Flexible power and synthesis plant concepts with integrated chemical power storage

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Structure

- **Project HotVeGas**
- **Future challenges for conventional power plants**
- **Power-to-Gas Technology**
- **Analysis of IGCC-EPI concept**
- **Conclusion**

Research Project Overview HotVeGas II – Future high temperature gasification and gas cleaning processes

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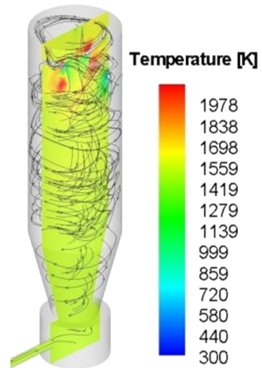
Gasification Kinetics

- Kinetics at high temperature (1800° C) and high pressure (50 bar)
- Development of reaction models for heterogeneous char gasification

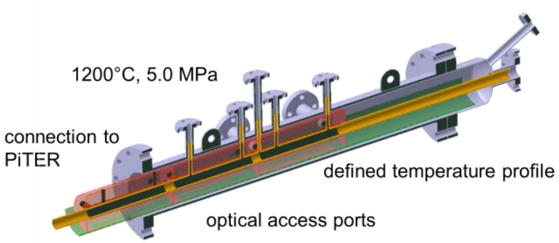


CFD - Modeling

- Design of pyrolysis and gasification models
- Particle tracking and slag flow modeling
- Modeling of condensation of trace elements

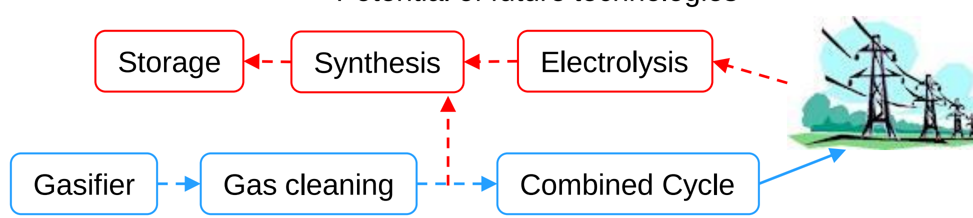
Cooling Behavior of Trace Elements

- Condensation behaviour of trace elements
- Deposition of trace elements on probes



Overall Process Evaluation

- Flexible IGCC-concepts with polygeneration and excess energy storage
- Biomass co-gasification
- Potential of future technologies



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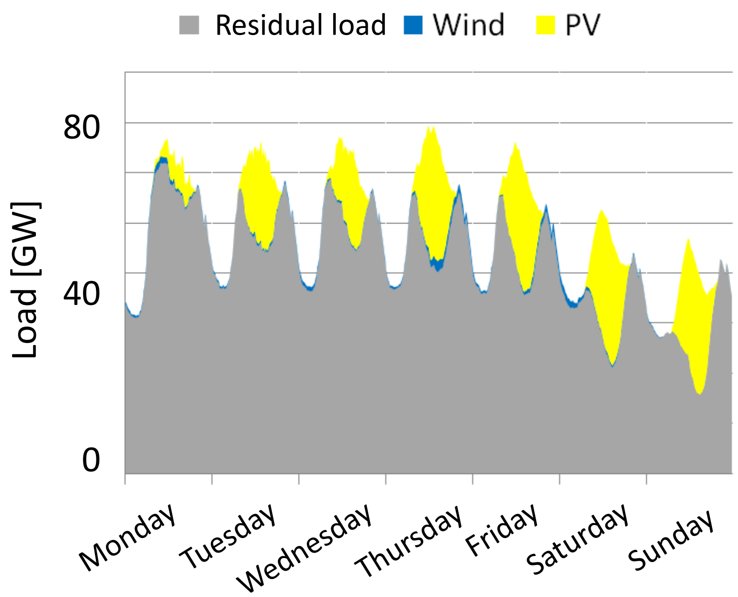
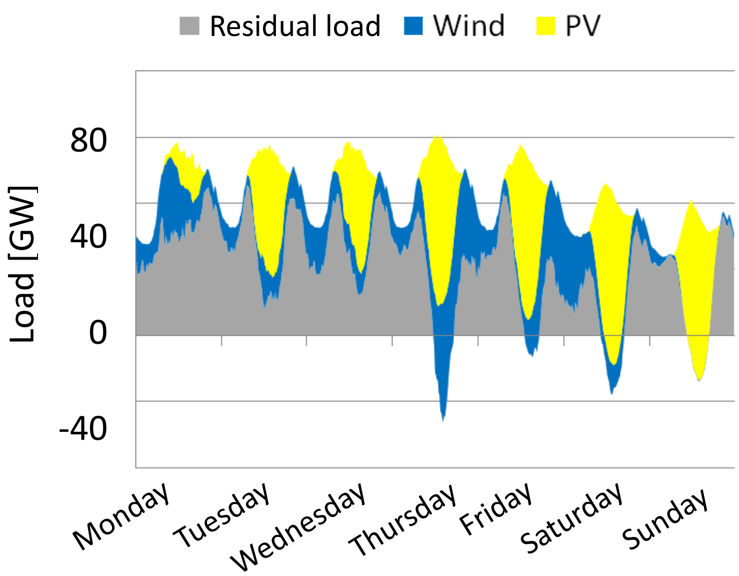
Future development of energy system in Germany

