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STRise
Stuttgart Research Initiative on Integrated Systems Analysis for Energy

EFFICIENT PATHWAYS FOR THE ENERGY TRANSITION BY SOFT COUPLING OF OPTIMIZATION AND SIMULATION MODEL

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DLR

The project EraFlex

- Studying energy transition, the gap between model results and reality should be narrowed to assure model based pathways as efficient as possible

Optimization (OPT)- E2M2	Agent-based (ABM) - AMIRIS
cost optimal system & investments	Simulation of behaviours of actors
considering techno-economic parameters	Changing environment (actors, regulatory framework)
certainty of the whole system	Uncertainty of actors

- Couple optimization (OPT) model with agent-based simulation model (ABM)

- Iteratively adjustment of both models' results leads to a cost optimized energy system that should be economically feasible for all actors: focus is set on flexibility options

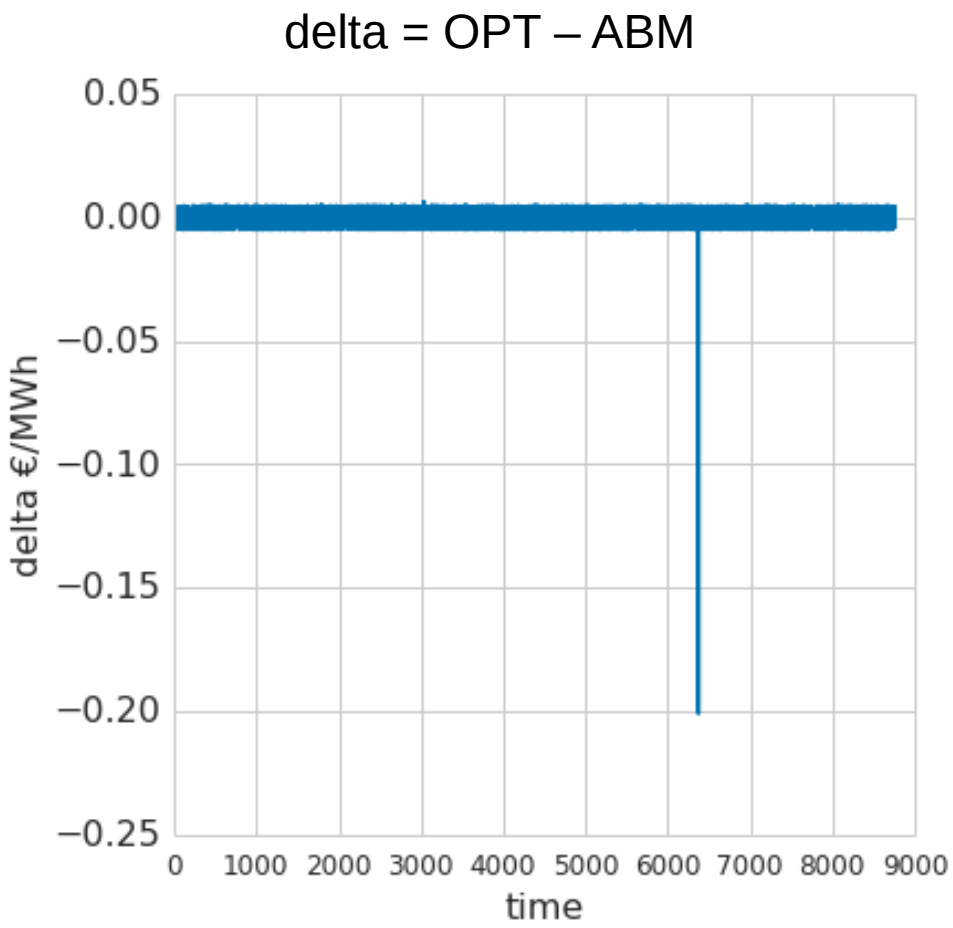
Why a harmonization of models

- Understanding of differences in operation of flexibility options is the goal
- Learn about result differences for „base“ scenario, ie without flexibility options
- How to compare wholesale market prices with system costs of OPT?
- Duality of optimization problems: under certain conditions, strong duality is preserved and the dual variables to optimazation problems can be interpreted as prices
- Condition for strong duality: Slater‘s condition, convexity
- OPT (E2M2) should hold this conditions

Preparation for base scenario

	Used capacity increments	Max efficiency	Min efficiency	O&M costs [€/MWh_th]	Fossil fuel costs [€/MWh] average	CO2 [t/MWh_el]	ETS price [€/t] average
Lignite	in 200 MW blocks	0.45	0.3	4.4	4.0	0.401	13.84
Coal		0.46	0.35	4.0	13.55	0.342	
Nuclear		0.33	0.25	0.5	3.37	0.0	
Gas GuD		0.61	0.5	2.0	21.21	0.202	
Gas GT		0.39	0.3	2.0	21.21	0.202	
Demand	Time Series						
Offshore Wind	Time Series						
Onshore Wind	Time Series						
Photovoltaic	Time Series						

Result of base scenario – Delta of electricity prices



- Difference of prices/costs below |0.01| €/MWh – same results!
- Peak: OPT has 1MW higher VRE production –> have to check
- OPT system costs can be interpreted as wholesale market prices

