Balancing Power grid and Gas grid

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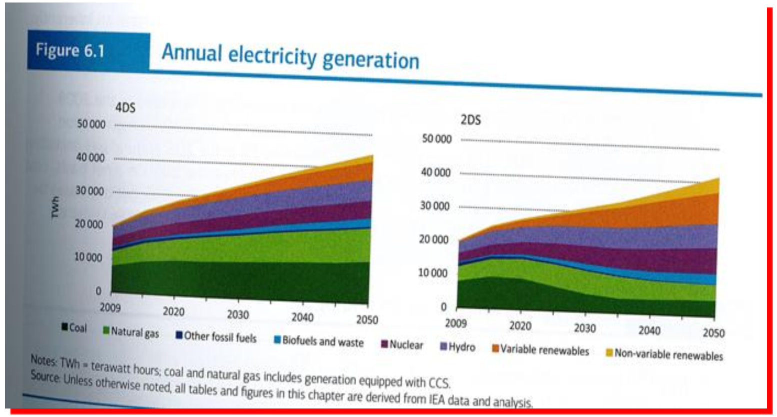
Balancing Power grid and Gas grid

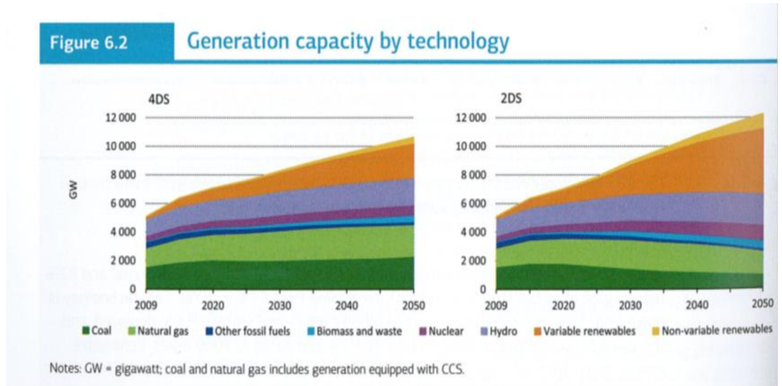
Energy Delta Convention 2012
“Gas powers”
Stéphane Walspurger

Groningen
21-11-2012

Changing energy landscape

- Future energy mix relies less on depleting fossil fuels
- In conventional power gas is favored due to relative lower carbon footprint.
- Renewable power from intermittent sources such as wind and solar penetrates significantly the electricity market
- Due to lower capacity factors, installed capacity is high

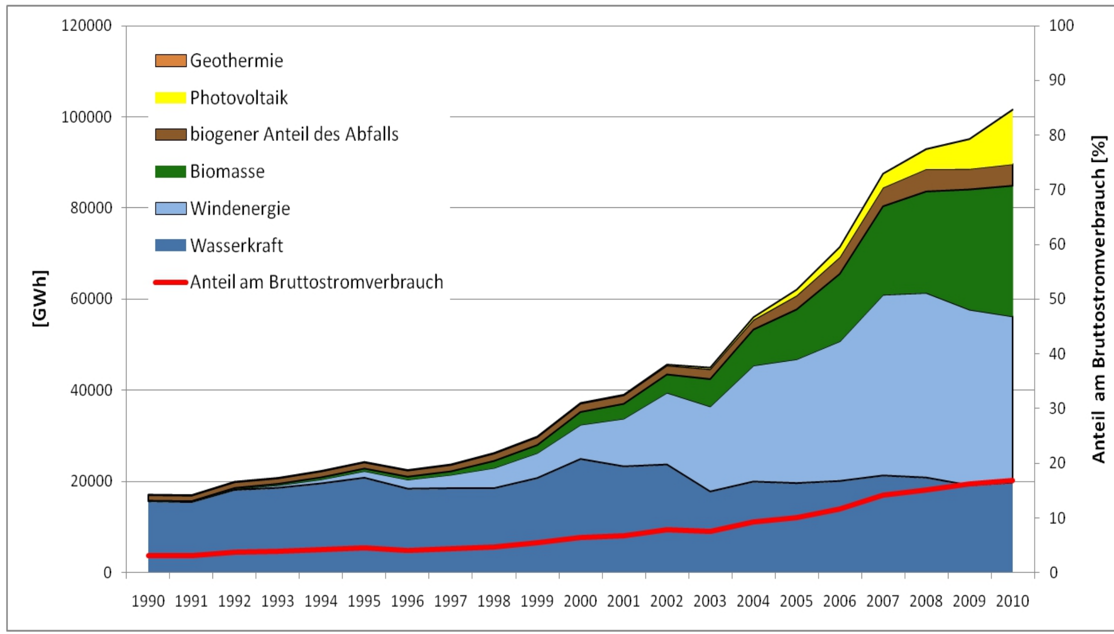




from IEA ETP 2012

Current German electricity mix

- Q1/Q2 2012
  25% of e-production
  is from renewables
- May-June 2012
  22GW peak solar
  electricity production
- 14,7 TWh solar power
  in 6 months (JAN->JUN)

