Storage of Bio-Energy - Substitute Natural Gas (SNG) as Contribution to Future Energy Systems

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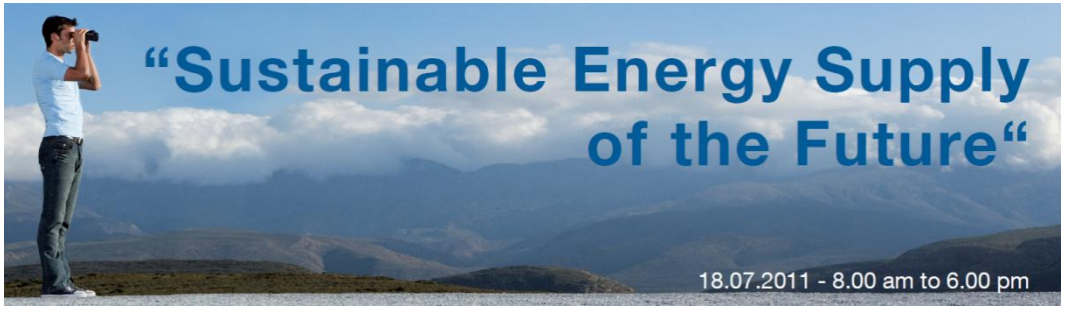

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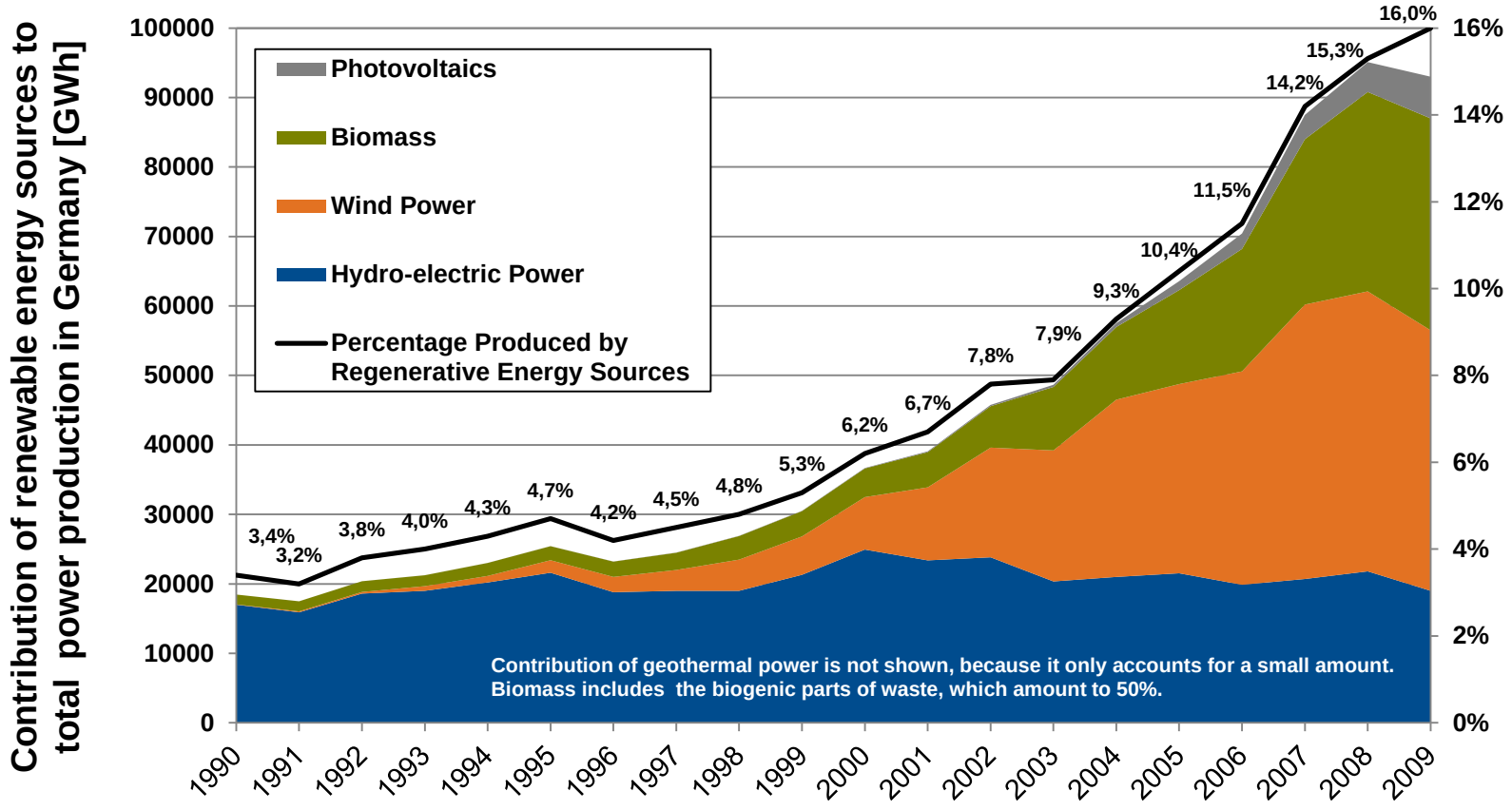
Status quo

