NEW ENERGY FOR INDUSTRY

NEFI CONFERENCE 2022

FLEXIBILITY IDENTIFICATION OF AN INDUSTRIAL PRODUCTION

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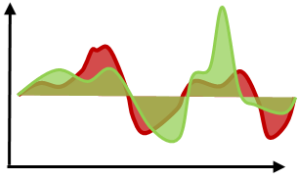
Erwin ZLABINGER, René HOFMANN

NEFI is an Energy Model Region funded by the Austrian Climate and Energy Fund

INTRODUCTION

Goal: zero CO2 generation by 2040



Volatile generation

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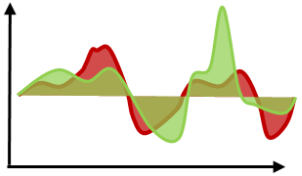
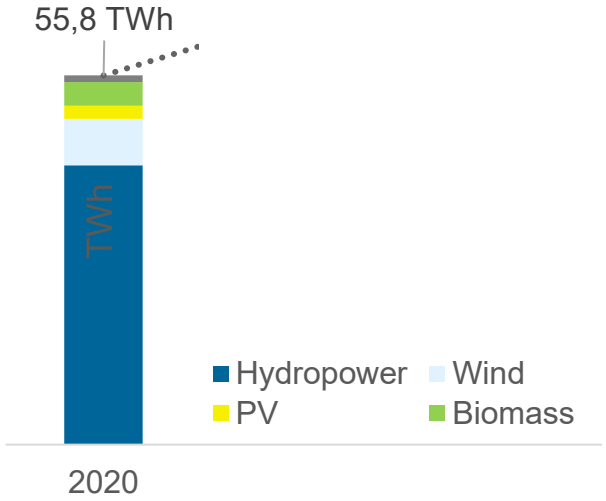
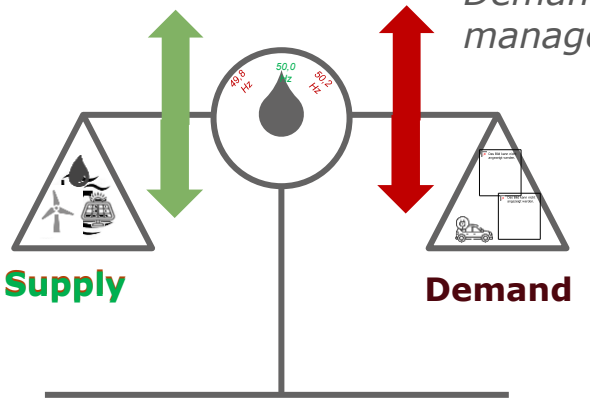