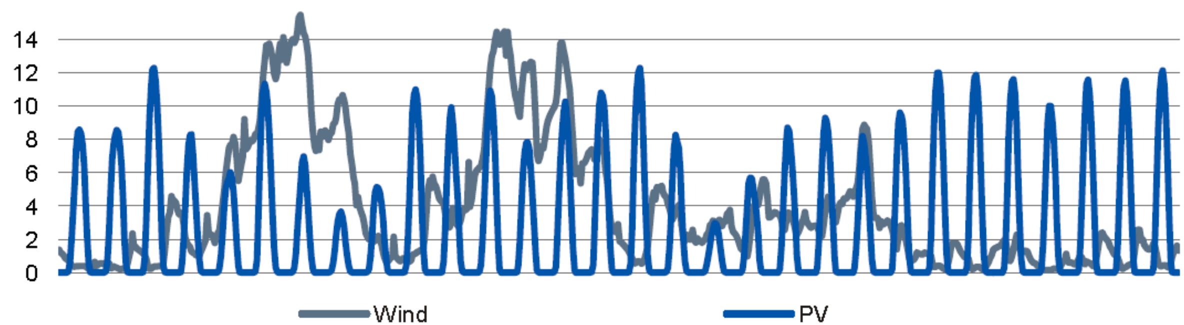


Success of renewables creates new issues

- Fluctuations difficult to predict and not controllable
- Not all green power can be fed into the grid
- Power grid does not store power. Load need to be smartly managed.

Fluctuations in wind and solar-generated electricity

Hourly feed-in values (GW), Germany, September 2011



Source: ENTSO-E

Part of the solution

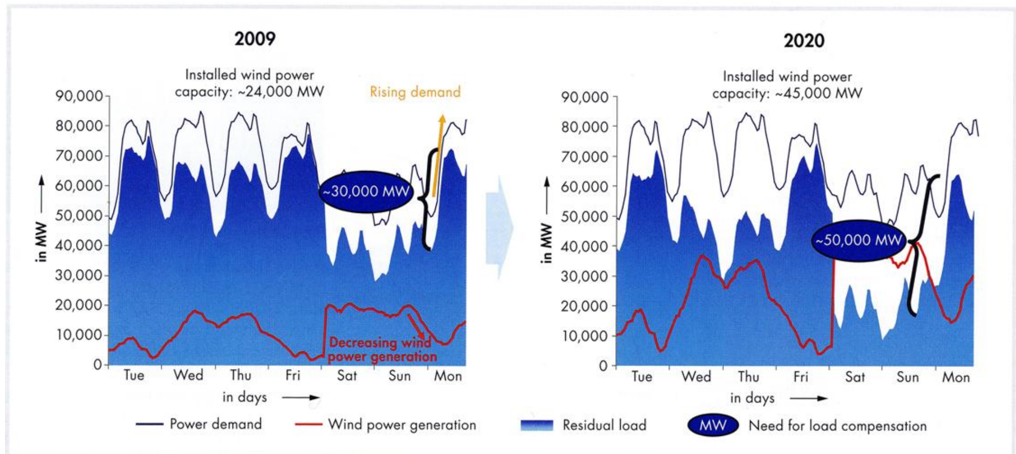


Figure 1. Residual power demand in Germany February 2009 and projection to 2020, Source: RWE.

Fübi et al. *VGB Power*, 3, **2012**, p30

- Maintain a sufficient efficient fossil fired power plant fleet
- Adapt conventional power plants for high load shift
- Optimize shut down/start-up procedure

But Load, capacity and efficiency…

- Shut down/start-up of power plants is costly
- Operating at low load is inefficient and costly
- Power carbon footprint increases
- As a consequence investment in new power plant are unattractive currently, but remain necessary to cope with highly fluctuating loads.
- IEA calls for use of highest efficiency technologies such as NGCC or supercritical coal combustion plants to achieve higher efficiencies than 45% (net LHV basis) operating with capacity factor of more than 85%.