- At the moment, more than 80% of global energy still comes from fossil fuels (oil, natural gas and coal)
- The share of renewable energy sources in Germany's (and the world's) energy mix grows steadily
- Power generation from renewable energy sources - especially wind and solar - is fluctuating over a wide range (seasonal as well as in the course of some hours)
- Energy storage becomes an increasingly important issue in order to reliably provide energy to the households and industry
- The ultimate energies heat, electrical power and fuel have to be available without limitations and crisis-proof

 Sustainable supply of energy from renewable sources for everyone, but in a reliable, efficient, safe and economic way

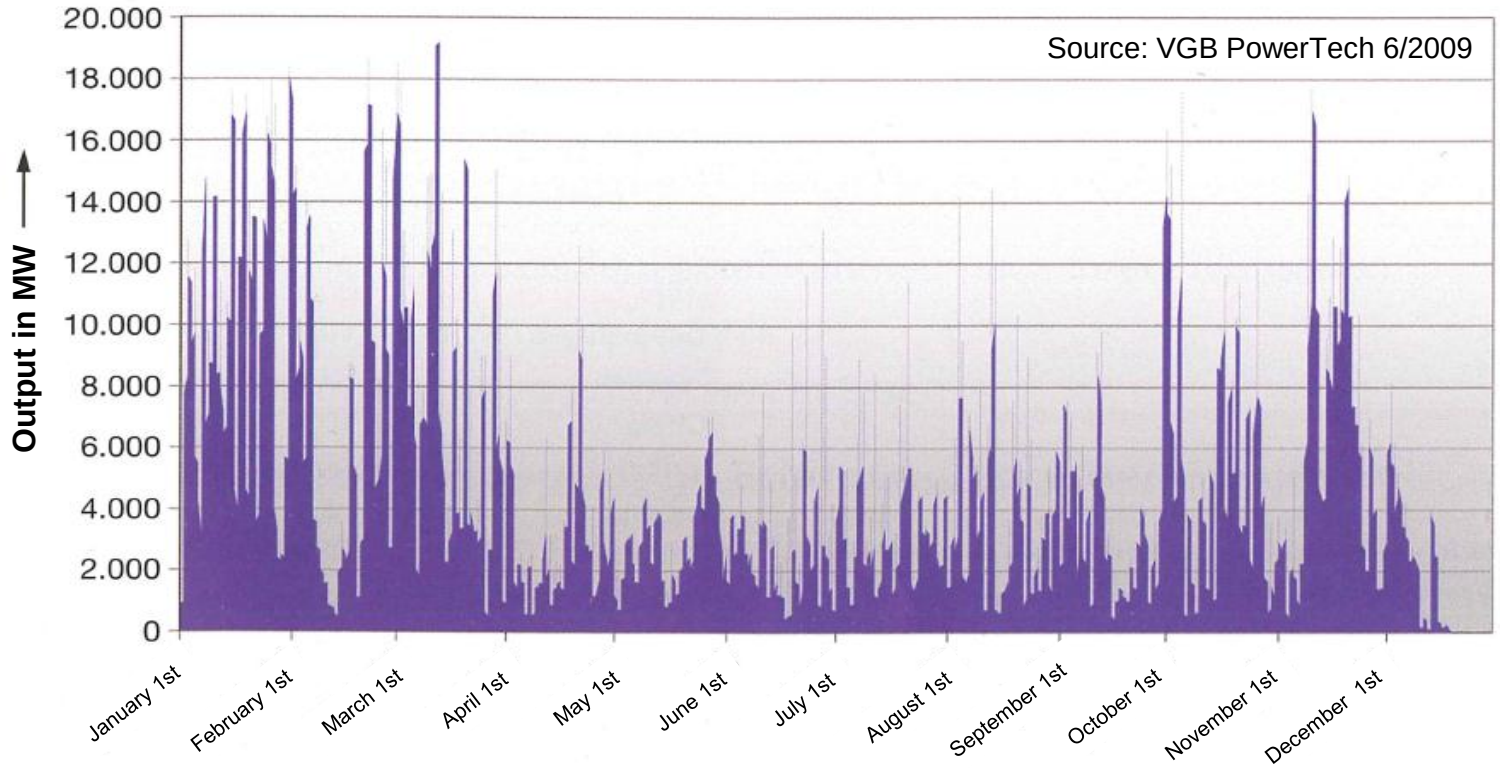
Contribution of renewable energy sources



