

# Flexibility in the natural gas value chain

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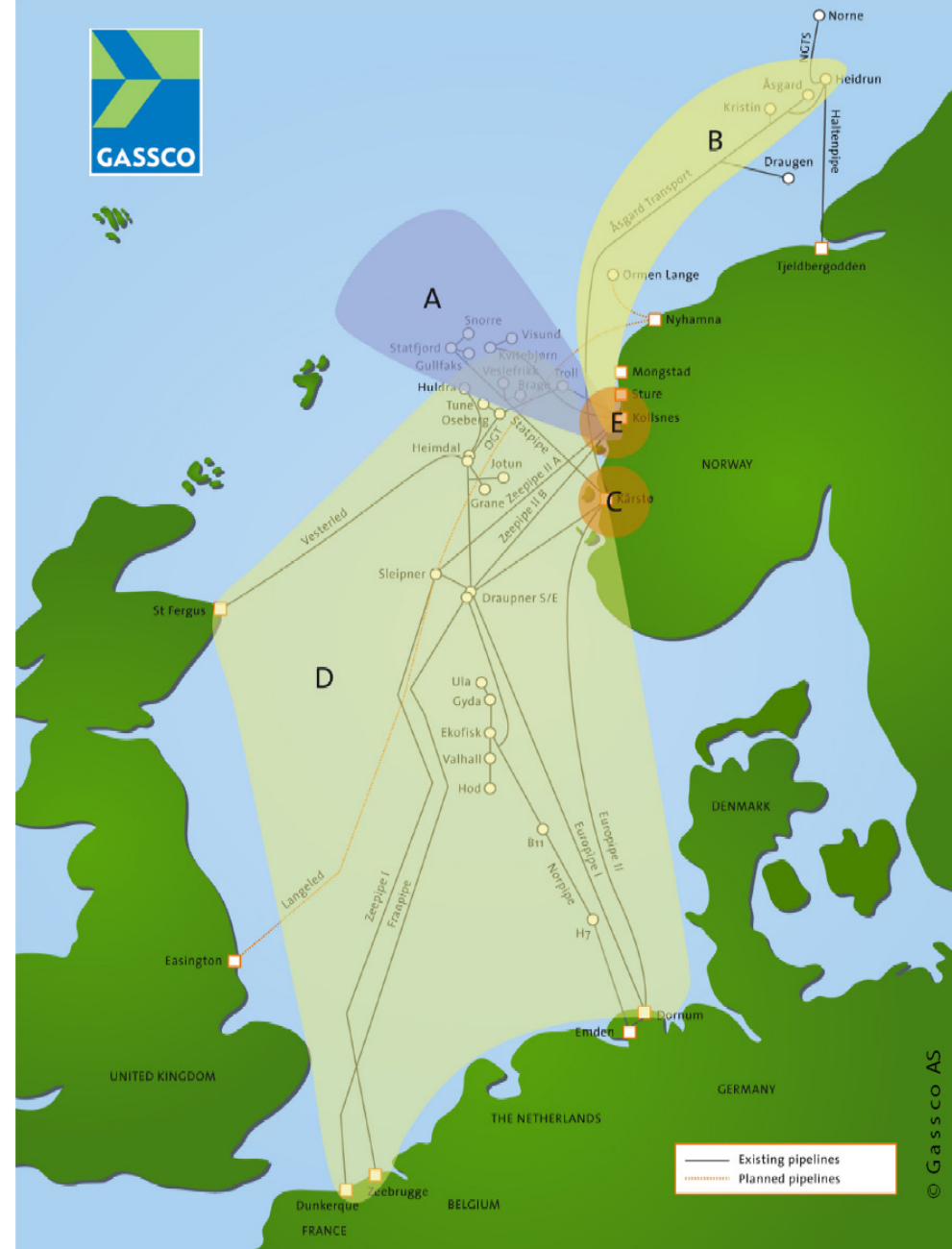
CenSES

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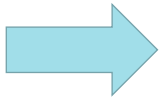
# The Norwegian natural gas value chain

- World's largest subsea gas transport system, 7800 km
- Gas quality issues
- System effects
- Liberalized markets
- Linepack
- Events
- Security of supply
- Need for flexibility
- Uncertainty
  - Supply
  - Demand
  - Volume, quality, prices, ...