2012



23% RE

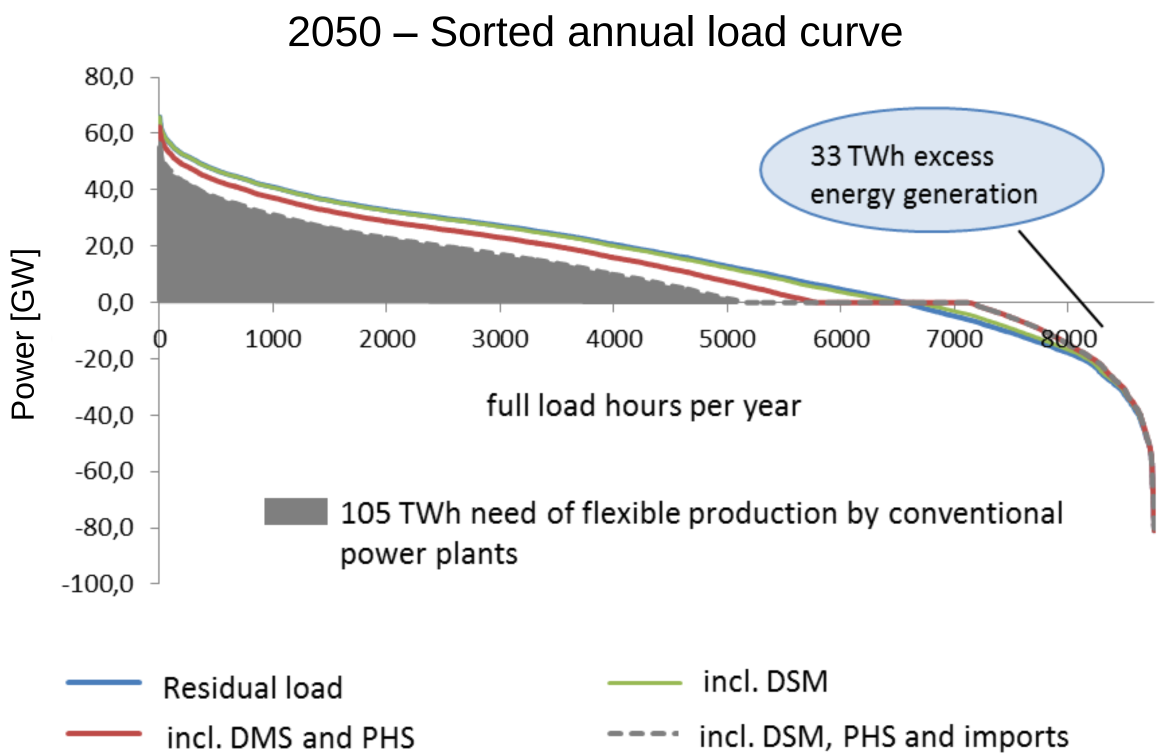
2050



80% RE

(Energy policy goal of the German government)