Target value until 2020: 30% renewable energy sources

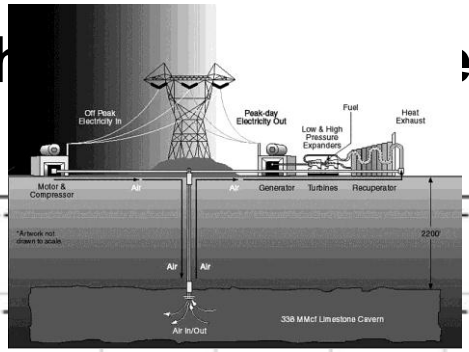
Source: Bundesministerium für Umwelt, Bundesverband für erneuerbare Energien, Arbeitsgemeinschaft Energiebilanzen

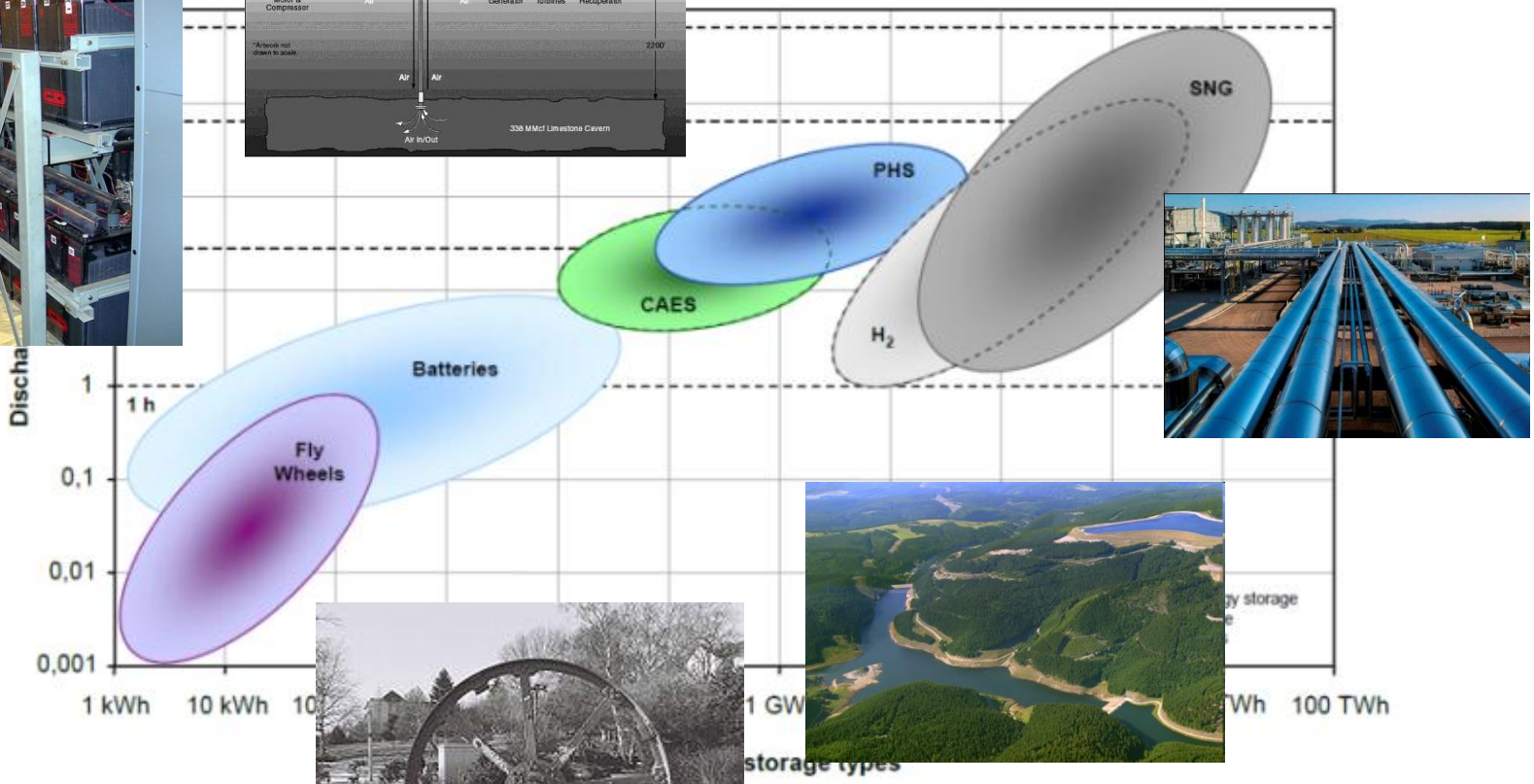
Wind output Germany (2008)