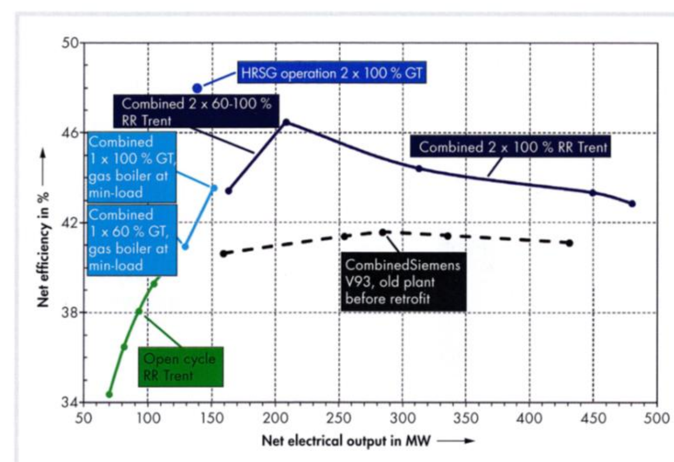
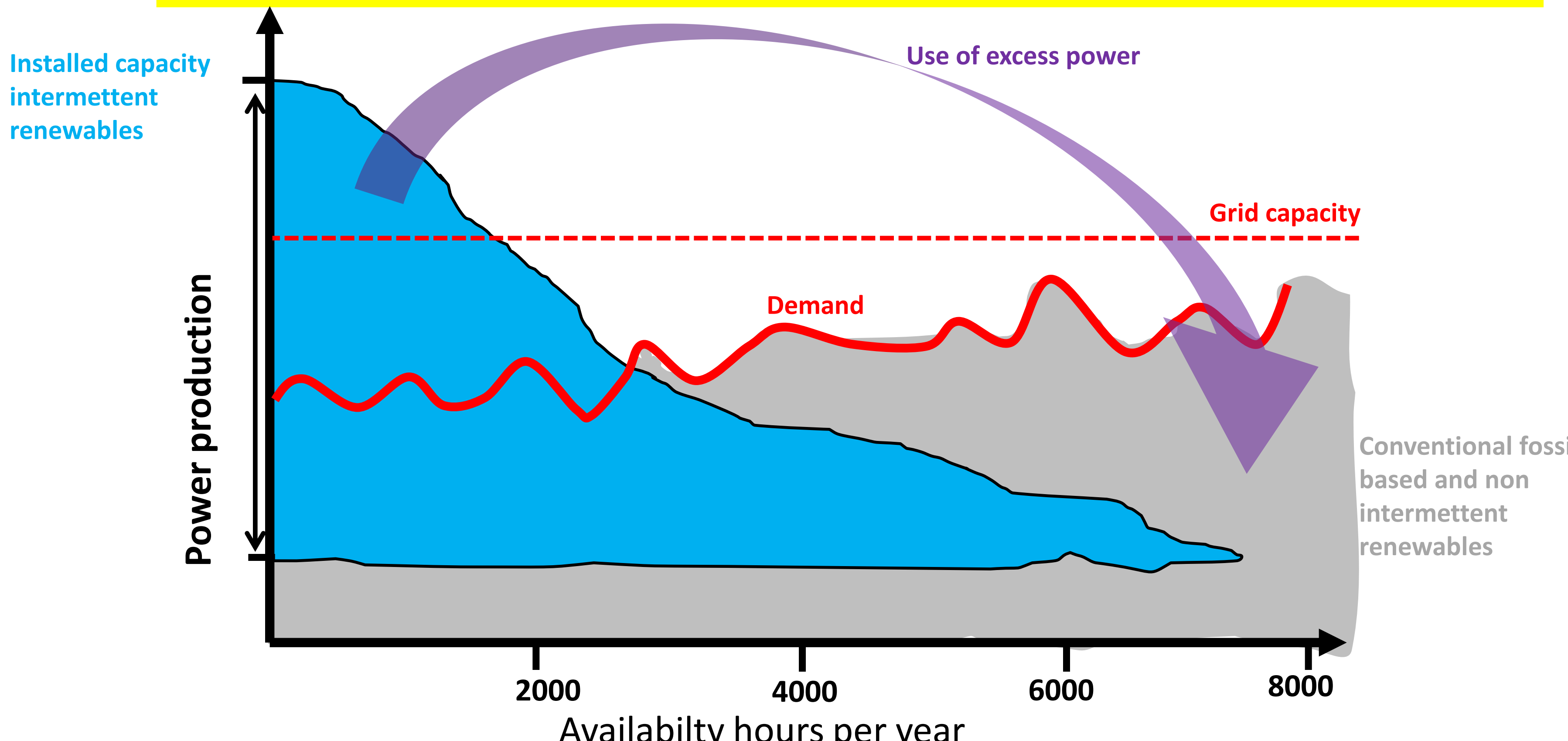


Figure 5. Expected plant performance of the gas combi units at Lingen, Germany: Improved efficiency, minimum-load and full-load capability, Source RWE.