Future challenges for conventional power plants



Challenges:

→ Decreased utilization
→ Increased flexibility requirement
→ Excess energy storage

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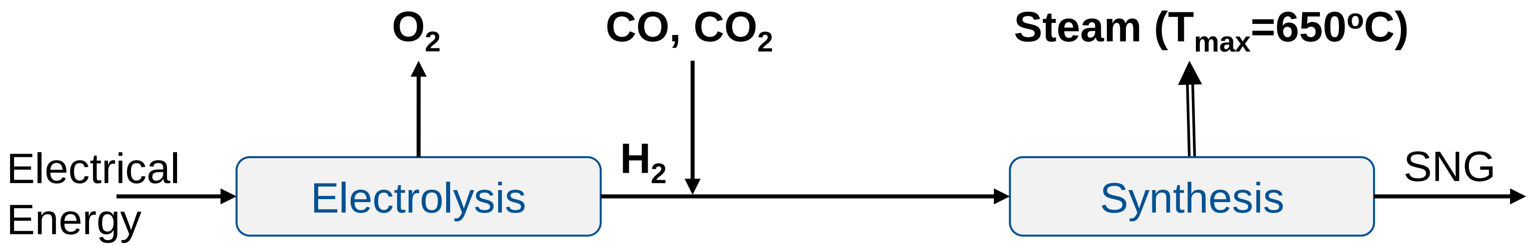
Power to gas technology



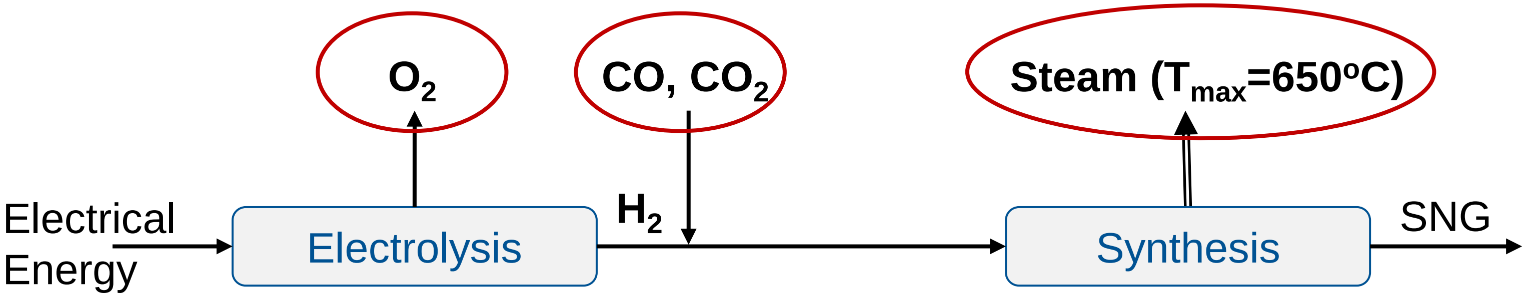
Advantages

+ High energy density
+ Full use of the existing NG infractructure
+ Reconversion with state of the art technology possible

