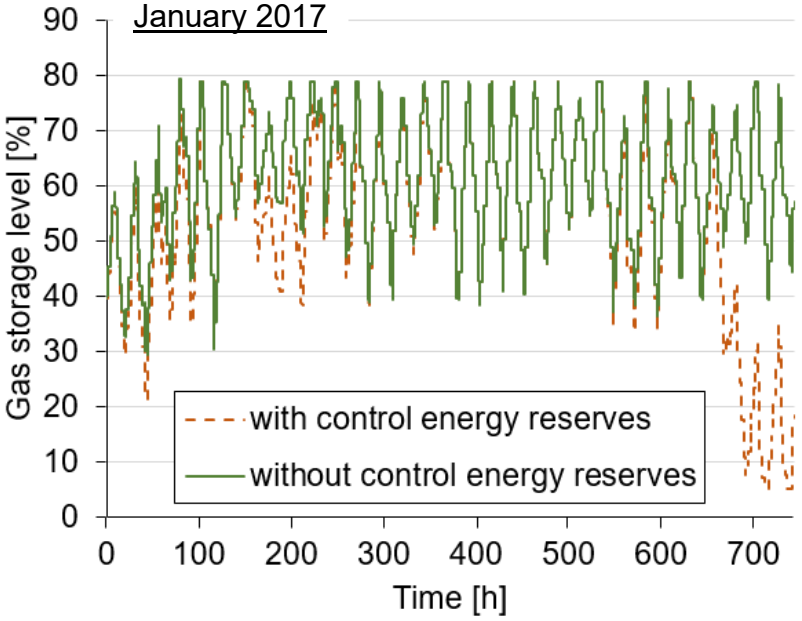


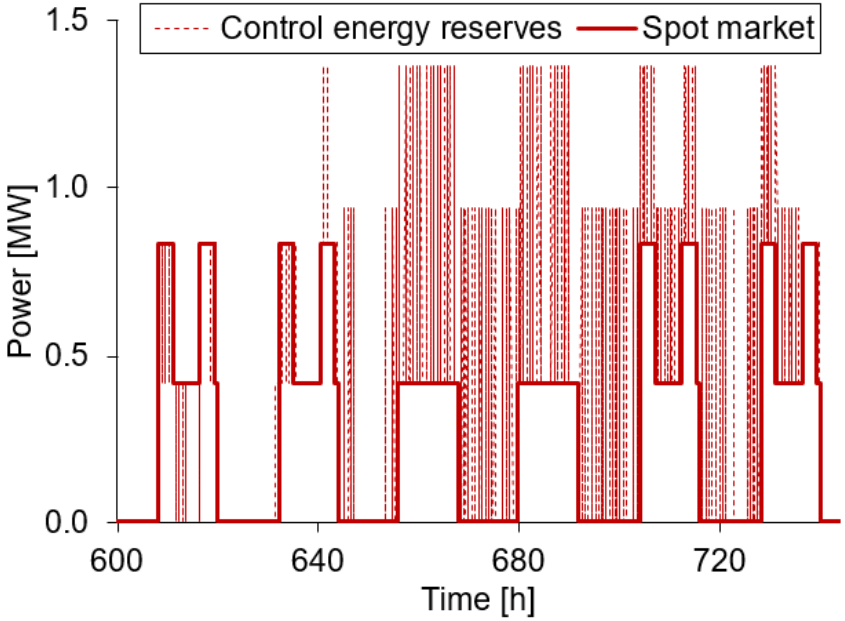
Gas storage capacity

- Installed gas storage capacity proved to be sufficient for almost all of the simulated cases
- Very frequent activation of positive control energy reserves can lead to insufficient biogas supply

  → Reduction of biogas upgrading capacity

  → Short-termed increase of biogas production through demand-oriented biogas production