Volatile generation



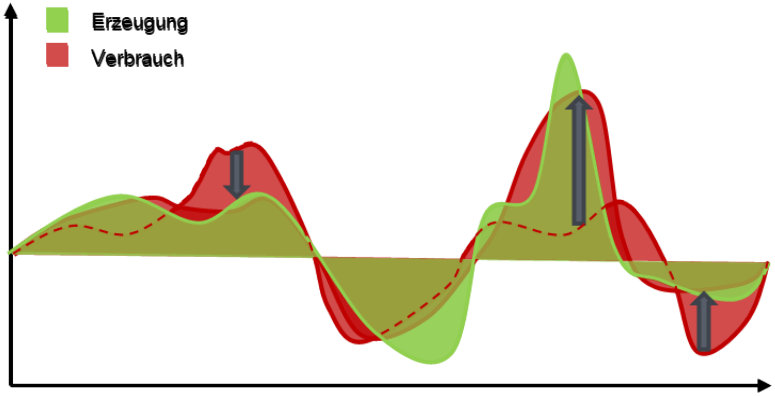
Demand side management

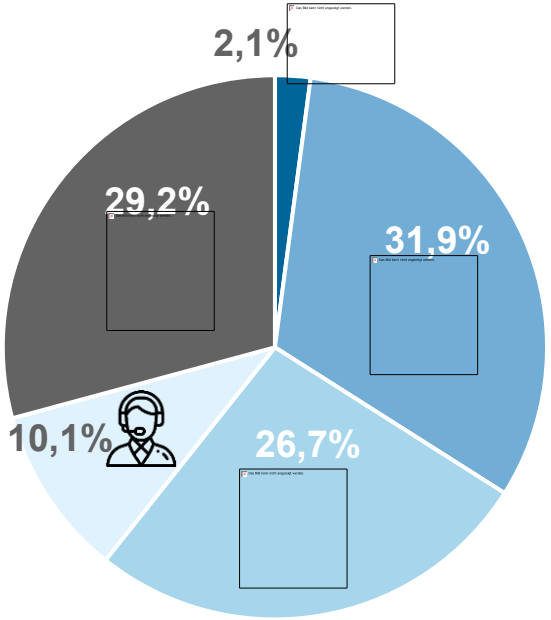


#MISSION2030: DIE ÖSTERREICHISCHE KLIMA- UND ENERGIESTRATEGIE

INTRODUCTION

Industrial Flexibility necessary for Demand Side Management

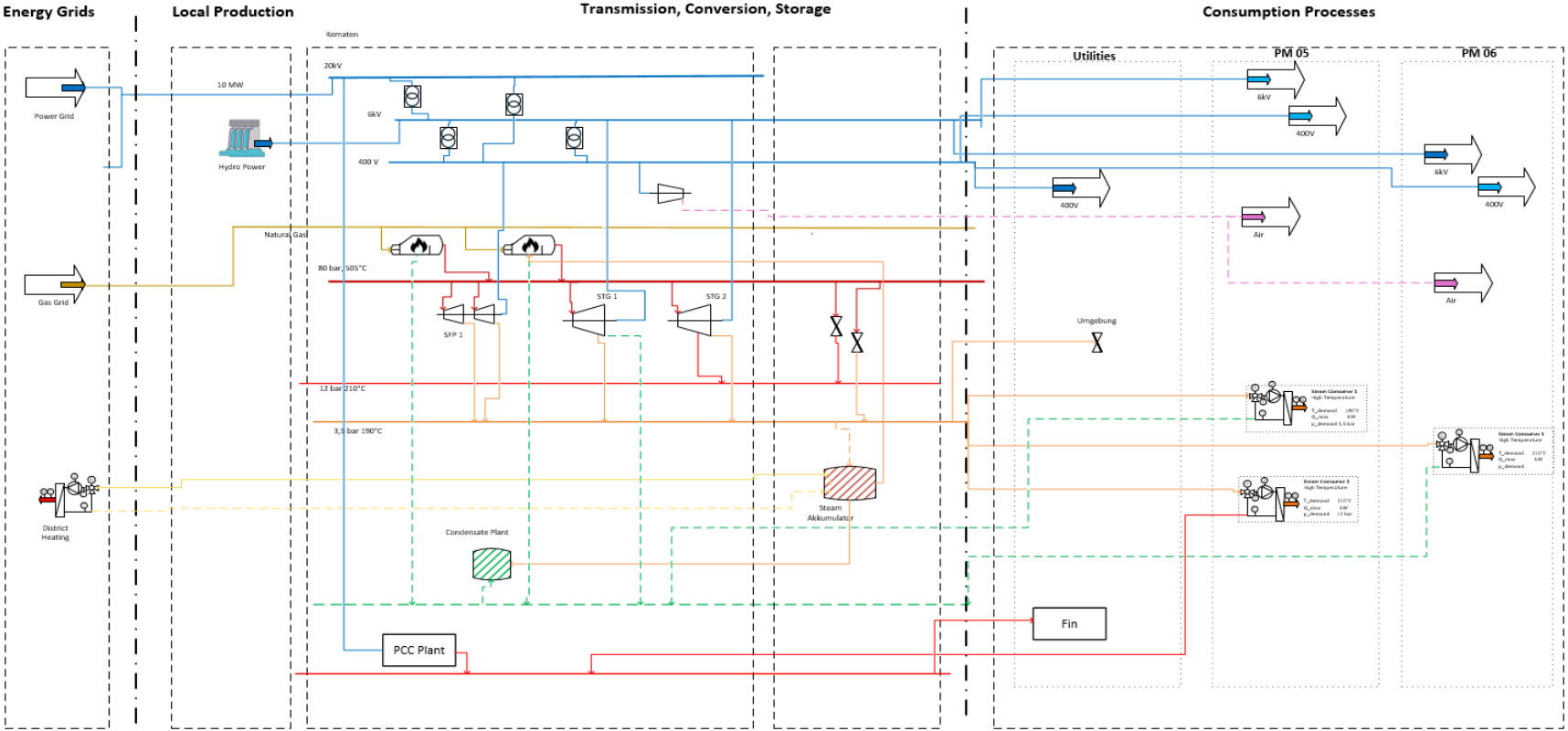




Final Energy Consumption in Austria 2020[1]