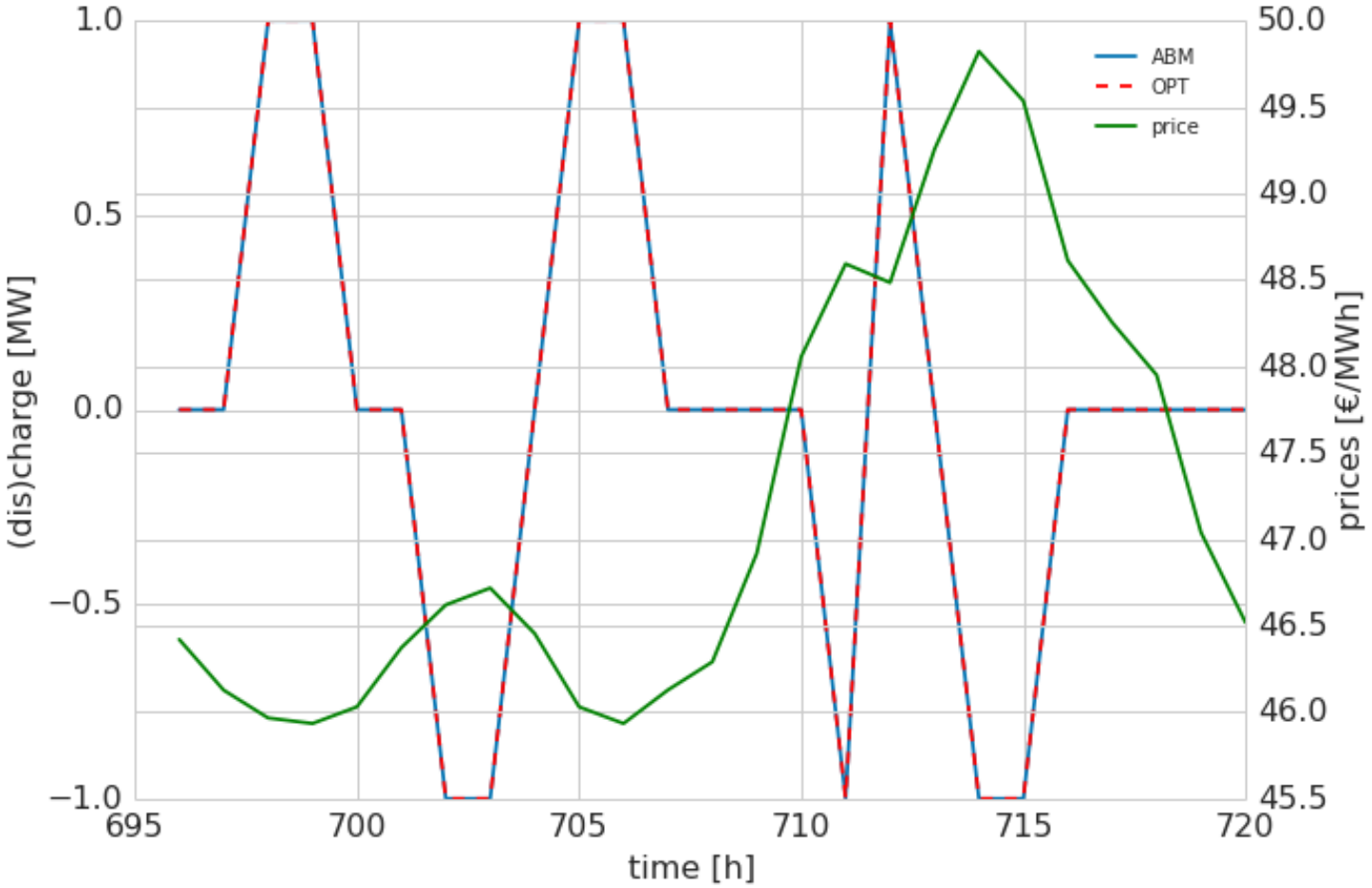
Understanding storage usage in both models

- OPT: use storage to minimize system costs
- ABM: use storage for **arbitrage**, to optimize portfolio, to reduce balancing costs
    - Charge storage at low prices
    - Discharge storage at high prices

