Hydrogen in gas networks

How existing infrastructure can enable successful energy transition

Gasmarknadsrådet, 24 Juni 2020

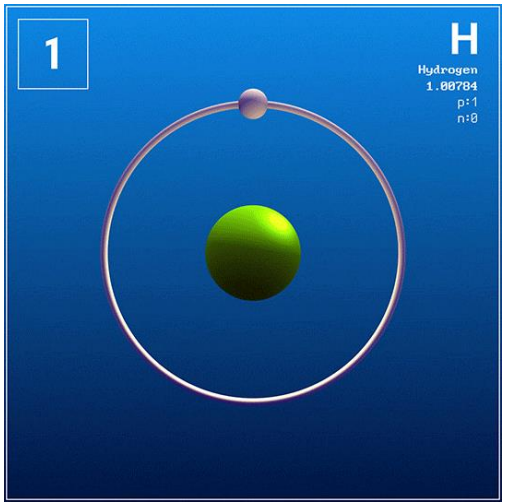
GAS FOR CLIMATE
A path to 2050

OGE

Objectives

- Share some insights on H2 in the future energy mix
- The role and capability of gas infrastructure
- Latest developments in Europe and Germany
- Outlook/Vision for the future

Getting you curious and excited about…



Source: www.giphy.com

Agenda

1. OGE
2. Why are we talking about hydrogen? Why Gas-for-Climate?
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OGE at a glance

2004
Established as E.ON Gastransport
1 September 2010
Renamed Open Grid Europe

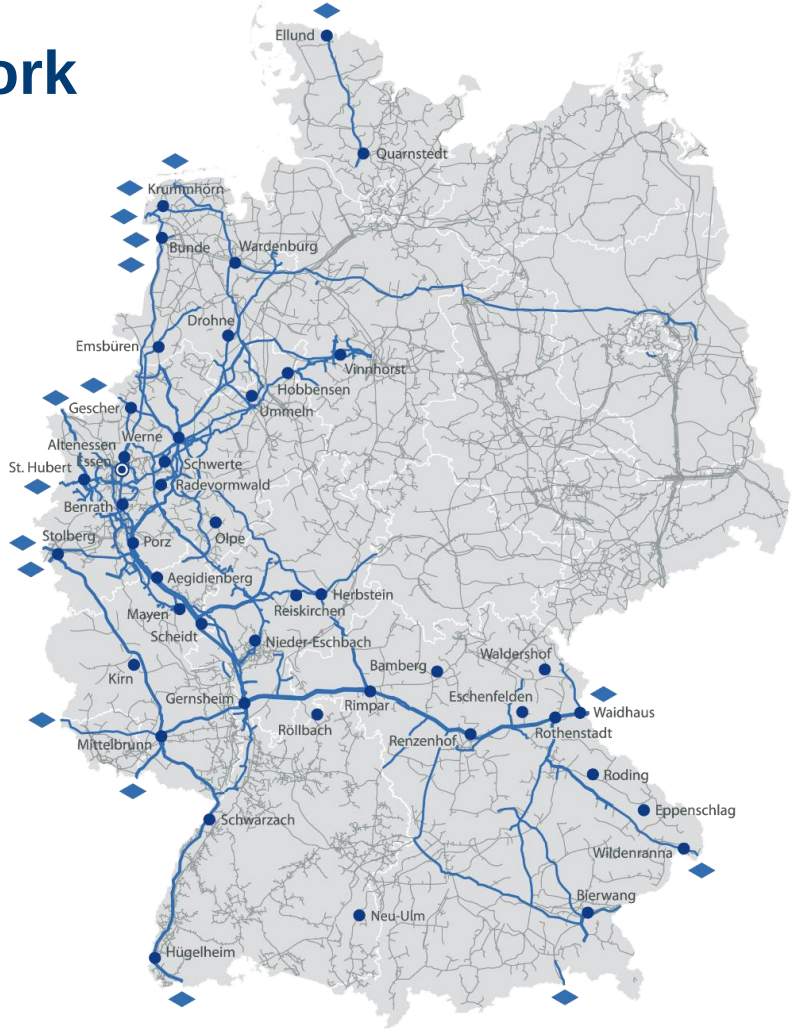
One of Europe‘s **leading gas transmission system operators**

Some **1,450 employees** across Germany;
Head office: Kallenbergstraße 5,
45141 Essen / Germany

