Pöyry Study: Hydrogen from natural gas – the key to deep decarbonisation

Energetika, 13th November 2019 St Petersburg
Pöyry Discussion Paper for Zukunft Erdgas

Pöyry 2018 “Fully decarbonising Europe’s Energy System by 2050”
• Compares costs of “All Electric” decarbonisation pathway with “Zero Carbon Gas” pathway
• “Zero Carbon Gas” includes hydrogen produced from natural gas using Steam Methane Reforming and Carbon Capture and Storage

Pöyry 2019 “Hydrogen from natural gas – the key to deep decarbonisation”
• “Zero Carbon Hydrogen” Pathway adds potential of producing hydrogen from pyrolysis
The scale of the decarbonisation challenge

Source: EU Clean Planet for all. In-depth analysis in support of the commission communication COM (2018) 773 November 2018

Source: Pöyry. Hydrogen from natural gas – the key to deep decarbonisation. July 2019
Benefits of hydrogen in decarbonisation

- Industrial and residential heat can be decarbonised
- Carbon free storage to improve integration of RES and provide flexibility
- Transportable by shipping / pipe / truck
- Reliable alternative where direct electrification is not feasible esp. in some transport sectors
- Feedstock to help decarbonize carbon intensive industries
- Allows existing gas infrastructure to be utilised

Source: Pöyry. Hydrogen from natural gas – the key to deep decarbonisation. July 2019
Pöyry Modelling overview – system cost approach

- **All Energy**: Decarbonising Electricity, Heat, Transport
- **Hourly Resolution**: Hourly supply/demand with intermittent technologies
- **Active Customers**: Smart participation of customers to balance the system
- **Technology Options**: Batteries, wind, solar, hydrogen, nuclear, CCS, EVs, heat pumps
- **Least cost**: Optimal decarbonisation including cost of grid

Source: Pöyry. Hydrogen from natural gas – the key to deep decarbonisation. July 2019
Overview of pathways

'All-Electric'

Decarbonisation vector
Electrification of heat and transport

Fuel availability
No hydrogen or biomethane, overall European biomass limit

Technology availability
No hydrogen, no carbon capture and storage (CCS), no hybrid heat pumps, decommissioning of district heating

'Zero Carbon Hydrogen'

Decarbonisation vector
Economics and avoidance of stranded assets

Fuel availability
Competition between all fuels; limited supply of biomethane and biomass

Technology availability
All options, incl. carbon capture and storage (CCS), electrolysis, methane reforming and pyrolysis

Zero Carbon Hydrogen is similar to Zero carbon gas but adds pyrolysis as production option for hydrogen.
Different methods of hydrogen production from natural gas

**SMR/ATR with CCS**
- Thermal process already used today. Reacts methane (CH₄) with steam to produce hydrogen and CO₂.
- Cost-effective and most developed technology.
- Need for CO₂ storage: unavailable in many countries, and political opposition.

**Electrolysis**
- Small-scale use today. Splits water (H₂O) into hydrogen and oxygen.
- No carbon by-product or direct emissions.
- Higher costs and questions about scalability.

**Pyrolysis**
- Developing technology. Decomposition of CH₄ into hydrogen and solid carbon.
- Residual carbon occurs as a solid, not a gas. Easier to store and potential selling value.
- Early stages of technology development.

Source: Pöyry. Hydrogen from natural gas – the key to deep decarbonisation. July 2019
Hydrogen from natural gas competes with electrification to achieve decarbonisation

**Transport**
Electric vehicles dominate in lighter segments while fuel cell vehicles are a more economical alternative in heavier transport segments.

**Heating**
Where gas networks exist they are converted to allow hydrogen boilers in homes and businesses, otherwise heat pumps are deployed. CCS installations are used for capturing industrial emissions, otherwise hydrogen is used in industry.

**Power generation**
Renewables require some form of zero carbon peak support, which comes from Gas CCS where available, and hydrogen as well as significant interconnector contribution.

**Smart networks**
Power networks allow demand side response, including flexible charging and vehicle-to-grid. Many gas distribution networks convert to hydrogen, but transmission networks continue to carry natural gas. District heating networks are retained.

- Existing natural gas infrastructure adapts to support the deployment of hydrogen and CCS
- Hydrogen production can come from pyrolysis (CO₂ free), methane reforming with CCS (restricted to countries with easy access to North Sea storage) and electrolysis (requires cheap, carbon neutral electricity to be economic, which is very limited due to flexible EV charging)

Source: Pöyry. Hydrogen from natural gas – the key to deep decarbonisation. July 2019
Hydrogen demand and supply

Hydrogen demand (TWh)  
- Power: 403
- Heat - non-process: 518
- Heat - process: 515
- Transport: 418

Hydrogen supply (TWh)  
- SMR with CCS: 1163
- Pyrolysis: 971
- Electrolysis: 609

Source: Pöyry. Hydrogen from natural gas – the key to deep decarbonisation. July 2019

EU Natural Gas Demand in 2018 was 5047 TWh
Role of hydrogen in the ‘Zero carbon hydrogen’ pathway

Source: Pöyry. Hydrogen from natural gas – the key to deep decarbonisation. July 2019
Hydrogen makes decarbonisation more achievable

- Reduces the need for new nuclear
- Mitigates the performance risks of heat pumps
- Reduces electricity demand
- Reduces interconnection requirement

Source: Pöyry. Hydrogen from natural gas – the key to deep decarbonisation. July 2019
Flexible demand balances intermittent renewables

Electrolysis is only economic where there is very cheap and high yield solar

Source: Pöyry. Hydrogen from natural gas – the key to deep decarbonisation. July 2019
Lower investment costs by using hydrogen from natural gas

Comparison of nuclear and biomass required in different pathways (GW)

Additional renewables required to replace natural gas in hydrogen production (GW)

Source: Pöyry. Hydrogen from natural gas – the key to deep decarbonisation. July 2019
‘Zero carbon hydrogen’ pathway reduces risk of missing targets

Source: Pöyry. Hydrogen from natural gas – the key to deep decarbonisation. July 2019
Pöyry recommendations to policy makers

• Targets for zero carbon gas in the European energy mix should be set

• Policies that support the role of hydrogen in decarbonisation efforts and allow different technologies (including zero carbon gas) to compete on an equal basis

• Research into implementation of hydrogen technologies should be supported

• Investments in energy networks should be considered based on the impact of the investment on decarbonisation
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