Disadvantages

- High costs
- Low power-to-power efficiency

Motivation for system integration concepts



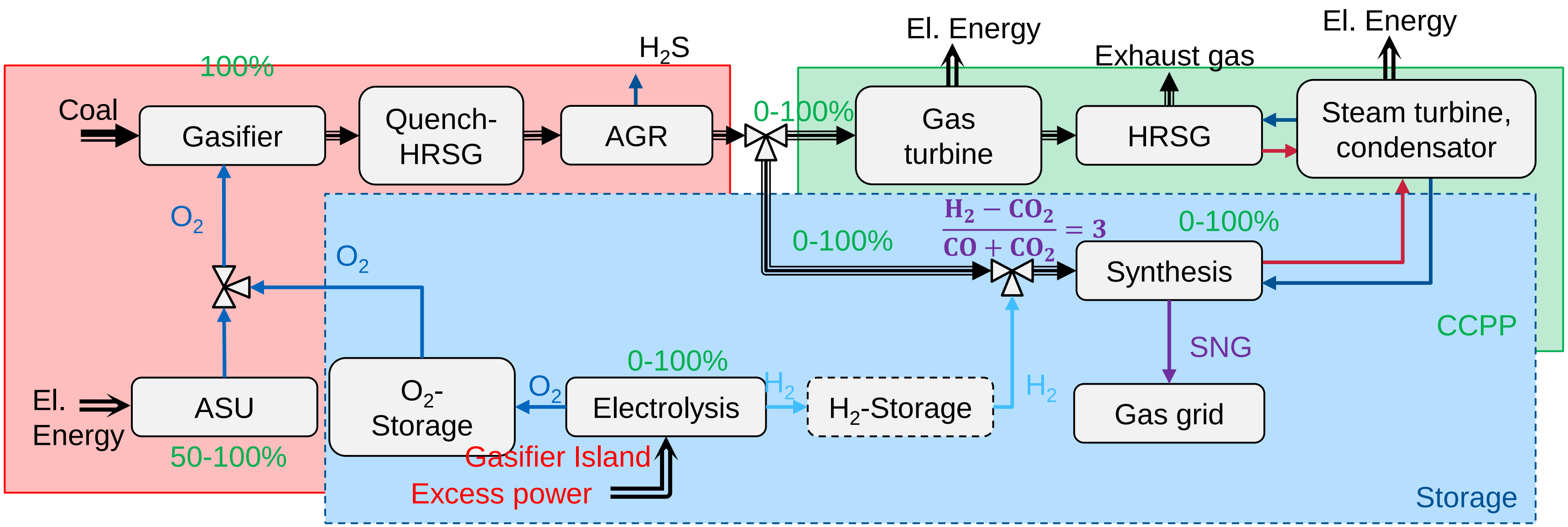
Overall efficiency of P2G:

$$\eta_{Power \rightarrow Power} = \underbrace{0{,}7}_{\eta_{Electrolysis}} \times \underbrace{0{,}95}_{\eta_{CO2}} \times \underbrace{0{,}8}_{\eta_{SNG}} \times \underbrace{0{,}6}_{\eta_{CC}} = \mathbf{32\ \%}$$

Possibilities for efficiency enhancement:

- Use of the byproduct O_2 of the electrolysis
- Integration of the CO/CO_2 source
- Use of the heat of the exothermal synthesis
- CHP plant for reconversion of the SNG

IGCC-EPI (Excess Power Integration) concept



Features:

- \+ High **positive and negative flexibility** at baseload operation of the gasifier island
- \+ **No CO-Shift reactor and CO_2 sequestration** for adjustment of synthesis gas composition → conversion losses and investment costs can be avoided
- \+ **Integration of O_2** from electrolysis for gasification
- \+ **Integration of the heat** of the synthesis plant in the CCPP