Sole responsibility for the **operation, control, expansion and marketing** of the company’s pipeline network

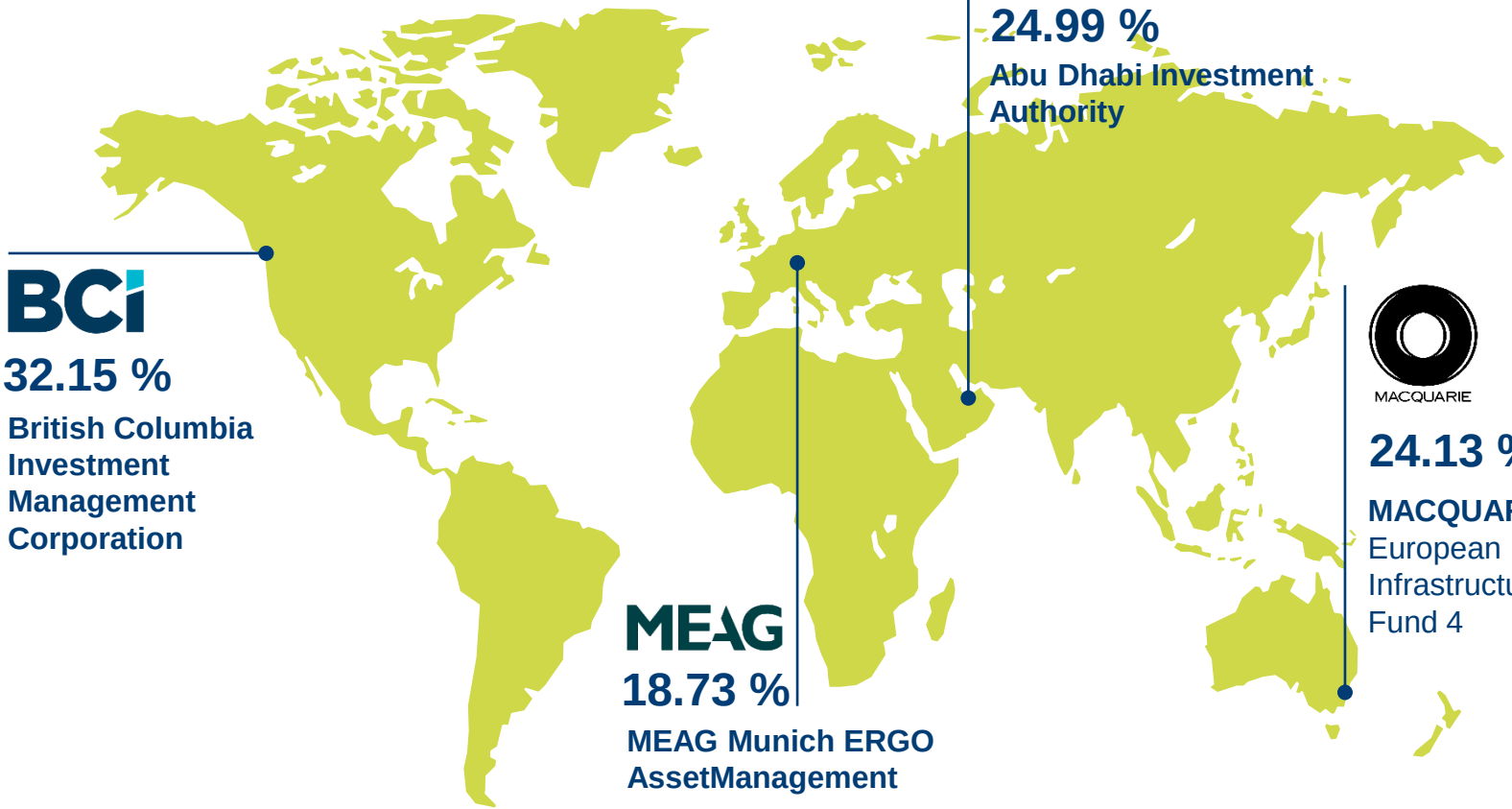
Some **450 German and European customers**

Our pipeline network



- Head office
- Compressor station/field site
- OGE transmission pipeline
- Other transmission pipeline
- Cross-border interconnection