- Installed capacity: 23 GW
- Load: approx. 15 – 20 % (2008: approx. 1700 full load hours, 2009: approx. 1500 full load hours)
- Secured output: approx. 10 %

Storability - Th el of renewable energies





eicherung von Bioenergie und erneuerbarem Strom im Erdgasnetz, FVEE • AEE Themen 2009

Concepts for SNG production – potential/possibilities

- Biogas-to-SNG
- BioSyngas-to-SNG (via thermochemical conversion)
- Wind-to-SNG (via electrolysis)
- Combinations of the concepts

Concepts for SNG production – potential/possibilities

- Biogas-to-SNG

Possible efficiency:	60 - 75 %
Potential in Germany:	72,2 TWh/a*

Wet biomass (corn, (energy) crops, manure, agricultural waste)

- Anaerobic fermentation
  - Biogas (50-70% CH_4 + 30-50% CO_2 + H_2O and impurities)
    - (Optional: Methanation of remaining CO_2
      - $CO_2 + 4H_{2,add} \rightarrow CH_4 + 2\ H_2O$)
    - Upgrading of raw-gas to grid quality
      - CO_2 and H_2O separation (PSA, scrubber,…)
      - Cleaning of impurities like H_2S, N_2, O_2 etc.
        - **SNG**

State of the art, commercial plants in operation all over Europe

Concepts for SNG production – potential/possibilities

- Dry biomass (wood chips, forestry residues, waste, …)
  - BioSyngas-to-SNG*
    - Gasification

*Research project at LES

- BioSyngas (depending on gasification type: mainly CO_2, CO, H_2, CH_4, N_2 + H_2O plus impurities, particles, ash, tars etc.)
- Gas cleaning (particle removal, tar removal/ conversion, S/Cl-components removal)
- (Optional: CO_2 separation)
- Methanation of Syngas
- $CO + 3H_2 \rightarrow CH_4 + H_2O$ ΔH_R = - 206 kJ/mol
- $CO_2 + 4H_2 \rightarrow CH_4 + 2\ H_2O$ ΔH_R = - 165 kJ/mol