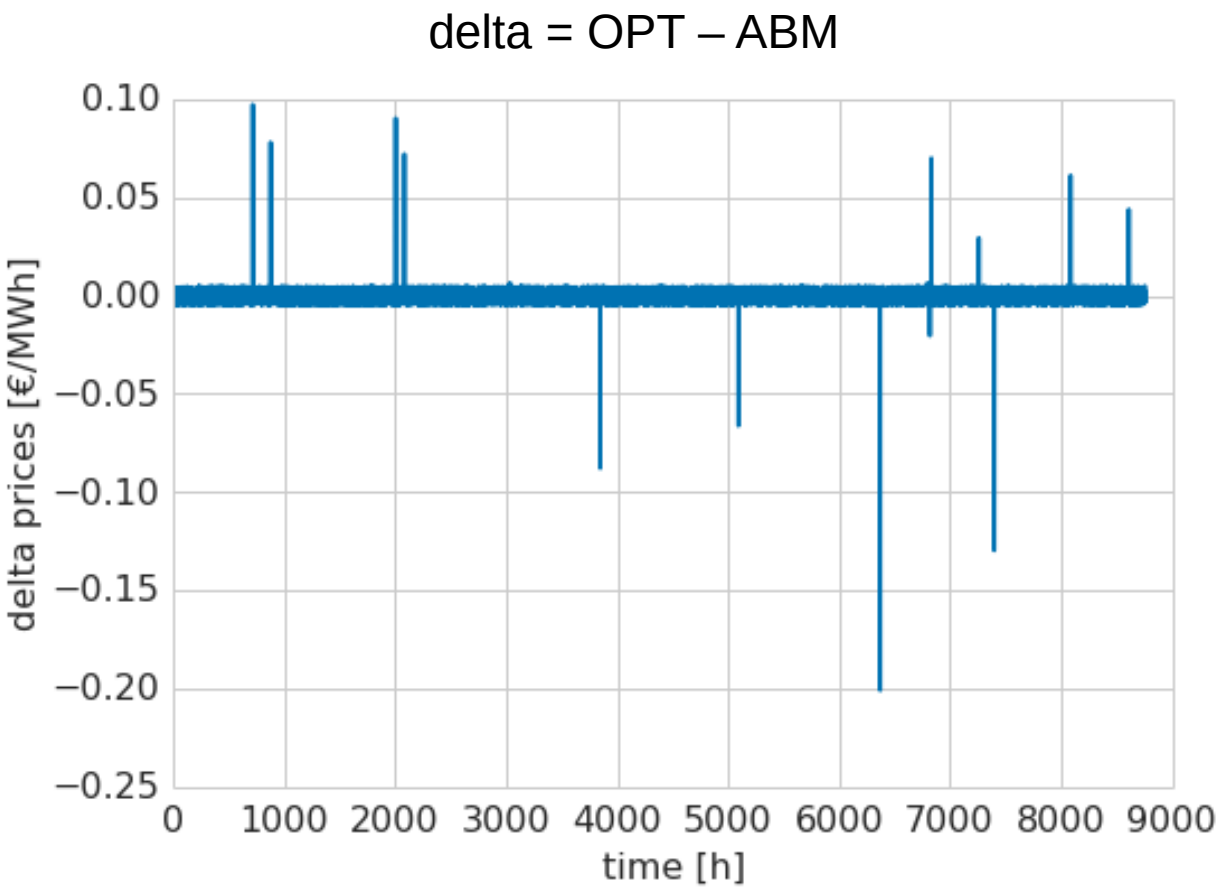
=> Expect same storage operation in case of **one small** storage and perfect forsight of agents