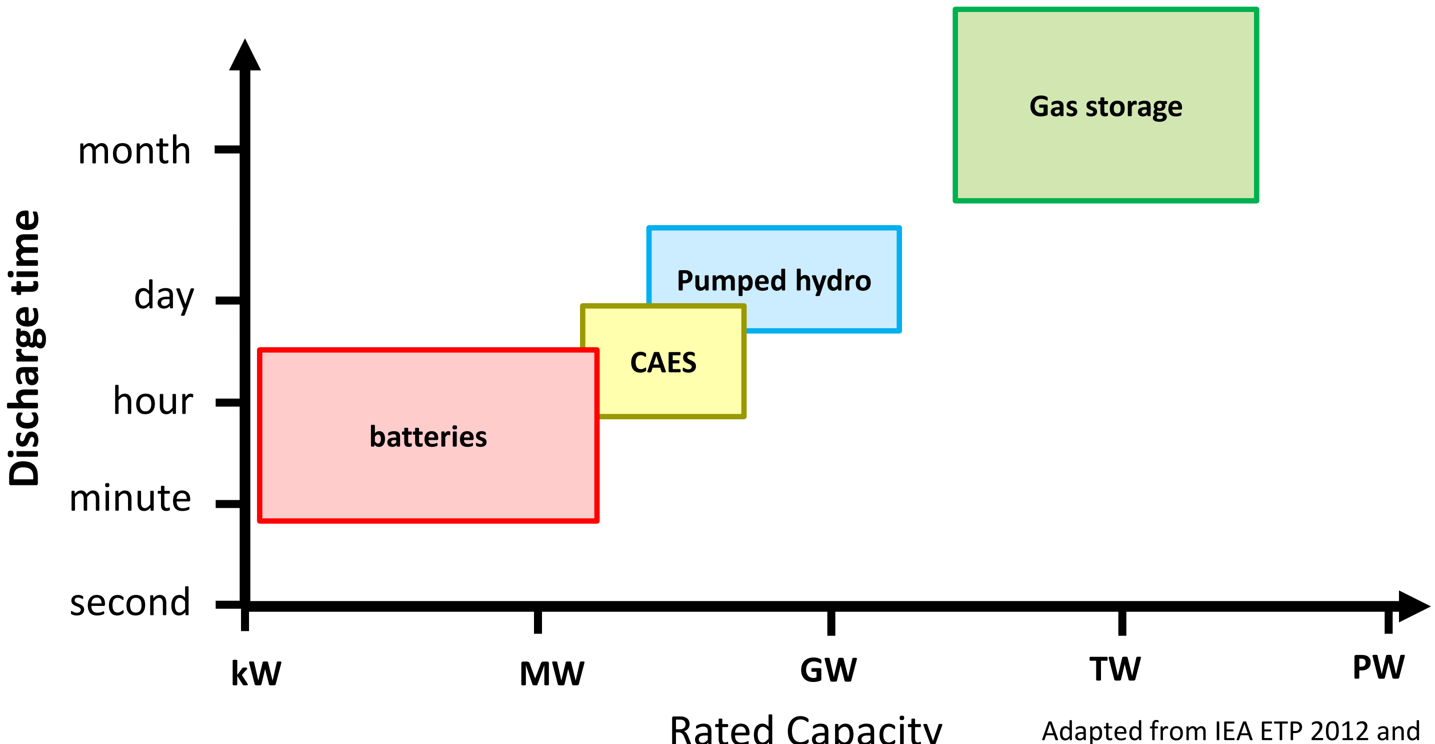
Fübi et al. *VGB Power*, 3, **2012**, p30