[1] ENERGIE IN ÖSTERREICH: ZAHLEN, DATEN, FAKTEN, [2] INDUSTRIES, ENERGIEINFRASTRUKTUR FÜR 100% ERNEUERBARE ENERGIE IN DER INDUSTRIE, [3] IEA

USE CASE


Energy Grids
Local Production
Transmission, Conversion, Storage
Consumption Processes
Power Grid
Gas Grid
District Heating
Hydro Power
10 MW
Kematen
20kV
6kV
400 V
Natural Gas
80 bar, 505°C
SFP 1
STG 1
STG 2
12 bar 210°C
3,5 bar 190°C
Steam Akkumulator
Condensate Plant
PCC Plant
Utilities
PM 05
PM 06
6kV
400V
Air
Umgebung
Fin

USE CASE

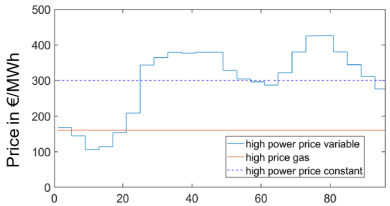
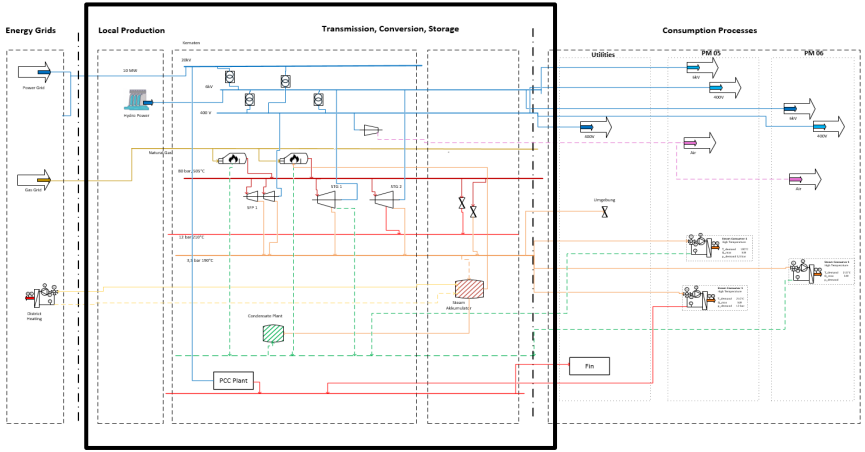
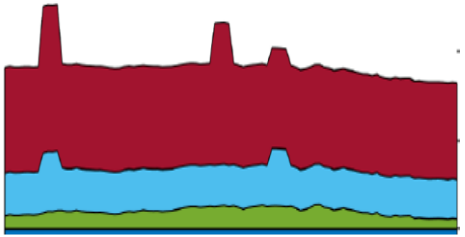


Figure 3: high price scenario energy costs





Industrial production - operational environment

- Energy demand of production
- Energy prices of grid-bound energy sources
- Indusdrial energy supply system the connection link - flexibility source

FLEXIBILITY IDENTIFICATION

Figure 3: high price scenario energy costs

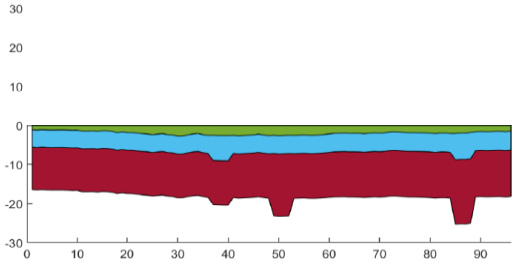
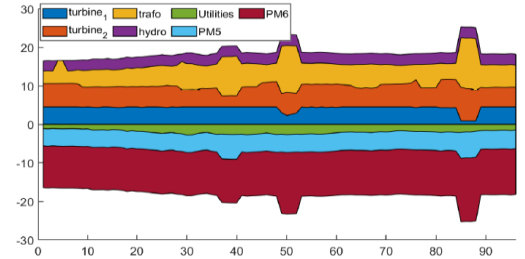