P [MW]	E2P [h]	Efficiency (in,out, storage)
1	2	100%

Small storage and perfect foresight



Small storage and perfect foresight delta wholesale prices

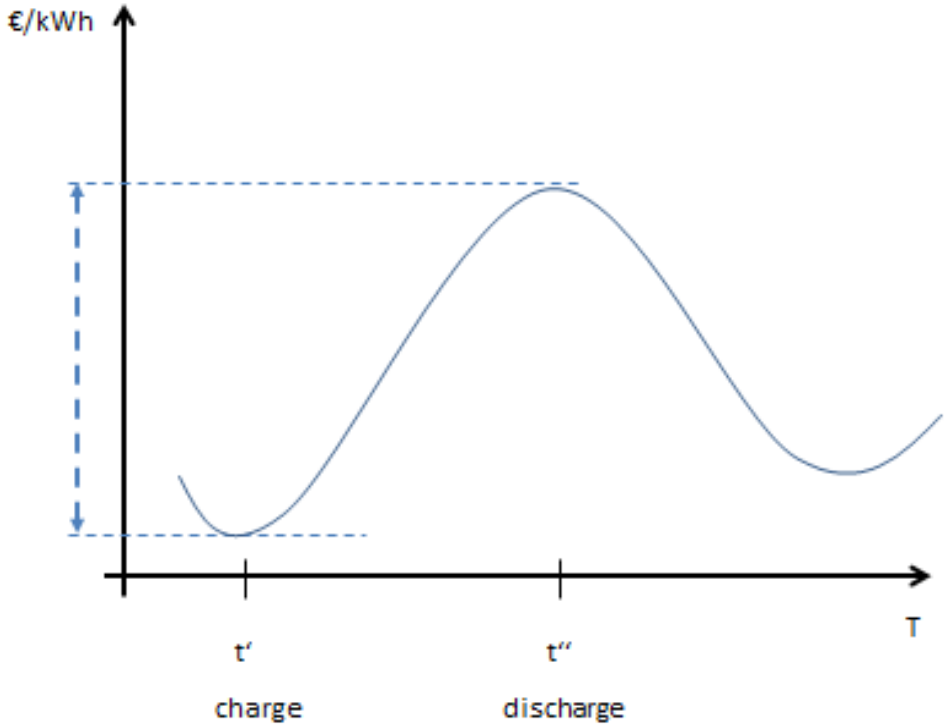


Wholesale prices at about > 30 €/MWh

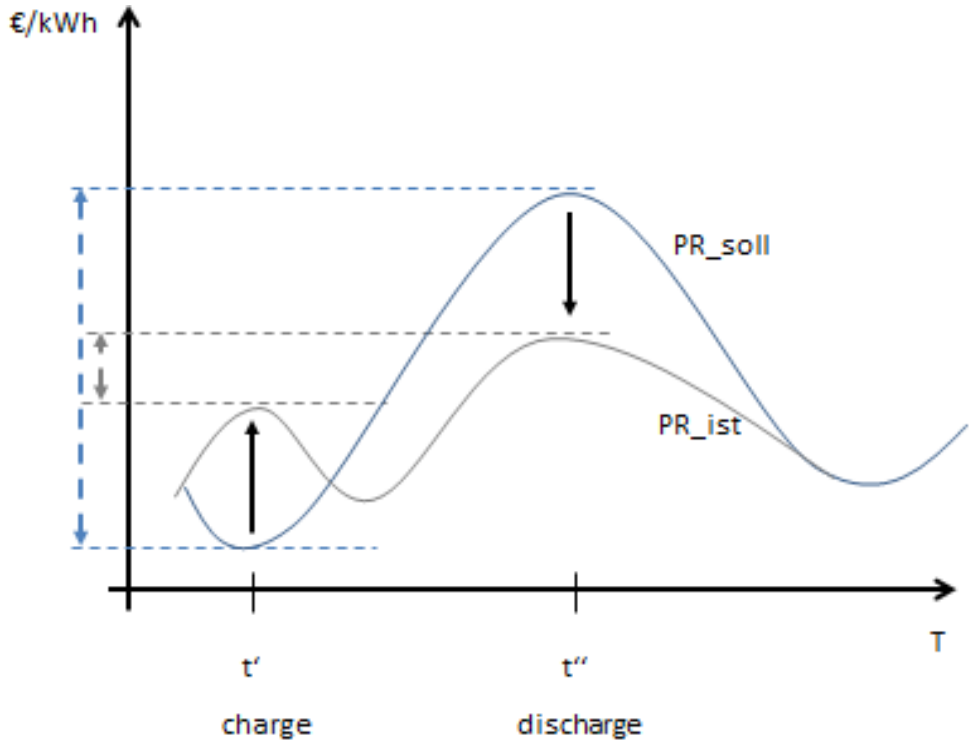
=> Minor differences that can be disregarded

(OPT storage sometimes charge with less power)

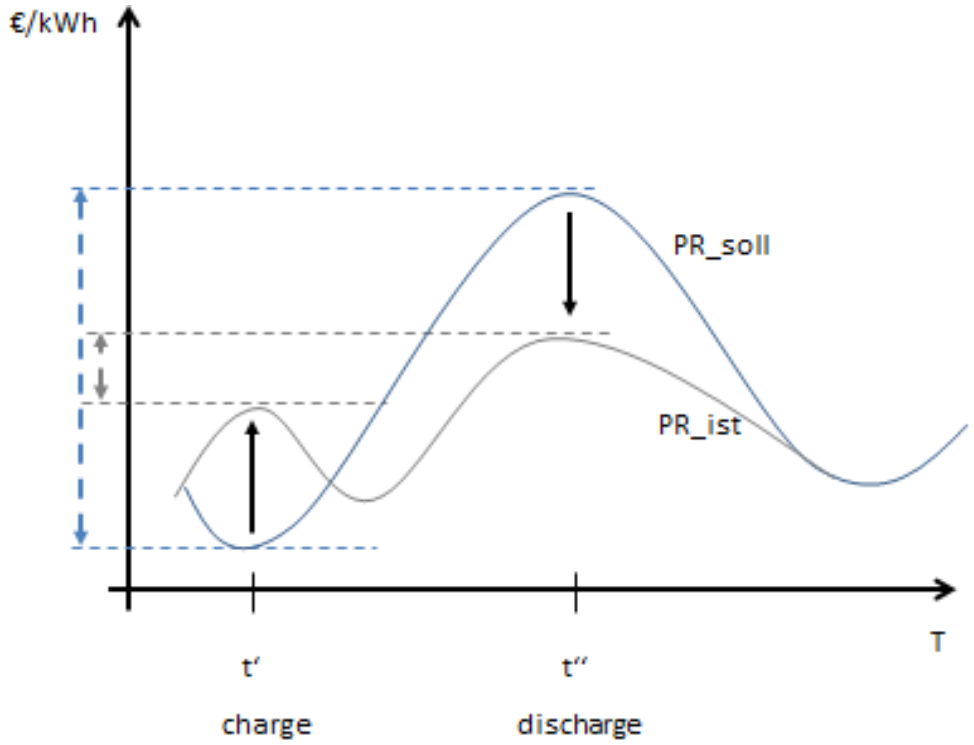
Big storage capacities for the whole electricity system