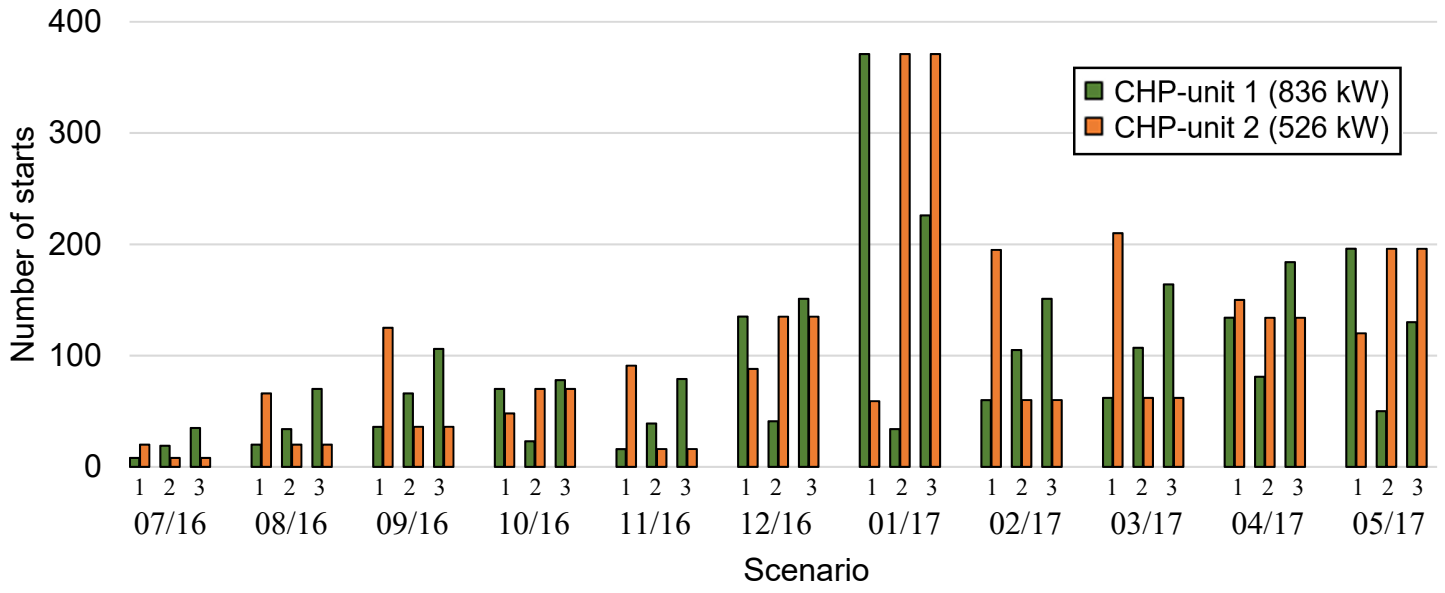




CHP-units

– Demand-oriented power generation and participation at control energy market can lead to an increased number of CHP-unit starts

→ Increased mechanical exposure of technical components leads to decreased lifespan of CHP-units

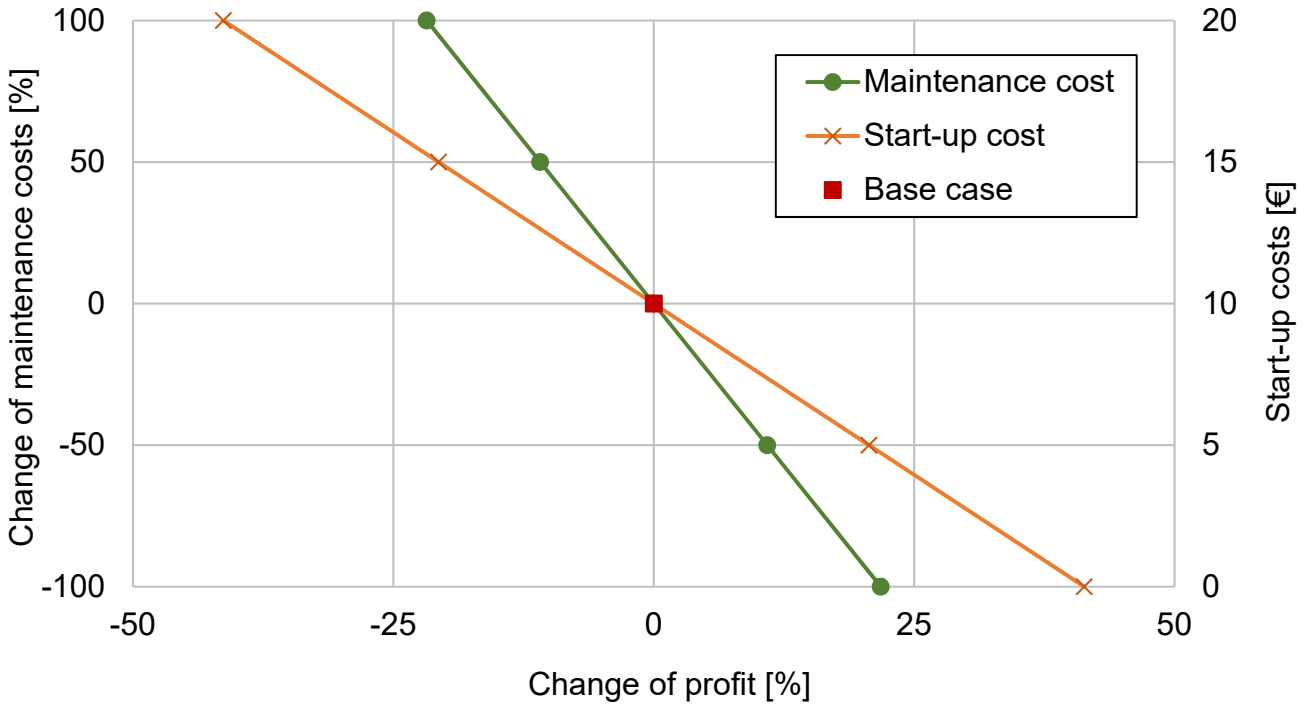


CHP-units

– Start-up costs and increased maintenance costs decrease profitability of flexible power generation

→ Pre-heating and pre-greasing of the engines

→ Usage of appropriate starting systems



Summary

Conclusion

- Necessary technical adaptions for flexible power generation may include adaption of gas storage capacity
- Appropriate financial supporting scheme is needed to make flexible power generation economically feasible
- Higher prices and price fluctuations at spot market and participation at control energy market can increase profitability
- CHP-unit start-up and maintenance costs affect profitability and should be minimized

Acknowledgements

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