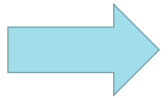
# Linepack

Pressure in  
Volume in



Gas inventory in the pipeline  
(cushion gas + linepack)

Pressure out  
Volume out



- More gas can be inserted in a given time period than we extract from the pipeline
- At a later point in time, we can then extract more than we insert in that same time period
- Higher inventory leads to a higher pressure in the pipeline, which again influence the transportation capacity in the pipeline (and the network)

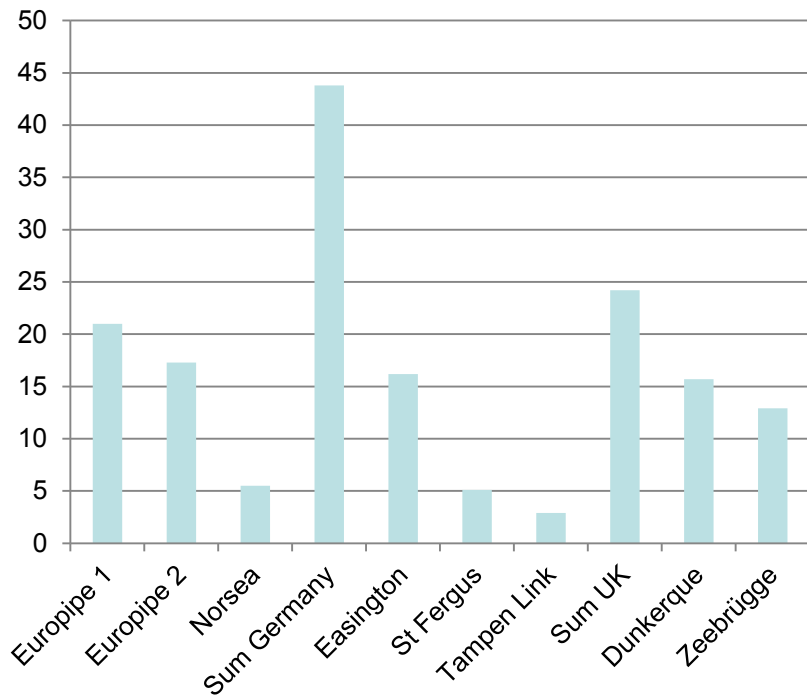


# Natural gas flexibility

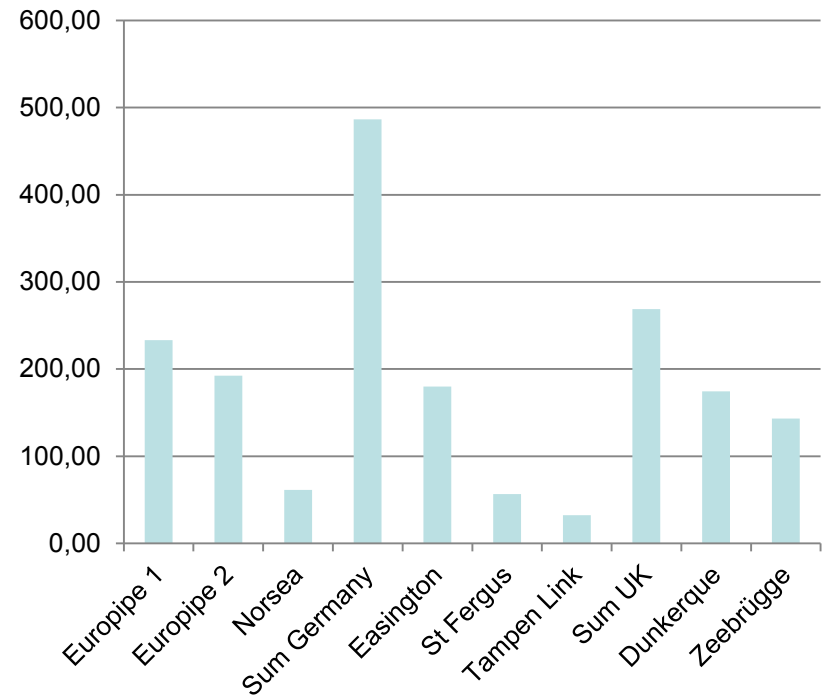
- The storage potential in the natural gas value chain
  - Reservoirs
    - Seasonal, weekly, ...
  - Linepack
    - Short term balancing
  - Conventional storages
    - Aquifers, salt caverns, abandoned reservoirs, etc.
  - LNG storages
    - Coordination effects also with pipelines