Towards storing the excess power from renewables



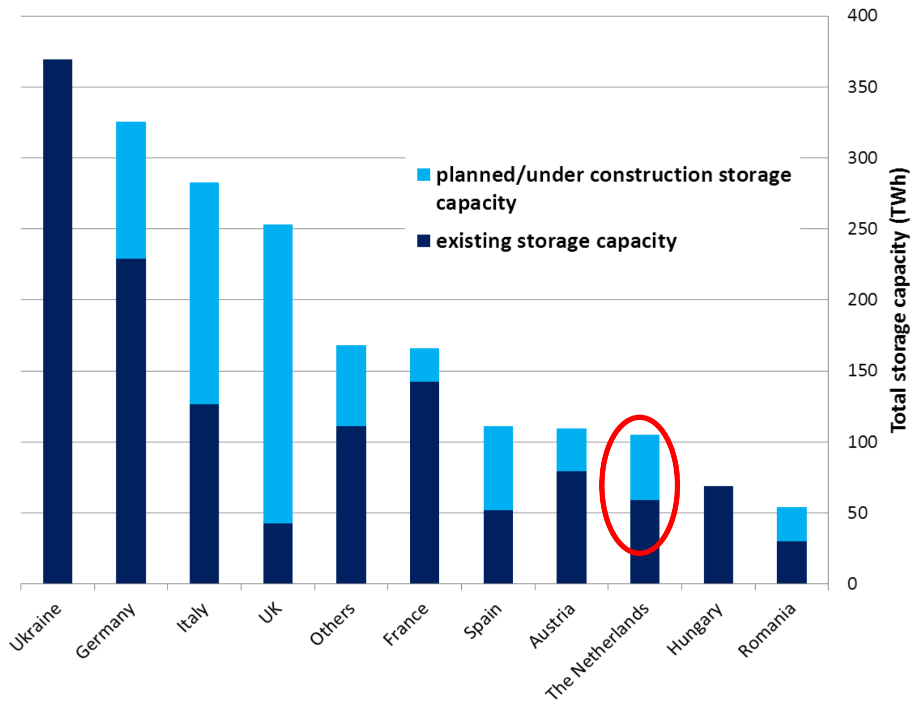
Adapted from DVGW, Jurgen Lenz

Storage technologies



Adapted from IEA ETP 2012 and
Zentrum für Sonnenenergie und Waterstoff

Storage capacity in Europe



Source: Gas Infrastructure Europe

Key facts	Bergermeer Gas storage
Working gas volume	**46TWh** (4.1 10^9 m^3)
Injection capacity	**0.47TWh per day** (0.042 10^9 m^3)
Withdrawal capacity	**0.64TWh per day** (0.057 10^9 m^3)
Netherland Gas consumption equivalent	**+/- 15 days**

http://www.bergermeergasstorage.com/

Power to Gas routes

- Power to Hydrogen by electrolysis

Pros	Cons
Direct conversion (electrolysis)	Storage
No carbon	Distribution
Load Flexibilty	

- Power to Substitute Natural Gas by electrolysis + methanation

Pros	Cons
Existing infrastructure	Multistep process (efficiency)
CO_2 utilisation	
Energy density	

Power to Gas key advantages

- Gas injection during high power production
- Controllable withdrawal and use in conventional NGCC
- Security of supply
- Flexible fuel:
  - For power production
  - For heat production
  - For domestic fuel
  - For transportation.

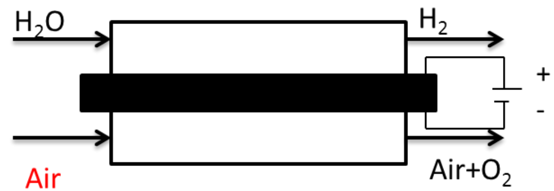
Electrolysis technologies

- Classical alkaline electrolyzers
  - Low temperature
  - Commercially available up to 100 MW scale
  - Operation at higher pressure possible
  - 70-75% efficiency at high load.
- PEM electrolyzers
  - Low temperature
  - Commercially available up to 100MW
  - Operation at higher pressure possible
  - Low load operation possible
- High temperature electrolyzers
  - High tenperature (600-900°C)
  - Higher efficiency (heat use)

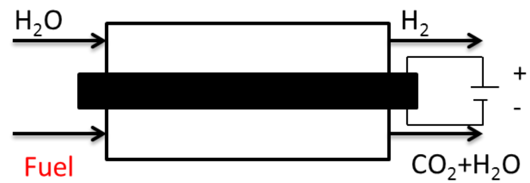
Energy Delta Gas Research Project Synthetic Methane

Challenges in HT electrolysis

- Electric mode:
  - SOE-E



- Fuel assisted mode
  - SOE-fuel



  - Cell development for reversible normal/fuel assisted operations
  - Modelling and efficiency assessment at full/part load
  - Stack configuration design
  - Integration in full conversion chain Power to Gas