Our shareholders



BCI

32.15 %

British Columbia Investment Management Corporation

ADIA

24.99 %

Abu Dhabi Investment Authority

MEAG

18.73 %

MEAG Munich ERGO AssetManagement

MACQUARIE

24.13 %

MACQUARIE European Infrastructure Fund 4

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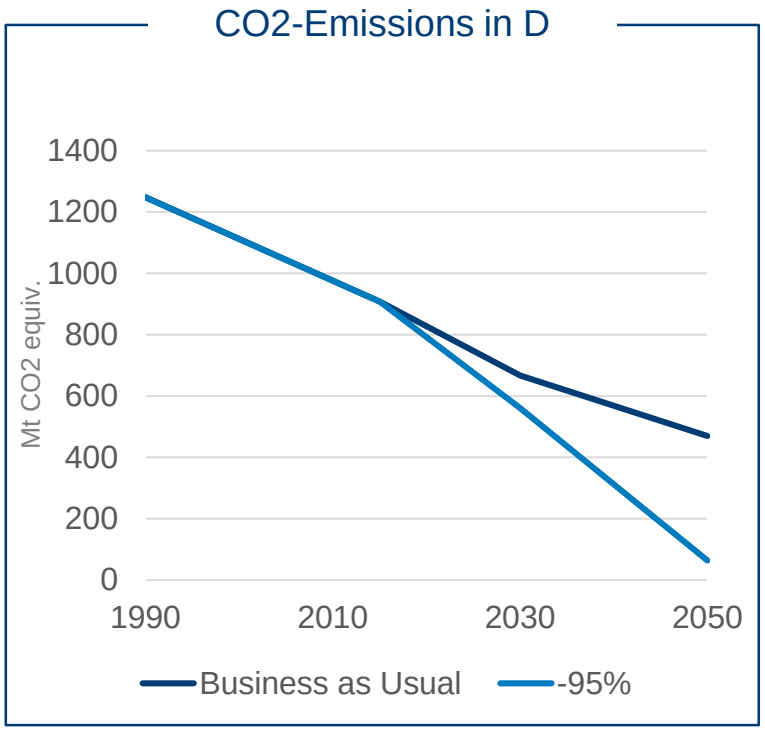
Severe CO2 reduction required to meet Paris targets



- Paris agreement set ambitious target for CO2 reduction
- Strong increase in decarbonisation efforts needed to reach targets
- Currently discussed „climate neutrality“ would require even more determined action
- Governments are enshrining CO2 ambitions into law

Substantial efforts required

Source: Dena Leitstudie 2018

Facing reality: Significantly decreasing role for natural gas beyond 2030 and towards 2050

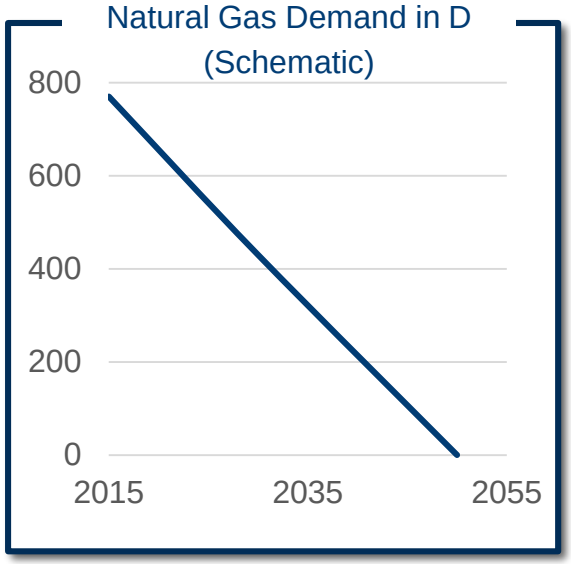
Natural gas is …

… abundantly available

… offers security of supply

… affordable

… much cleaner than coal



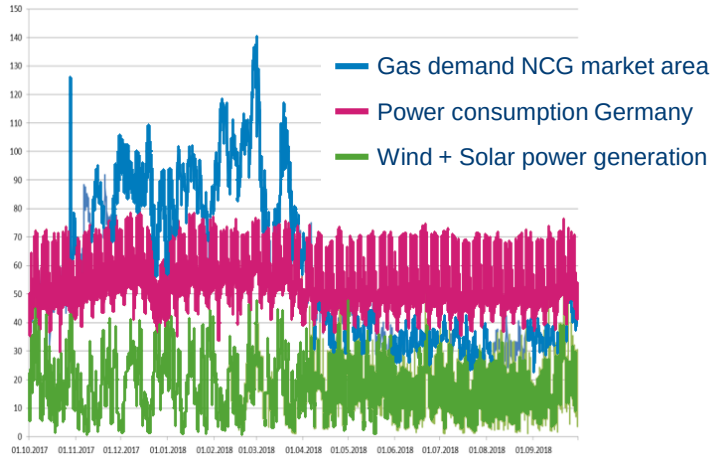
Source: Dena Leitstudie 2018

But its use has a negative climate impact!