Concepts for SNG production – potential/possibilities

- BioSyngas-to-SNG

Possible efficiency:	89 %
Potential in Germany:	238,1 TWh/a*

- Methanation of Syngas
  - $CO + 3H_2 \rightarrow CH_4 + H_2O$ $\Delta H_R = -206$ kJ/mol
  - $CO_2 + 4H_2 \rightarrow CH_4 + 2\,H_2O$ $\Delta H_R = -165$ kJ/mol
    - Raw-SNG
    - Conditioning of raw-gas to grid quality
      - Separation of water
      - Separation remaining CO_2 (e.g. by liquid scrubbing, PSA, …)
      - Pressurization and fine adjustment to grid quality
        - **SNG**

- Pilot plant stage (“Güssing”, ECN/Netherlands, GoBiGas/Schweden)

Concepts for SNG production – potential/possibilities

Possible efficiency:	> 60 %
Potential in Germany:	?? TWh/a

- Wind-to-SNG
  - Electrolysis of water with surplus wind power in high-wind times
    - Hydrogen ($H_2O \rightarrow H_2 + O_2$)
      - Methanation of CO_2 with $H_{2,\ from\ Electrolysis}$
        - **$CO_2 + 4H_{2,\ el} \rightarrow CH_4 + 2\ H_2O$**
          - Separation of water

            (depending on the source of CO_2: additional cleaning/upgrading steps)
            - **SNG**

- New concept under development, first test plants in trial

Concepts for SNG production – potential/possibilities

e.g. Biogas/Wind-to-SNG

Wet biomass

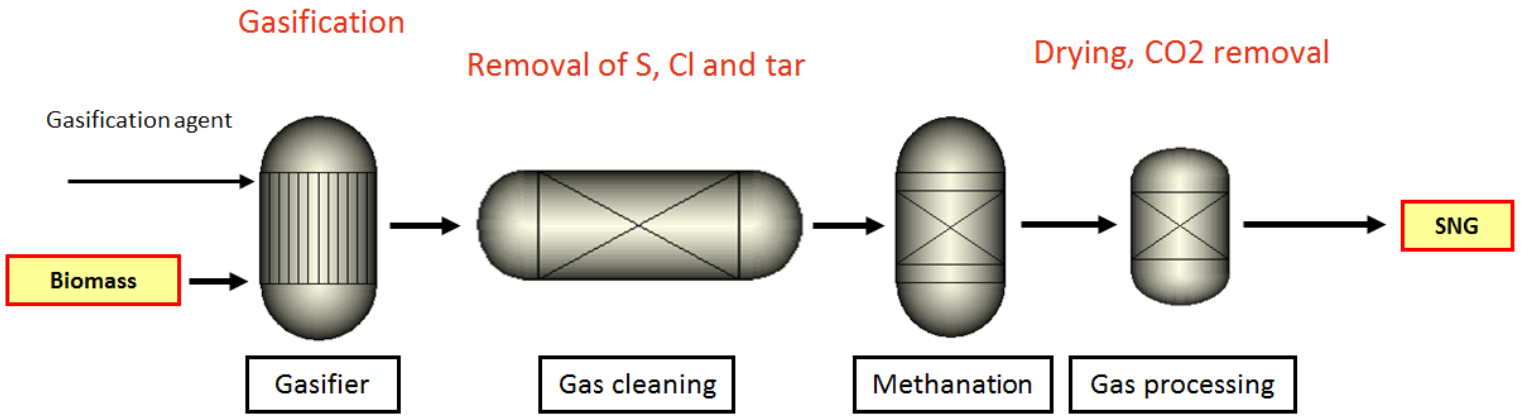
- Anaerobic fermentation
  - Biogas (50-70% CH_4 + 30-50% CO_2 + H_2O and impurities)
    - CO_2 separation (rest bypass to upgrading unit)

Electrolysis of water with surplus wind power (+ temp. H_2 storage)

- $H_2O \rightarrow H_2 + O_2$

- Combinations of the concepts
  - Methanation of $CO_{2,\ from\ biogas}$ with $H_{2,\ from\ electrolysis}$
    - **$CO_{2,\ biogas} + 4H_{2,\ el} \rightarrow CH_4 + 2\ H_2O$**
      - Upgrading of raw-gas to grid quality
        - **SNG**