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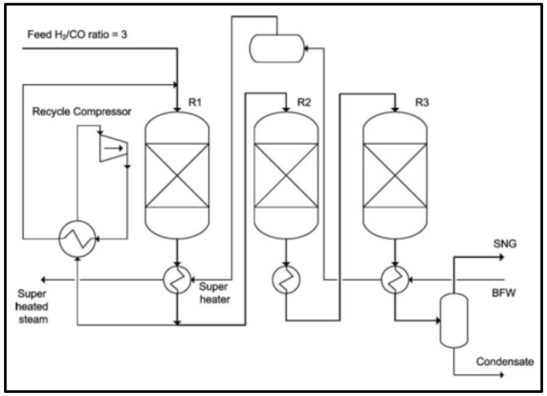
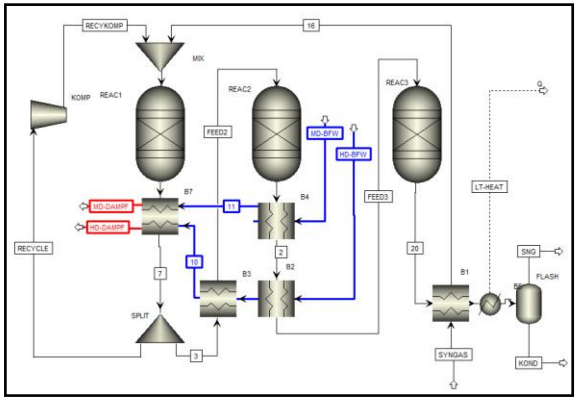
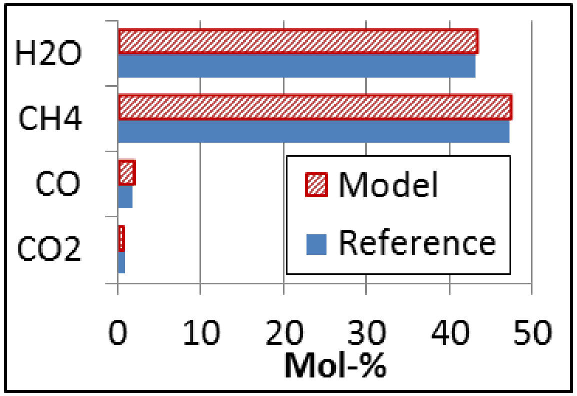
Methodology – Overall System Evaluation





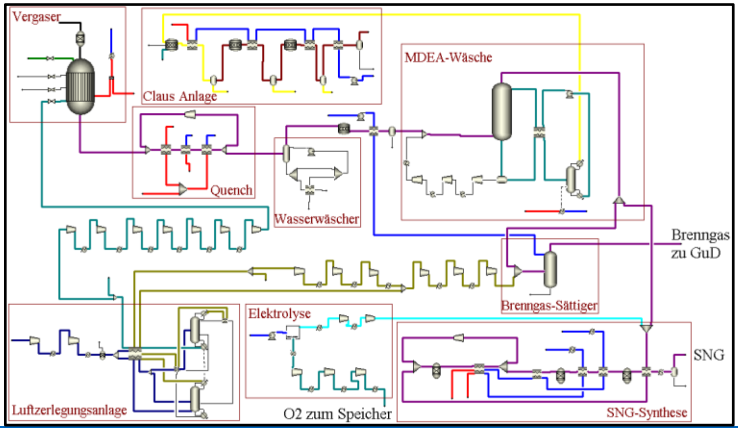


Reference: Industrial data from a 20 MW TREMP process

Literature-research

- Process schemes
- Process parameters
- Limitations

→ **Modeling of sub systems** → **Verfication of Subsystems**



Overall system → **Analysis** → **Optimization**

- Energetic
- Exergetic
- Economic

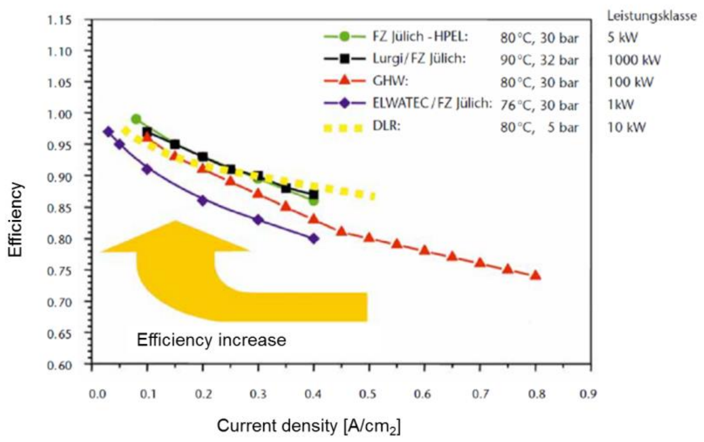
Main boundary conditions of the simulation of a 125 MW_{th} concept

Storage properties:

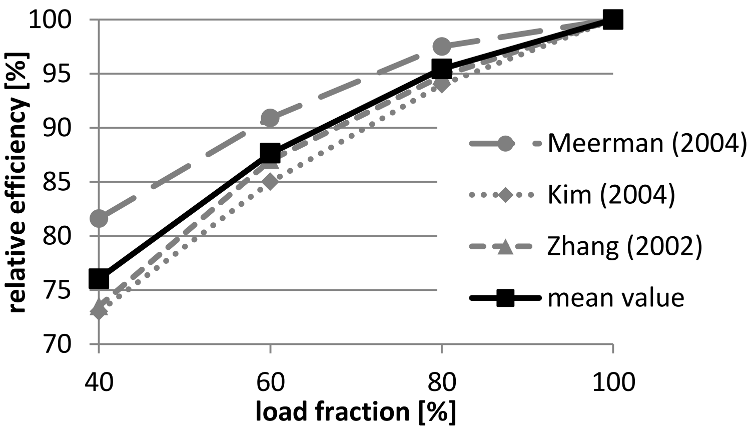
SNG feed in pressure:	p_{SNG}=60 bar
Mean O2 storage pressure:	p_{O2}=75 bar
Specific energy consumption of the electrolyzer:	$E_{S,Elektrolyse}$=4,4 kWh/Nm³ (400 mA/cm²)

Part load behavior:

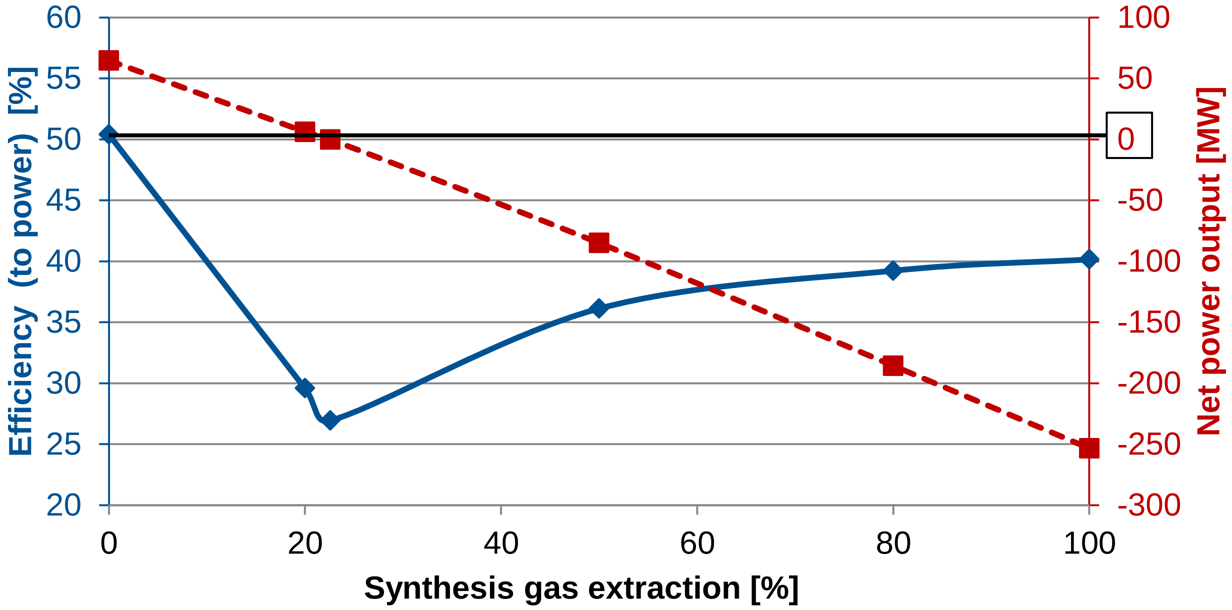
Electrolysis



Gas turbine



Overall system part-load efficiency (including reconversion of storage medias to power)