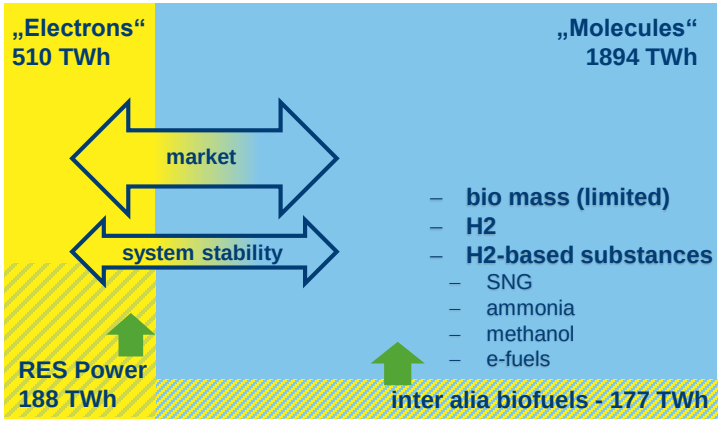
Starting point for OGE Strategy Review in 2018

The future energy system requires molecules - H2 one of very few available alternatives

Energy Capacity Requirement in Germany
(in GW)



Final Energy Demand in Germany
(in TWh/a)



Source: Arbeitsgemeinschaft Energiebilanzen für das Jahr 2017 (08/2018)

High seasonality and energy density require (clean) molecules → H2

The key questions for policy makers re green gas

1. Is there enough climate friendly H2 available at competitive costs?
2. Where will it come from and how will it get to market/customers?
3. How can a market and demand be incentivized and the transition kick-started

Opportunities for TSO

- Making H2 transport feasible, tangible AND a „real“ option
- Aligning partners across the value chain and facilitating services

→ **Preserving asset value and key role in energy system**

OGE strategy reflects H2 as major opportunity for OGE to preserve asset value & develop business opportunities

Purpose

„We enable energy supply. Today and in the energy mix of the future“

Vision/Aspiration OGE 2030+ (2018)

„OGE - The infrastructure and service provider for gaseous energy. We are standing for a transformation of the energy system in Germany and beyond“

Strategic Objectives for 5 years (conf. 2019)

Key H_2 related Projects (2018 – 2020)

- ***Proof of concepts***
- ***Business Development***
- ***Understanding our Grid***

Key policy / lobbying initiatives (2018 – 2020)

- ***Gas-for-Climate (since 2017)****, Taxonomy*
- ***German NDP*** *with green gas scenario and „Visionary Hydrogen Grid “*
- ***Joint initiative*** *to adjust legal framework*
- ***European Hydrogen Backbone***

Why „Gas for Climate“?

Who we are

Gas for Climate was initiated in 2017 to analyse and create awareness about the role of renewable and low carbon gas in the future energy system, aiming for **full compliance with the Paris Agreement target** to limit global temperature increase to well below 2°C.

To this end, the entire economy has to become (net) zero carbon by mid-century.

The Gas for Climate group consists of ten leading European gas transport companies and two biogas consortia:

Source: Gas for Climate

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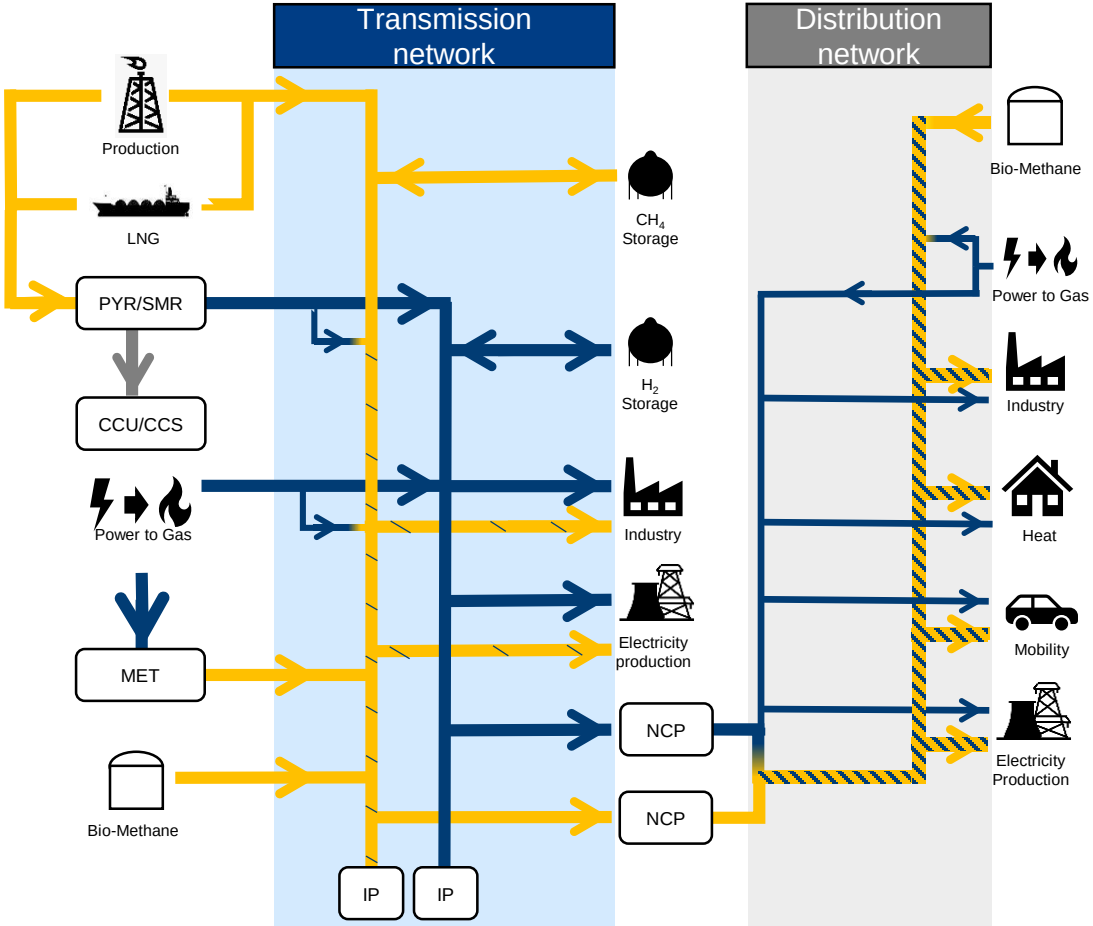
Many studies confirmed: Significant societal cost benefits from mix of renewable power & green gas

Gas and gas infrastructure have a significant role to play – but pre-requisite is that gas is decarbonized (including competitive prices & security of supply)

Long-term vision of the gas infrastructure



PYR = Pyrolysis
SMR = Steam Reforming
ATR= Autothermal Reformer
CCU = Carbon Capture & Usage
CCS = Carbon Capture & Storage
MET = Methanation
IP = Interconnection Point to adjacent system operators
NCP = Network Connection Point to distribution network

Nationwide H2 infrastructure with high potential to curb CO2 emissions

OGE developed vision of nationwide H2 infrastructure with other TSOs:

— approx. 5900 km H2 grid

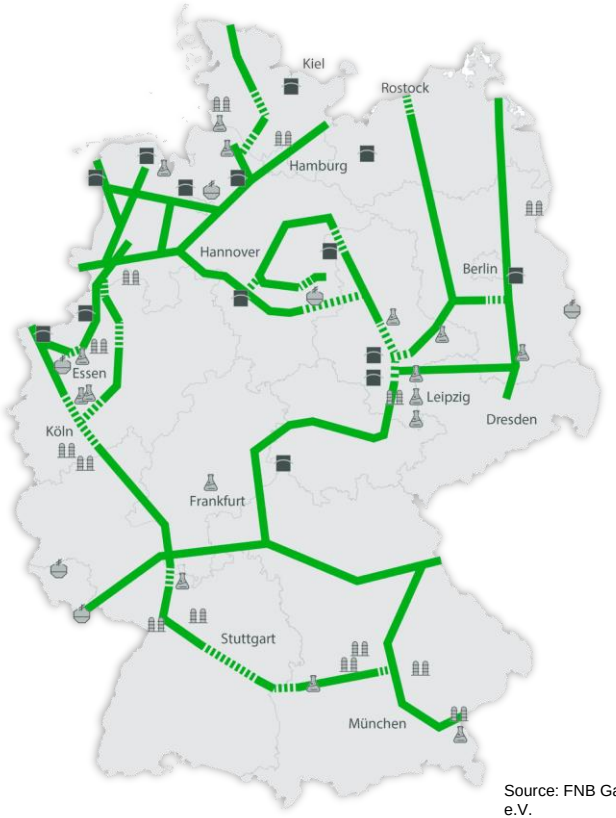
— 90% existing & conversion, 10% new construction