Sabatier reaction

$CO_2 + H_2 \rightarrow CO + H_2O$ Reverse WGS

$CO + 3H_2 \rightarrow CH_4 + H_2O$ Methanation

$CO_2 + 4H_2 \rightarrow CH_4 + 2\,H_2O$ Sabatier reaction

- Flexible process (good part load, fast response)
- Very exothermic -164 kJ/mol

Paul Sabatier (1854-1941)
Nobel Laureate in Chemistry 1912

Issues

SOE

- SOE characterisation, modeling and development

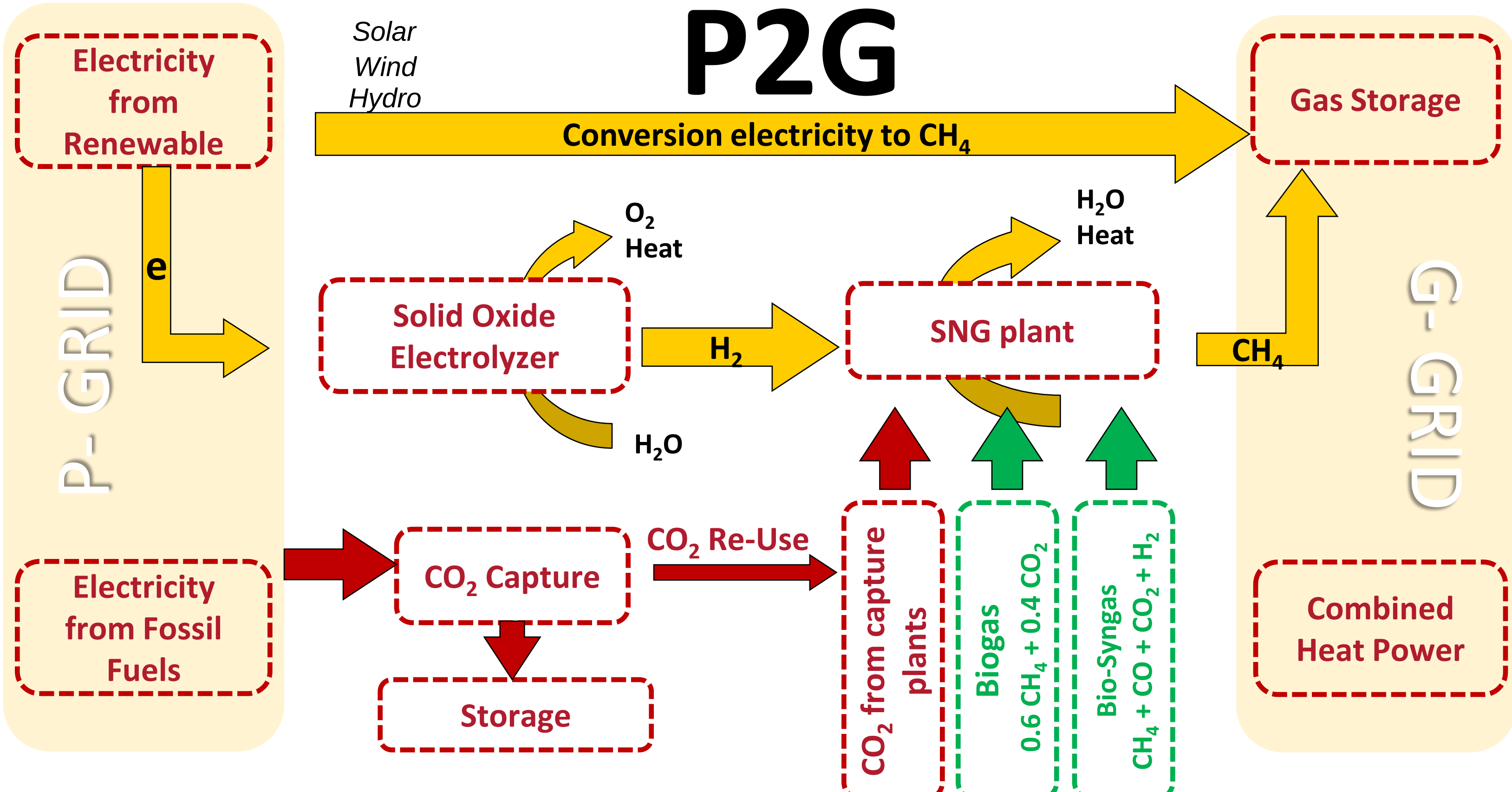
Methanation

- Feedstock quality (CO_2, biogas, producer gas)
- Gas cleaning
- Unit operation development
- Process design