# Yearly deliveries from Norway

## Billion sm<sup>3</sup> gas

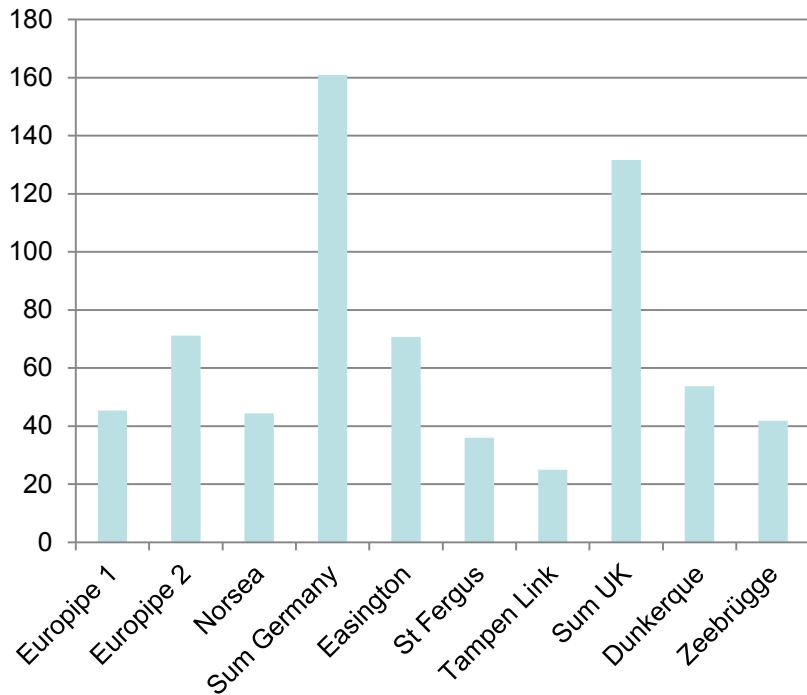


## Energy content (TWh)

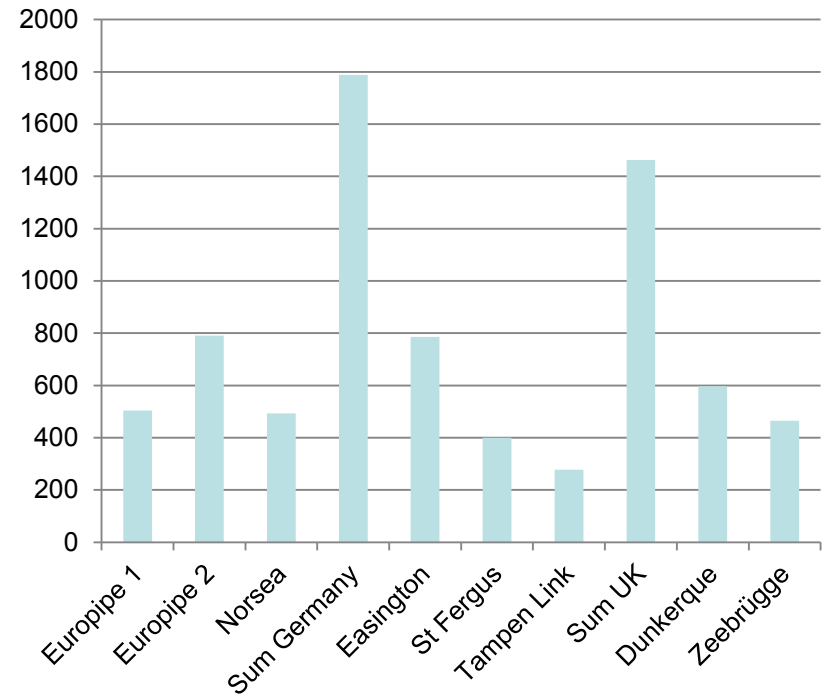


# Daily capacity

## Pipeline capacity (Msm<sup>3</sup>)



## Capacity in GWh



# Natural gas power plants

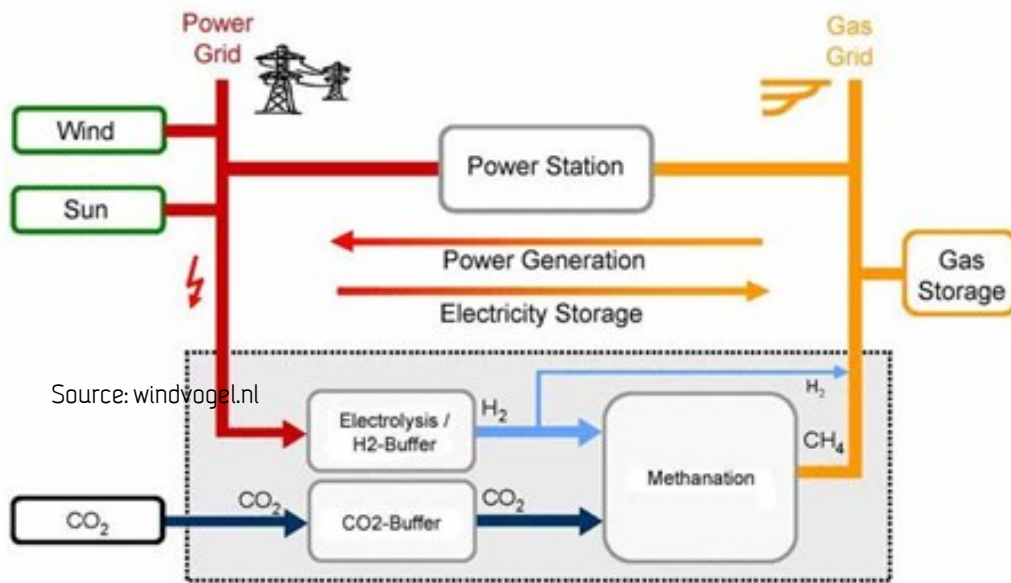
- Steamturbines (30 – 35% efficiency)
- Gas turbines (< 30 – 35% efficiency)
  - Very flexible – often used for peak shaving
- Combined cycle power plants (50 – 60% efficiency)
  - Both a gas turbine and a steam turbine
- Centralized and decentralized production
  - With production units close to consumption combined heat and power is a possibility
    - For industrial use
    - For households
  - Microturbines are also being developed (25 – 500 kW)
    - Size of refrigerators
    - Energy efficiency of up to 80%

# Norwegian gas as balancing service for Europe

- The electricity and gas markets are partly integrated, but far from perfectly
- Wind power may have a negative value (price) while gas are sold in the same geographical area
- The problem may increase when the share of non-dispatchable energy sources increase
- Today linepack is being used for security of supply (events, maintenance – both upstream and downstream)
  - It can also be used to increase the commercial value of natural gas
  - Or for balancing services



# Power2Gas



- Flexible
- Efficient transportation
- Available infrastructure
- Requirements:
  - Negative CO<sub>2</sub> prices
  - Low price electricity

# Conclusions

- A flexible value chain where (most) necessary investments already are done
  - Linepack, LNG, reservoirs, conventional storages, ...
- Efficient energy transportation
- Possible to strengthen integration with the power system and increase the storage potential through Power2Gas
  
- Important role to achieve a low carbon energy system
  - Replace coal based production
  - Can provide flexibility services to accommodate a large share of renewable, non-dispatchable power production
  - Transition fuel or long-term solution? Probably depends on the development of CCS technology (and policy development)