— Transmission network today approx. 40.000 km

Connection to steel works, refineries, large chemical sites, gas power stations, mobility → reaching 90% of the population

European connection feasible (especially NL, BE, AU, FR)

First implementation step in Network Development Plan 2020



Source: FNB Gas e.V.

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Comparison of Hydrogen and Natural Gas
There are differences, but they are manageable!

Hydrogen Flame

	Hydrogen		Natural Gas
Energy Density	33,3 kWh/kg	⇔	13,9 kWh/kg
	3 kWh/m³ (1bar)	⇔	10 kWh/m³ (1bar)
	1990 kWh/m³ (700 bar)	⇔	2660 kWh/m³ (200bar)
Boiling Temperature	-252,9°C (20,3K)		-161,5°C (111,7K) (-195 up to -155°C)
Density	0,0899 kg/m³		0,7175 kg/m³ (0,7 up to 1 kg/m³)
Flame Speed	346 cm/s	⇔	43 cm/s
Ignition Temperature (air)	560°C		595°C (575 up to 640°C)
Ignition Range (air)	4,0 bis 77,0 Vol.-%		4,4 up to 17,0 Vol.-% (4 up to 17 Vol.-%)
Ignition Energy	0,017 mJ	⇔	0,23 mJ

Henriksen and Joachim Lundberg. "A STUDY OF HYDROGEN FLAME LENGTH WITH COMPLEX NOZZLE GEOMETRY." (2017).

OGE Project „Grid of the future“

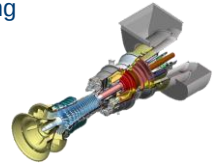
Pipe material/
welds

Gaskets

Flow
measuring

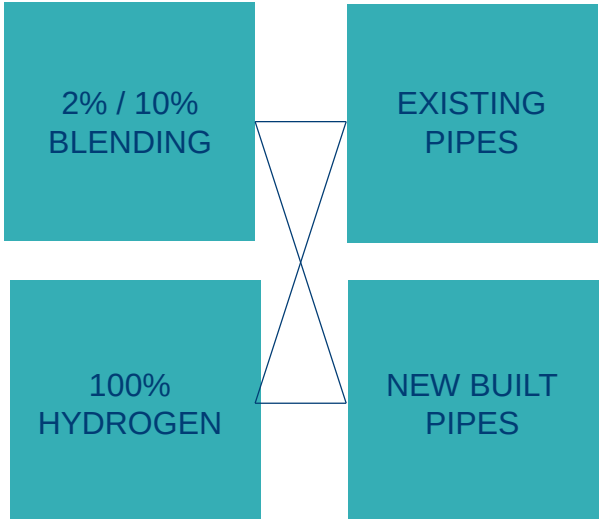
Quality
measuring

Mountings



Gasturbines

Compressors



Pipeline Transport of pure Hydrogen

In principle, NG pipelines **can be converted for hydrogen transport;** some technical modifications are needed