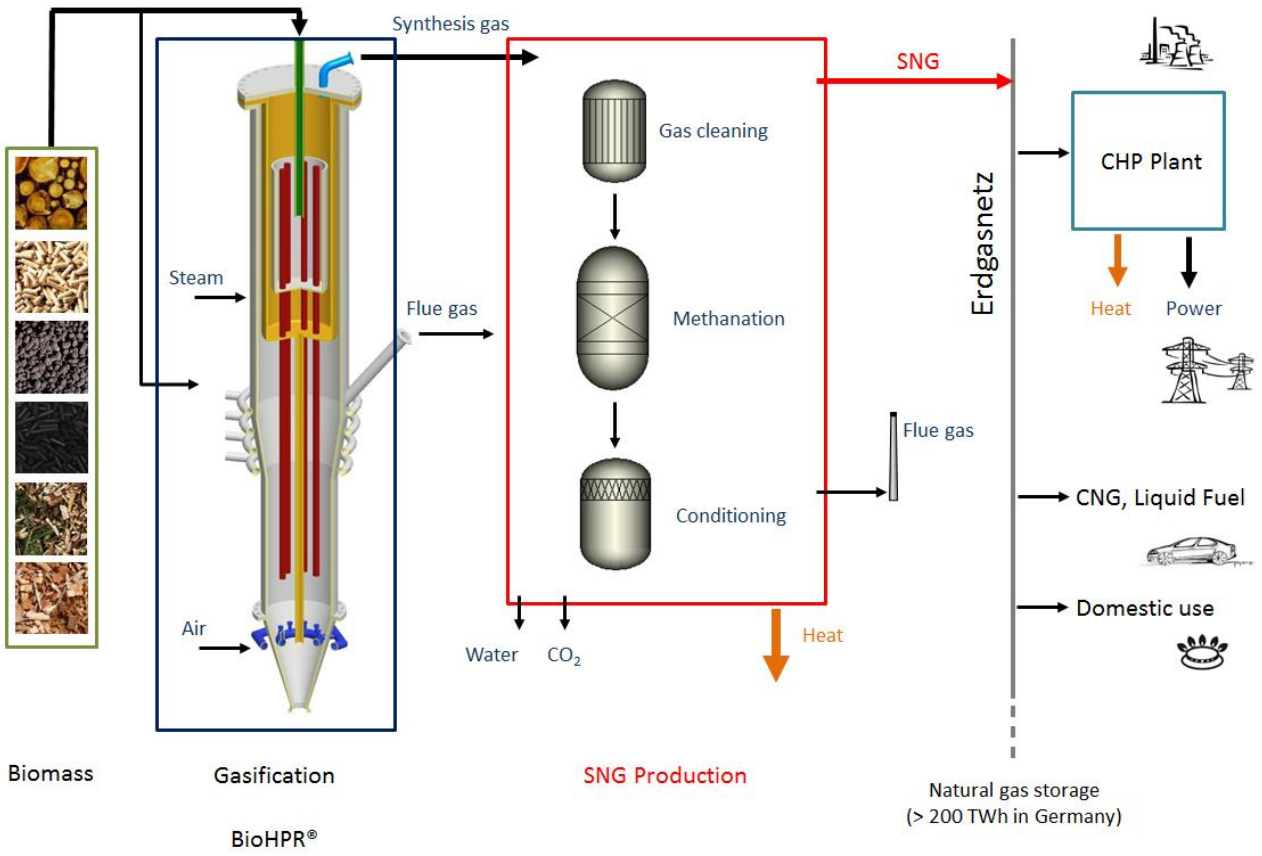
BioSyngas-to-SNG - General process steps