Big storage capacities for the whole electricity system



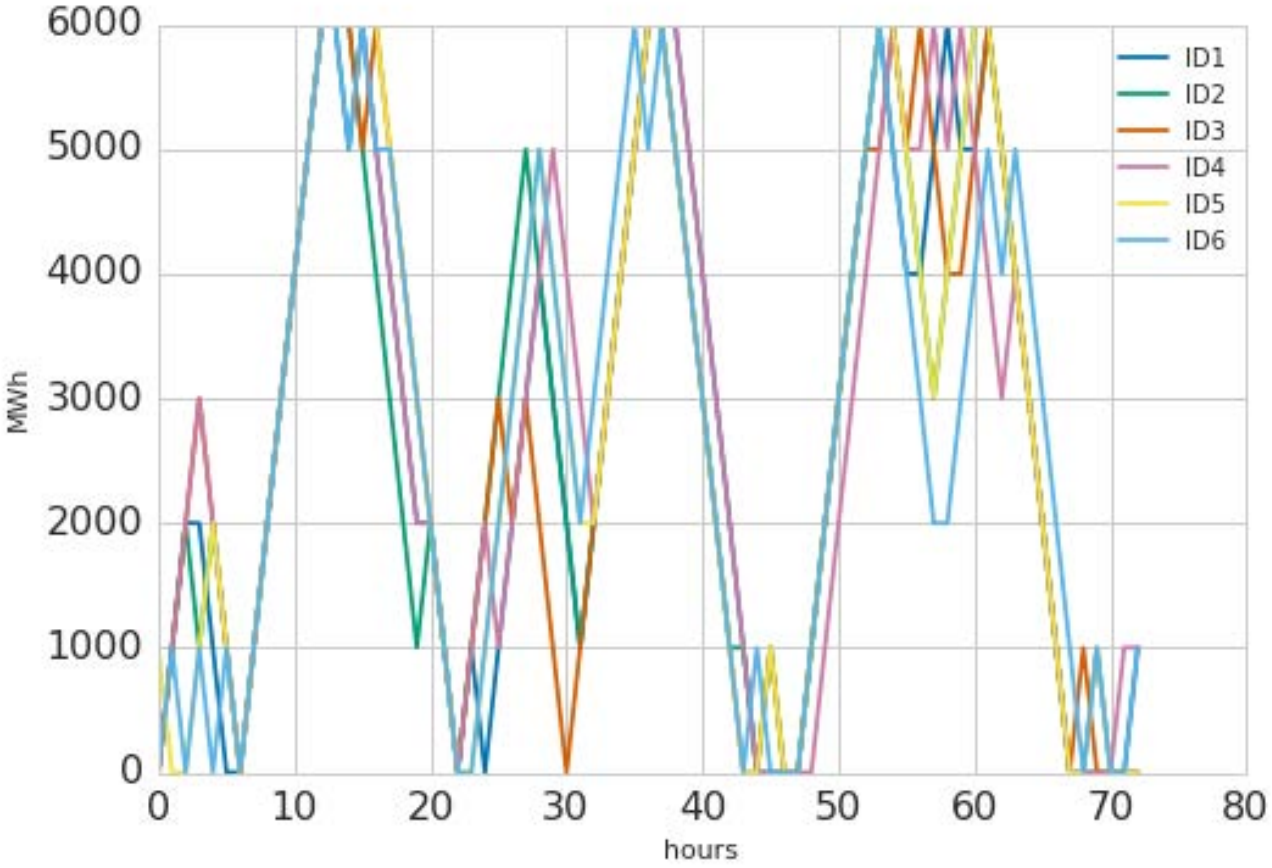
Big storage capacities for the whole electricity system



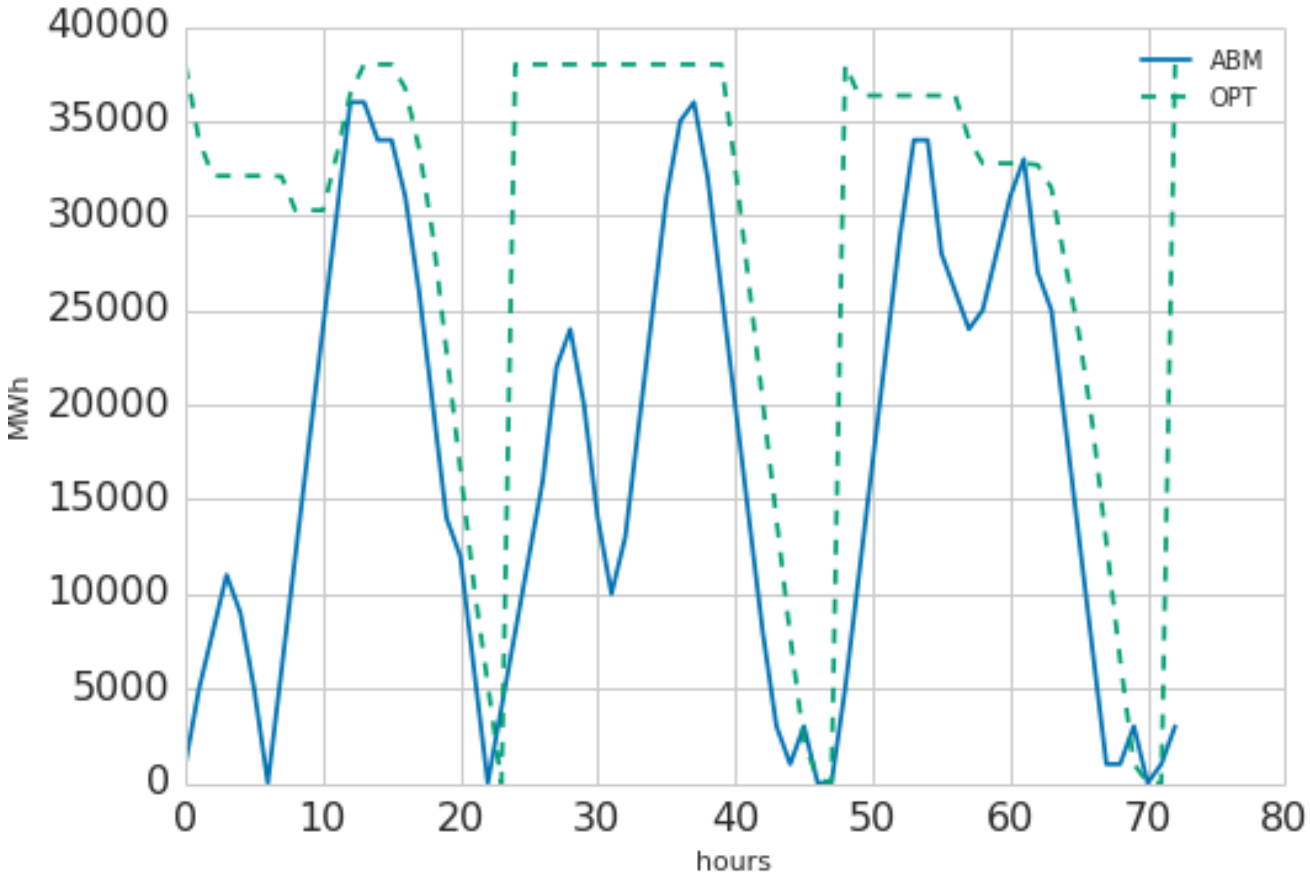
- Use different knowledge for every actor
- Game theoretic approach non cooperative
- …