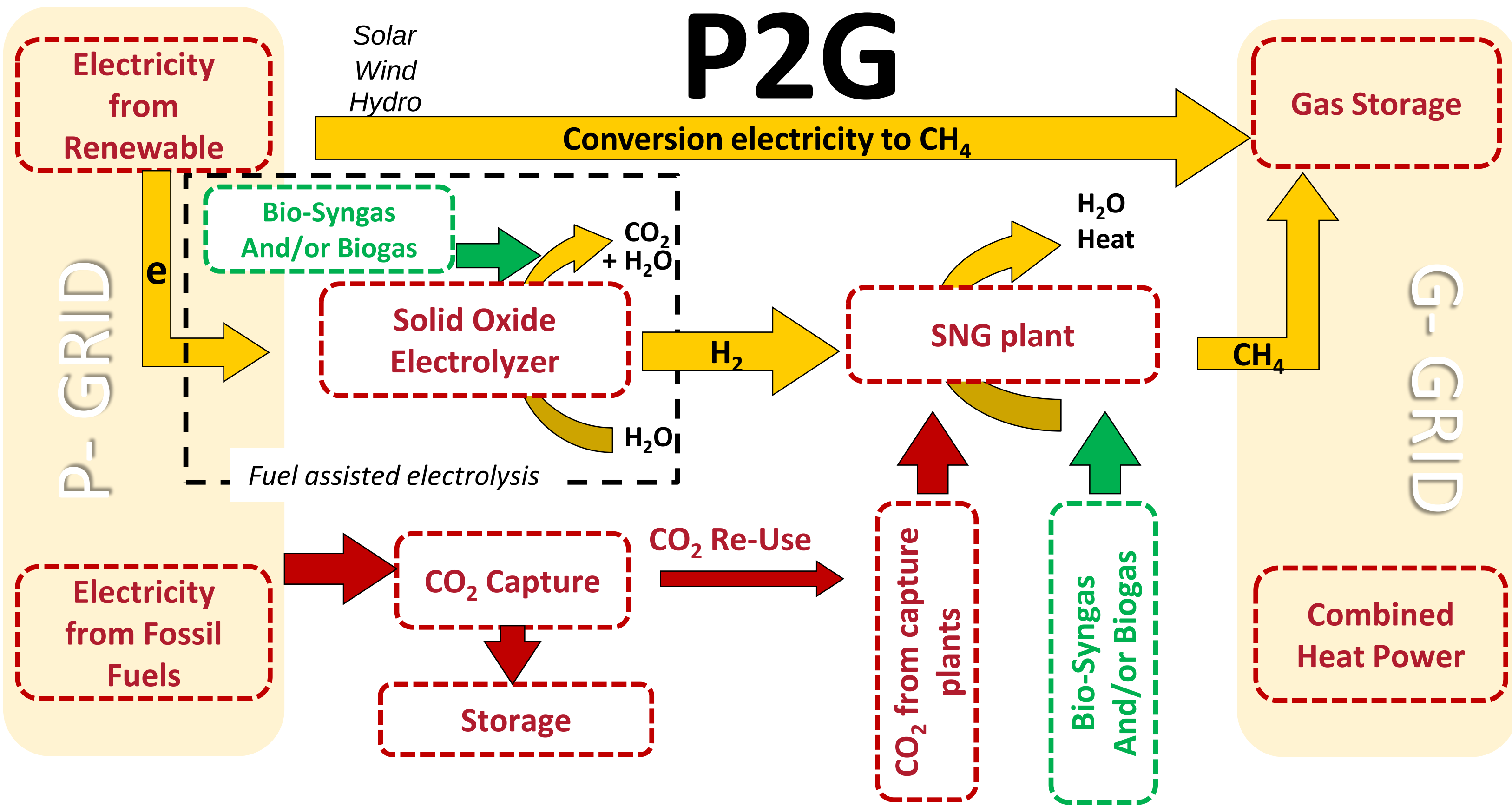
Chain and market aspects (Hanze, ECN, TUD)