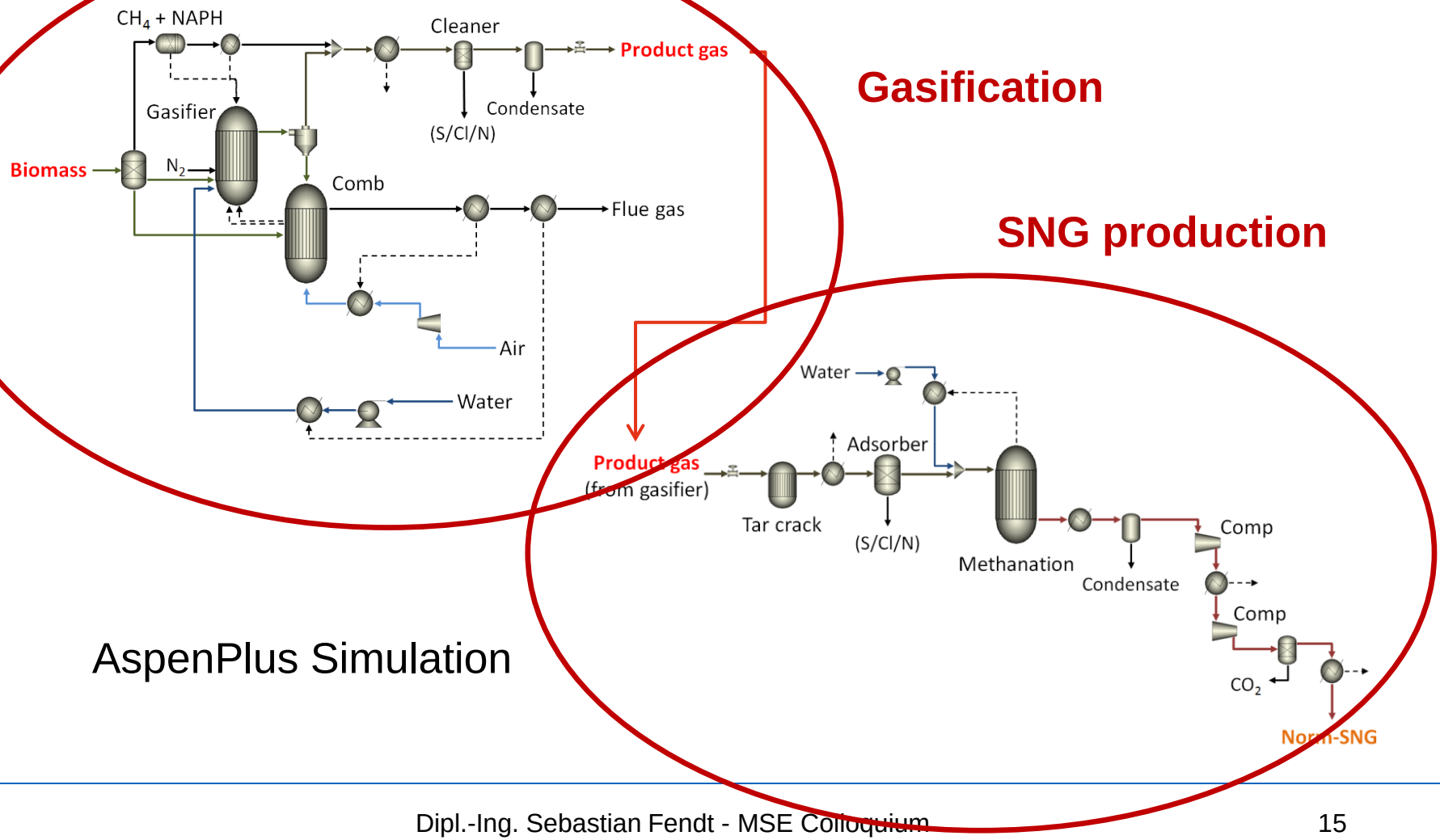
Gasification	Gas cleaning	Methanation	Gas processing
- Allothermal or autothermal - Fluidized bed, fixed bed or entrained flow	- Particle removal - Tar removal/ conversion - Sulfur and chloride removal - Removal of other impurities	- Fixed bed - Fluidized bed - Other concept (e.g. liquid phase methanation)	- CO shift - Water separation - CO_2 separation - Pressurization

Biomass-to-SNG concept at LES (= BioSyngas-to-SNG)

- Small scale
  (~ 500 kW – 1 MW)
  - reduced biomass transport logistics
  - efficient heat utilization
  - low environmental impacts
- Power generation in CHP unit or CC plant
  - Flexible
  - Adjustable to local heat and power demand
- Storage in NG grid