=> Used „different knowlegde“ ansatz so far

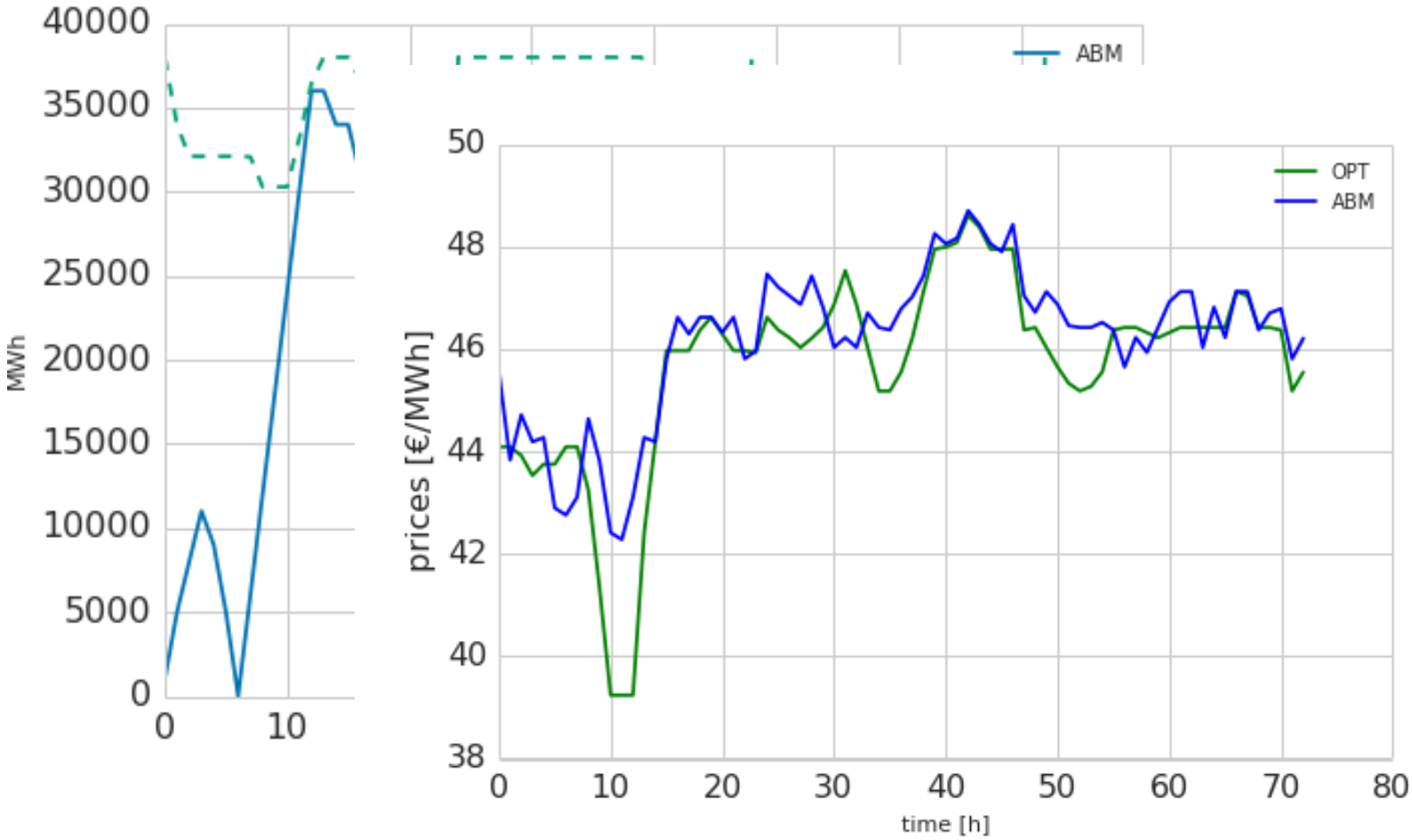
Results for big storage capacities



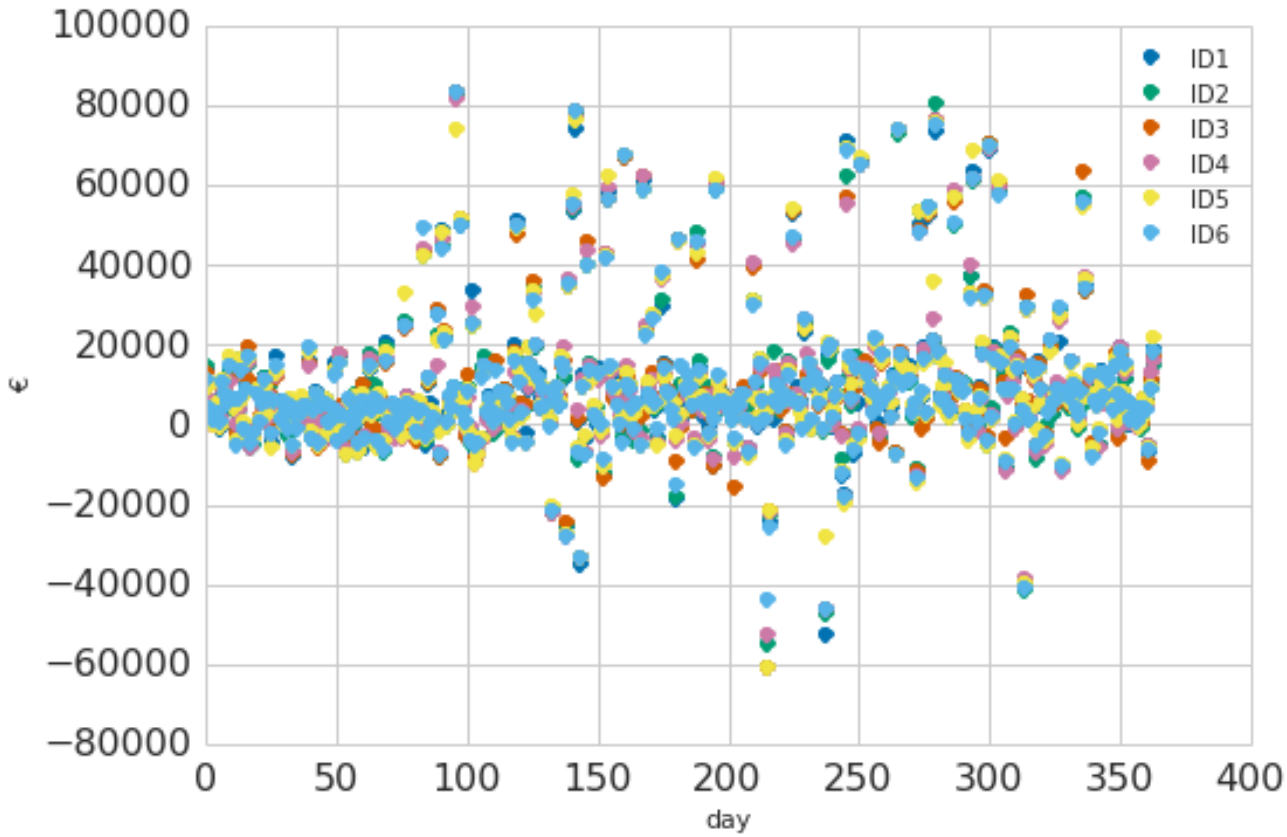
Results for big storage capacities



Results for big storage capacities



Results for big storage capacities



ID	Total income [€]
0	3434682
1	3463469
2	3537536
3	3458127
4	3609124
5	3544580

Summary/Outlook

- Integrate flexible biomass plants in the models

- Create assumption for regulatory framework: it might determine success or failure of business models for flexibility options
  - Curtailment
  - Participation on different markets
  - Use of storage (arbitrage, portfolio optimization, balance energy reduction)

- Check profitability within a scenario, if non-profitability is found:
  - regulations have to be adapted or
  - an alternative scenario has to be optimized and analysed by the ABM iteratively.

- This way, we hope to find efficient pathways for the energy transition by also considering socio-economic factors

Thank you very much!