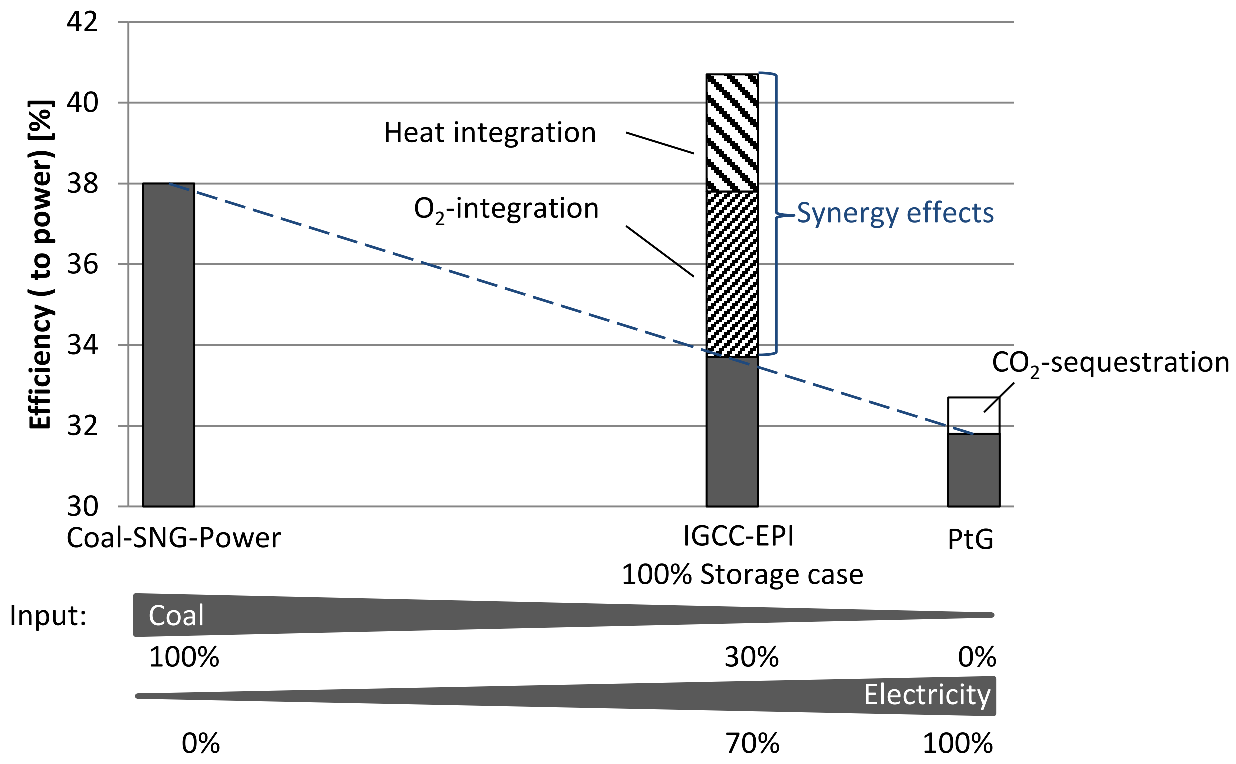


Efficiency definition:

$$\eta_{Power/coal \rightarrow power} = \frac{\overbrace{\dot{m}_{SNG} \cdot H_{u,SNG} \cdot \eta_{GUD}}^{P_{el}(SNG)} + \overbrace{\dot{m}_{O_2}\left(LZA_{Aq} + w_{s,V}\right)}^{P_{el}(O_2)} + P_{Netto}(P_{Netto} > 0)}{\underbrace{\dot{m}_{SK} \cdot H_{u,SK}}_{Q_b(SK)} - P_{Netto}(P_{Netto} < 0)}$$

$$\eta_{GUD} = 60\%; \;\; LZAaq = 0,27 \; kWh/kg$$

Impact of synergies on overall storage efficiency



→ Synergy effects result in an overall efficiency advantage of 6.4% points

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Conclusion

- Increased flexibility requirements for future conventional power plants
- High excess power potential and need for long-term energy storages
- Combination of power-to-gas and gasification technology results in:
  - Superior opertation range of conventional power plant
  - High overall storage efficiency due to synergy effects

Thank you for your kind attention.

Questions???