Figure 1: power supply baseline at variable electricity prices



1. Calculation of cost-optimal production (without considering flexibility) - **BASELINE**
   - Energy prices and demand profiles as boudaries
   - Solution of the corresponding UC problem
2. Identification of economic flexibilities
   - Power supply trajectory remains fixed
   - Price for flexibility provision is assumed
   - Solution of the adapted UC-problem -> available Flexibility

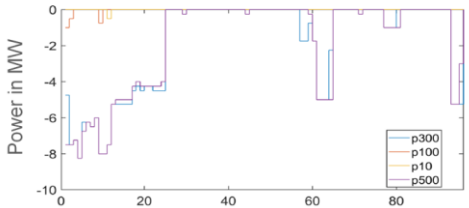
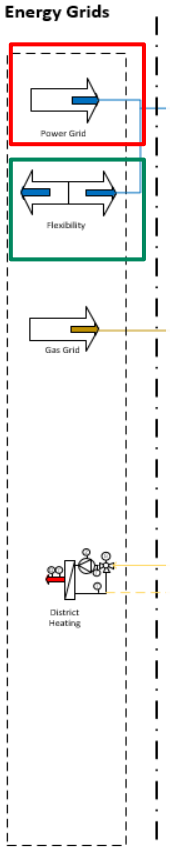


Figure 1: positive flexibility - variable low-price scenario

MATHEMATICAL FORMULATION



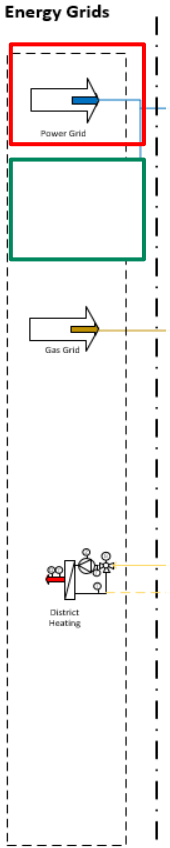
$$min \sum_{t=1}^{T} \left(p_G^t \; \boldsymbol{e_G^t} + (1-\delta) p_{EL}^t \; \boldsymbol{e_{EL}^t} - \delta \; p_{EL,Flex}^t \; \boldsymbol{e_{EL,Flex}^t} - p_{DH}^t \; \boldsymbol{e_{DH}^t} \right) \Delta t + \sum_{\boldsymbol{u}} \boldsymbol{C_{OM}^u}$$

$$\delta \; (\varepsilon - 1) \; P_{max,flex,pos} \; \Delta t \leq \boldsymbol{e_{el,flex}^t} \leq \delta \; \varepsilon \; P_{max,flex,neg} \; \Delta t$$

$$\delta \; \boldsymbol{e_{EL}^t} = \; \delta \; e_{EL,baseline}^t$$

Abbreviations				*Indices*	
p	*price in €/MWh*	t	*time*	G	*Gas purchase*
$\boldsymbol{e}$	*energy in MWh/h*	*pos*	*positive*	*EL*	*Electricity purchase*
P_{max}	*maximum capacity in MW*	*neg*	*negative*	*DH*	*district Heating feed-in*
Δt	*time step in h*	*flex*	*flexibility*	*OM*	*Operation & Maintenance*
$\boldsymbol{C}$	*costs*	*u*	*units*	*baseline*	

MATHEMATICAL FORMULATION



1.STEP: Baseline Calculation $(\delta = 0)$

$$min \sum_{t=1}^{T} \left(p_G^t \; \boldsymbol{e_G^t} + (1-\delta) p_{EL}^t \; \boldsymbol{e_{EL}^t} - p_{DH}^t \; \boldsymbol{e_{DH}^t} \right) \Delta t + \sum_{\boldsymbol{u}} \boldsymbol{C_{OM}^u}$$

$$0 \; \leq \boldsymbol{e_{el,flex}^t} \leq \; 0$$

Abbreviations				Indices	
p	price in €/MWh	t	time	G	Gas purchase
$\boldsymbol{e}$	energy in MWh/h	*pos*	positive	*EL*	Electricity purchase
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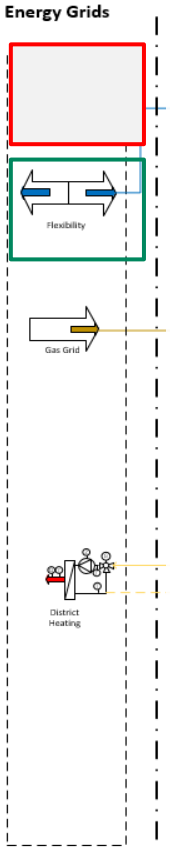