- Chain efficiency
- Preferred configurations
- Market opportunities – End User

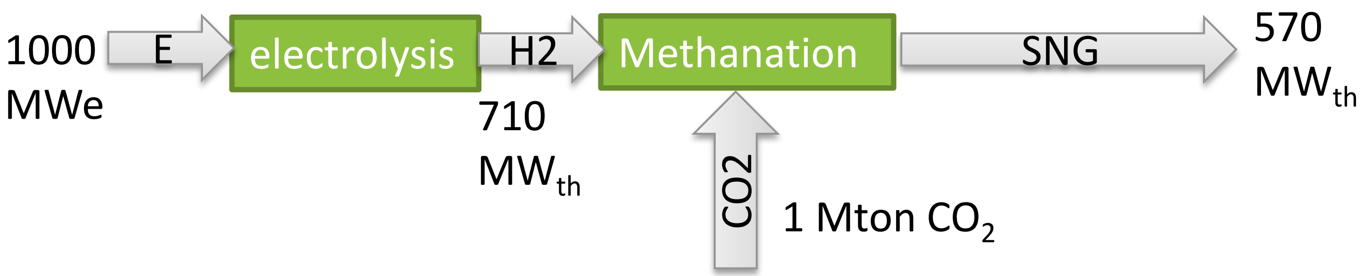
Large Surplus Electricity Production



Small Surplus Electricity Production



SNG from CO2



55-60% storage
Rather than
No storage

electrolysis

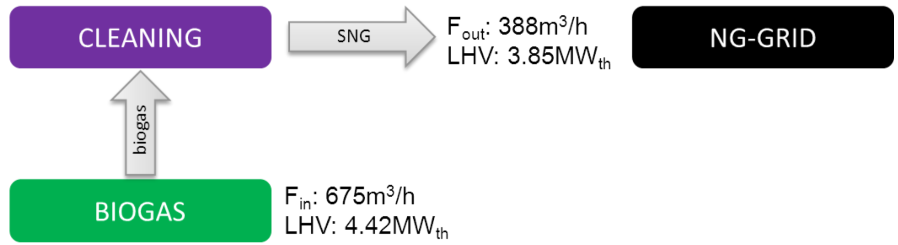
- Full/part load operation
- Switch on/off procedure resistance/idle operation
- Scale

Methanation

- CO_2 purity
- SNG product specs
- Part load response

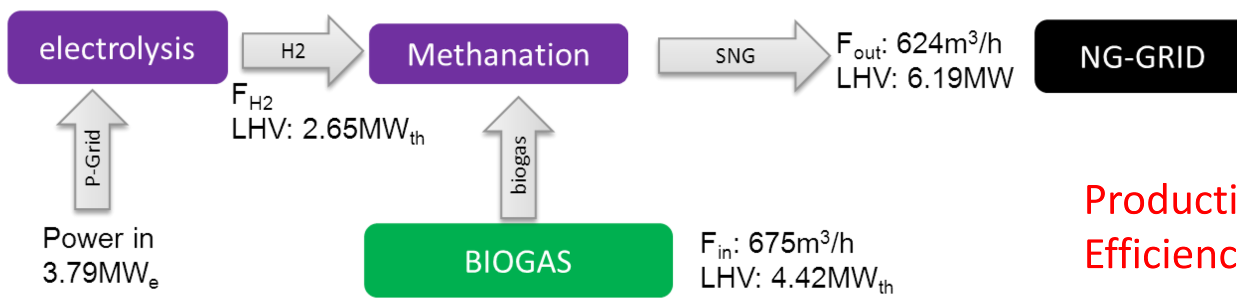
Biogas case

- Base case



Productivity 100
Efficiency 90-95%

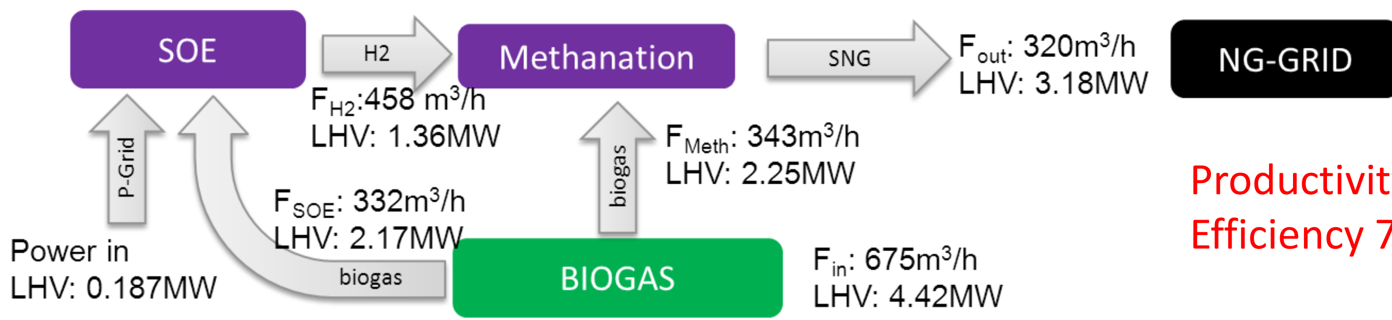
- Large surplus case



Productivity 160
Efficiency 70-75%

Going further with Biogas

- Small surplus electricity



Productivity 82
Efficiency 70%

- Towards continuous production:
  - Mixed Configurations Large surplus / small surplus
  - Robust gas cleaning strategy
  - Methanation Process design and integration

Outlook

There will be a business case for power to gas
in which it pays off to turn excess renewable electricity into SNG

- Case configuration and techno economics
- Robust reversible electrolyzer
- Innovation and flexibilization of SNG train
- SNG quality for end-user specs

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