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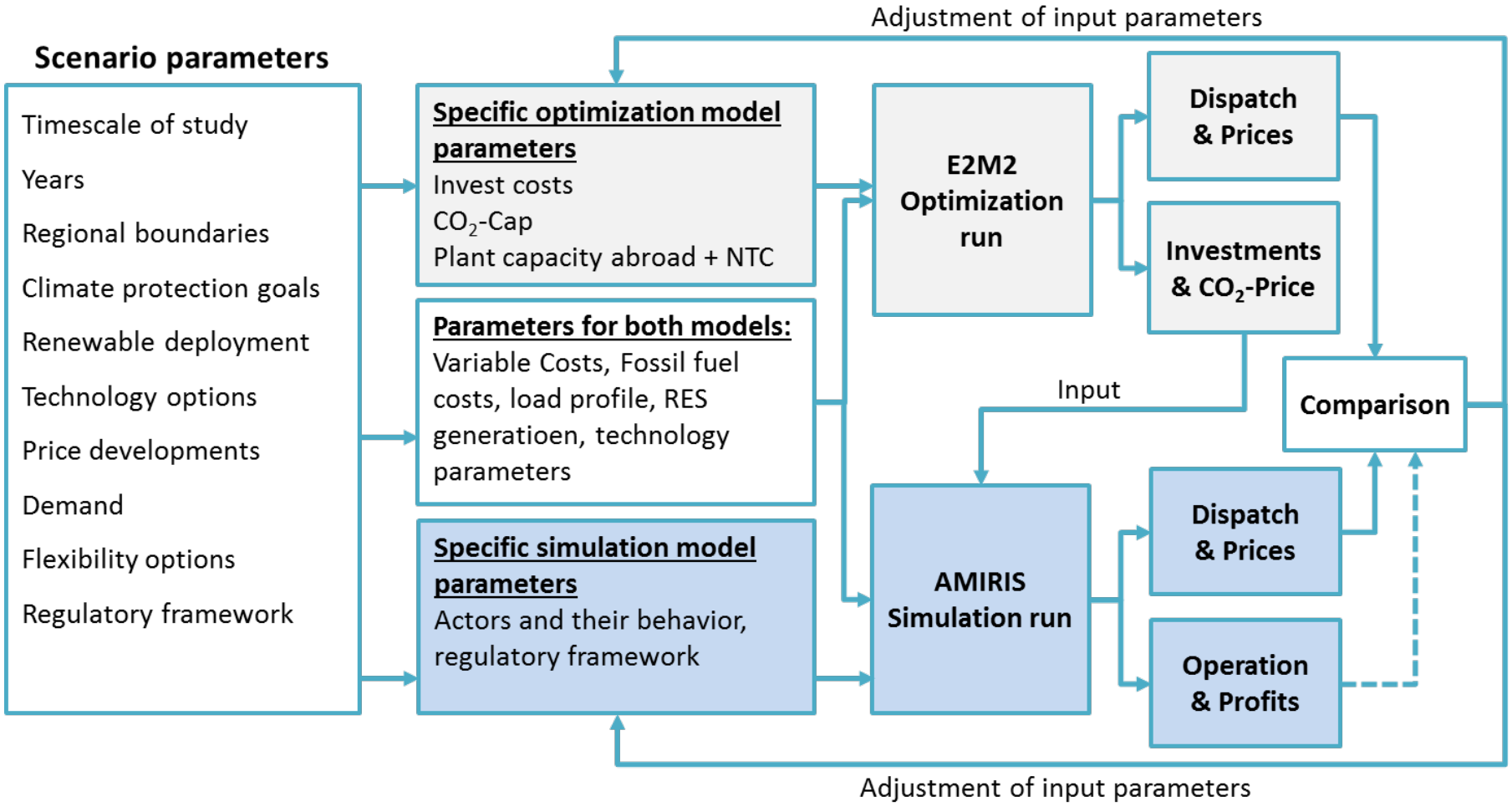
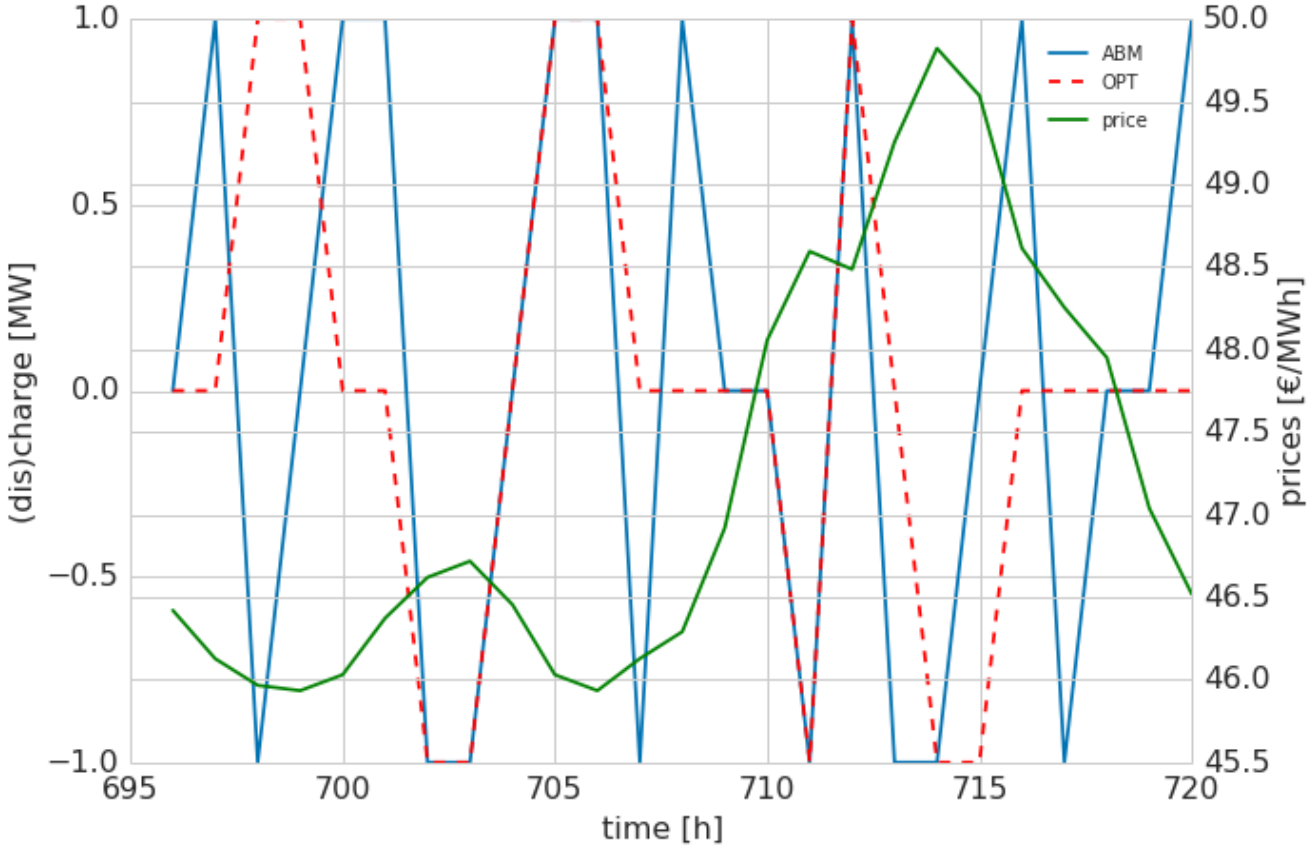
The soft coupling approach



Small storage no perfect foresight



PriceNPF = pricePF + sigma*gauss,

with sigma = 0.01

Storage not operated optimal =>less income