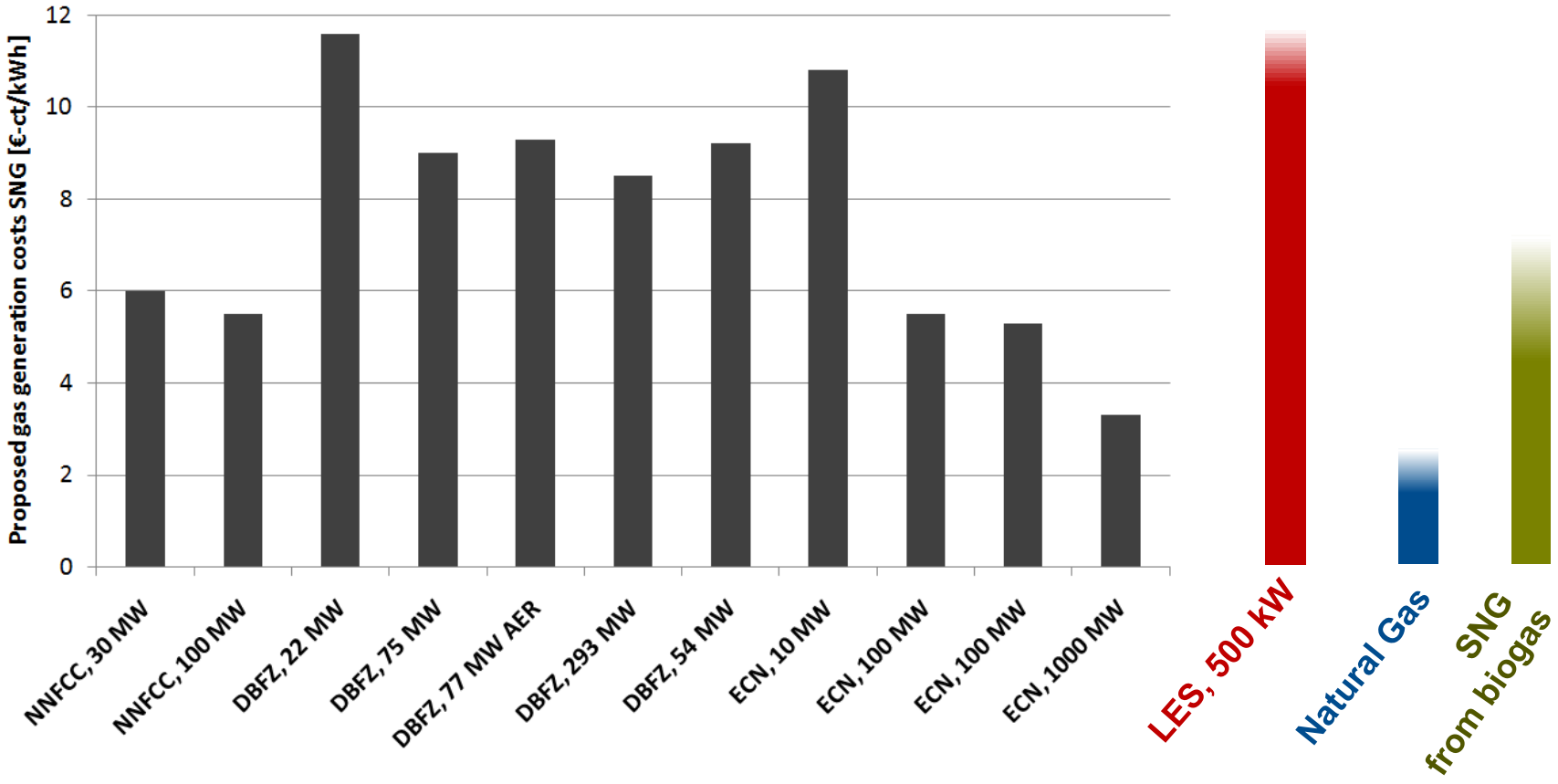


Process simulation of SNG concept



AspenPlus Simulation

Proposed SNG production costs compared to NG



Today, SNG is still not economically competitive to NG but could be in the future!

Discussion and Outlook

Numerous promising renewable energy sources can be connected by SNG with the great opportunity to store and distribute the energy in an existing, reliable and efficient infrastructure

Thank you for your attention!

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