2.STEP: pos. Flexibility Calculation $(\delta = 1,\ \varepsilon = 0)$

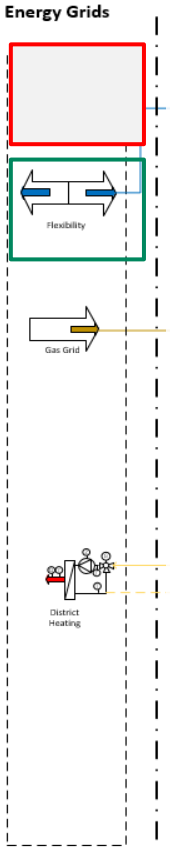
$$min \sum_{t=1}^{T} \left(p_G^t \ \boldsymbol{e_G^t} \right) - \delta \ p_{EL,Flex}^t \ \boldsymbol{e_{EL,Flex}^t} - p_{DH}^t \ \boldsymbol{e_{DH}^t} \Delta t + \sum_{\boldsymbol{u}} \boldsymbol{C_{OM}^u}$$

$$\delta \ (\varepsilon - 1) \ P_{max,flex,pos} \ \Delta t \leq \boldsymbol{e_{el,flex}^t} \leq \ 0$$

$$\delta \ \boldsymbol{e_{EL}^t} = \ \delta \ e_{EL,baseline}^t$$

Abbreviations				*Indices*	
p	*price in €/MWh*	t	*time*	G	*Gas purchase*
$\boldsymbol{e}$	*energy in MWh/h*	*pos*	*positive*	*EL*	*Electricity purchase*
P_{max}	*maximum capacity in MW*	*neg*	*negative*	*DH*	*district Heating feed-in*
Δt	*time step in h*	*flex*	*flexibility*	*OM*	*Operation & Maintenance*
$\boldsymbol{C}$	*costs*	*u*	*units*	*baseline*	

MATHEMATICAL FORMULATION



2.STEP: neg. Flexibility Calculation $(\delta = 1,\ \varepsilon = 1)$

$$min \sum_{t=1}^{T} (p_G^t \ \boldsymbol{e_G^t} \quad - \delta \ p_{EL,Flex}^t \ \boldsymbol{e_{EL,Flex}^t} - p_{DH}^t \ \boldsymbol{e_{DH}^t}) \Delta t + \sum_{\boldsymbol{u}} \boldsymbol{C_{OM}^u}$$

$$0 \ \leq \boldsymbol{e_{el,flex}^t} \leq \delta \ \varepsilon \ P_{max,flex,neg} \ \Delta t$$

$$\delta \ \boldsymbol{e_{EL}^t} = \ \delta \ e_{EL,baseline}^t$$

Abbreviations				Indices	
p	price in €/MWh	t	time	G	Gas purchase
$\boldsymbol{e}$	energy in MWh/h	pos	positive	EL	Electricity purchase
P_{max}	maximum capacity in MW	neg	negative	DH	district Heating feed-in
Δt	time step in h	$flex$	flexibility	OM	Operation & Maintenance
$\boldsymbol{C}$	costs	u	units	$baseline$	

RESULTS - BASELINE

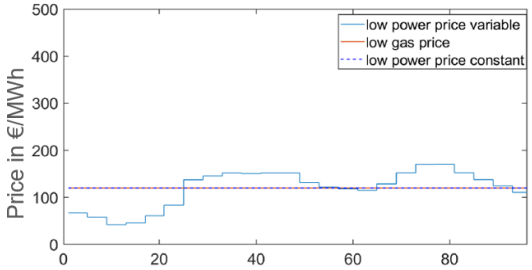


Figure 2: low price scenario energy costs

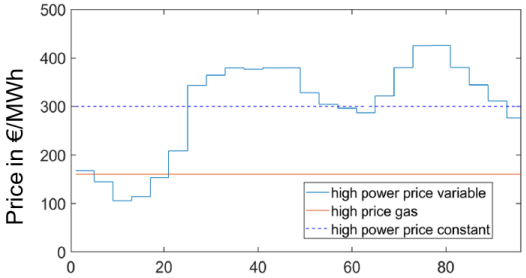


Figure 3: high price scenario energy costs

- Price profile has a significant influence on the energy purchase profile

RESULTS – FELIBILITY POTENTIAL

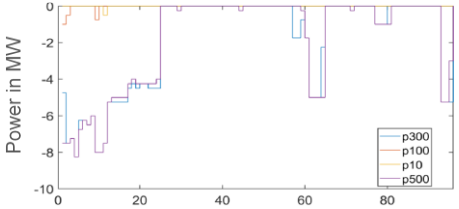


Figure 1: positive flexibility - variable low-price scenario

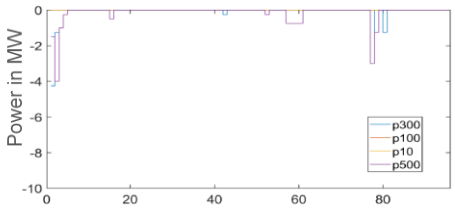


Figure 2: positive flexibility - constant low-price scenario

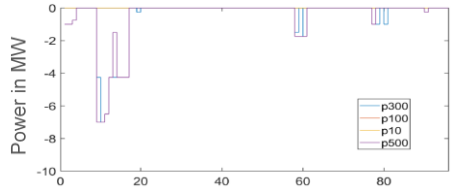


Figure 3: positive flexibility – variable high-price scenario

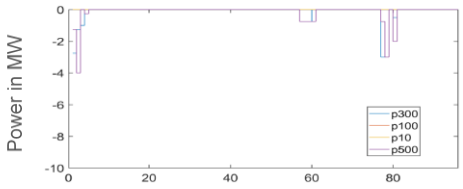
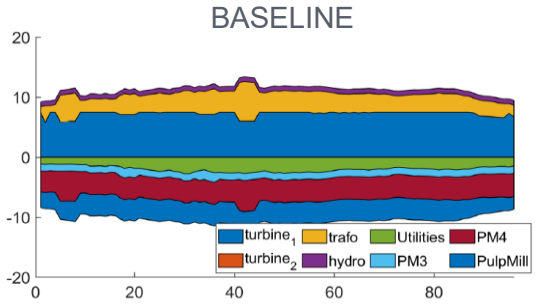


Figure 4: positive flexibility – constant high-price scenario

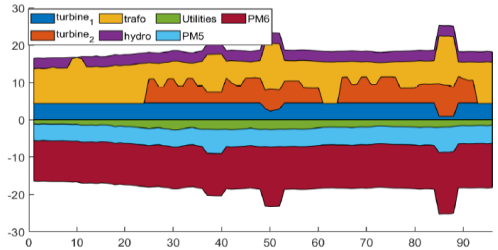
- Limited potential for provision of positive flexibility (heat driven energy production), high costs
- Significantly higher potential for provision of negative flexibility was identified
- Considerable negative flexibility (>5MW) May be offered at negative prices (due to reduction of gas incurred for self generation)
- Very efficient utilization of flexibility
- Base price profile also affects (economic) flexibility

RESULTS – PLANT OPERATION

SITE 1



SITE 2



- Positive flexibility is rather provided at site 2, negative at both
- Some units are identidified as „must-run“ - due to generation capacity limits

CONCLUSION & OUTLOOK

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- Identification of flexibility is affected by various parameters –> necessitates advanced methods
- Baseline price profile affects (economic) flexibilities
- Significantly higher potential for provision of negative flexibility
  – heat driven production rather an electricity consumer
- Considerable negative flexibility (>5MW) may be offered at negative prices – very beneficial utilization

- The **identified flexibilities must not be misunderstood as actual revenues**
- It is rather a possible potential to be marketed at flexibility and energy service markets
- Problem: Different timeframes, gate closure times and stochastic effects

➢ Development of a sufficient sophisticated bidding strategy is the actual ongoing research work

ACKNOWLEDGEMENT

This work was supported by the project ”Industry4Redispatch”, which is part of the energy model region NEFI - New Energy for Industry and is funded by the Austrian Climate and Energy Fund [FFG, No.887780]. We particularly thank our industrial partner Mondi Neusiedler, who enabled the analysis of the pulp and paper production plants, provided the sufficient data and supported with operational information.

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