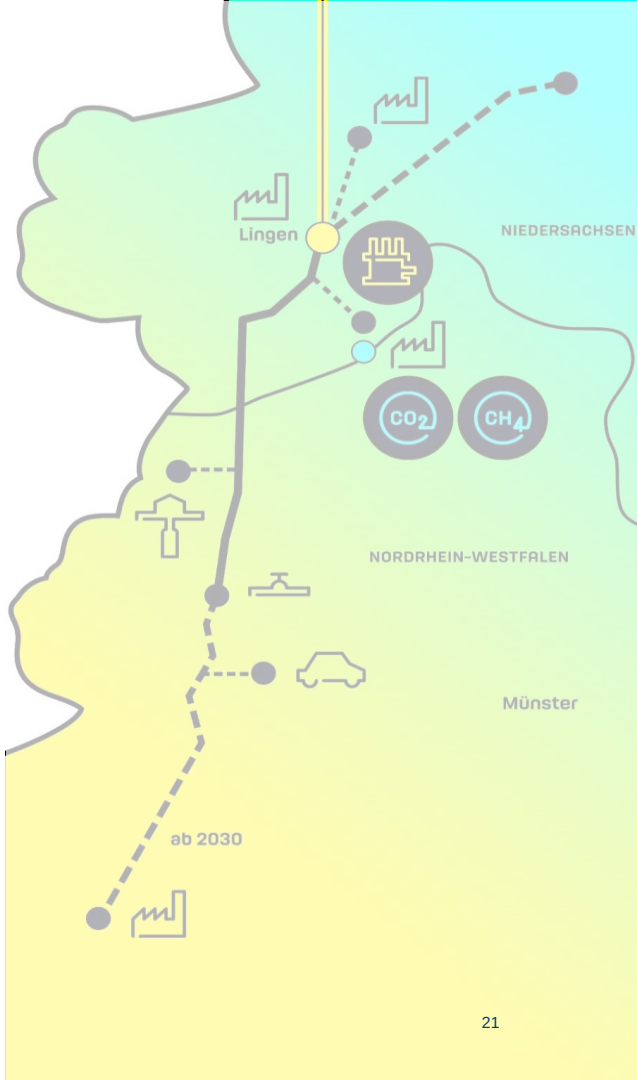
- ☐ **Further inspections based on condition assessment** (Pigging and on-site)
- ☐ **Material Analysis** (Higher content of manganese, phosphorus and sulphur)
- ☐ **Removal of outdated or unsuitable components**
- ☐ **Lifetime prognosis and monitoring of pressure cycles**
- ☐ **Hydraulic Pressure Tests** (only for MOP > 45 bar)

Outcome of the study:

„Regarding the future conveyed medium of hydrogen, there is no need to fear adverse effects on the pipelines“

der TÜV NORD Systems GmbH & Co. KG

Framework for CH_4-H_2 conversion is established, first promising cases have been investigated.



Conclusion

Hydrogen is technically controllable

NG Pipelines can generally be converted to hydrogen transport

Some technical modifications are needed, especially for compressors

Pipeline Transport of hydrogen is the best option for high volumes/capacities

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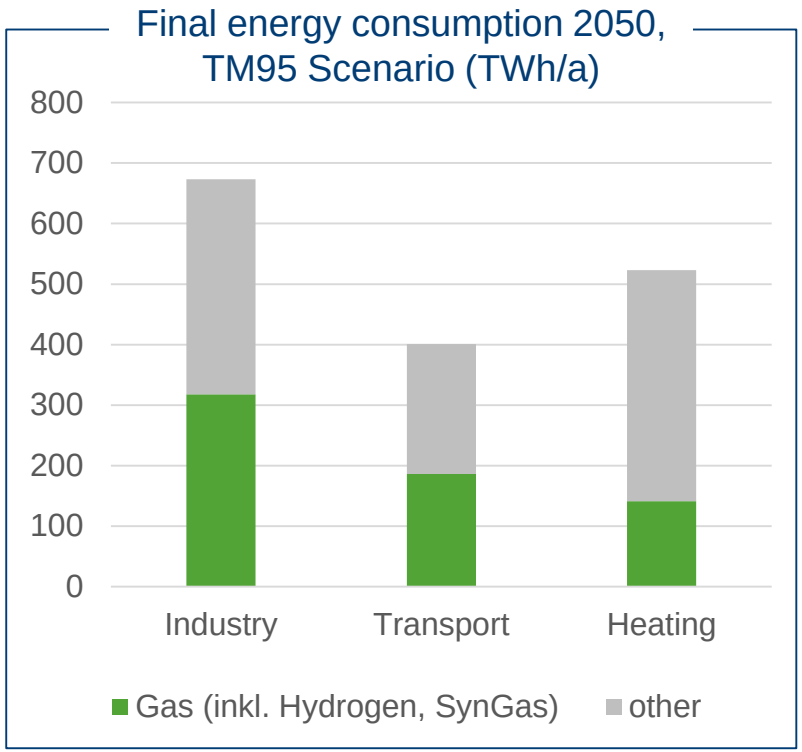
Dena: Demand for green gas will increase dynamically



Source: Dena Leitstudie 2018

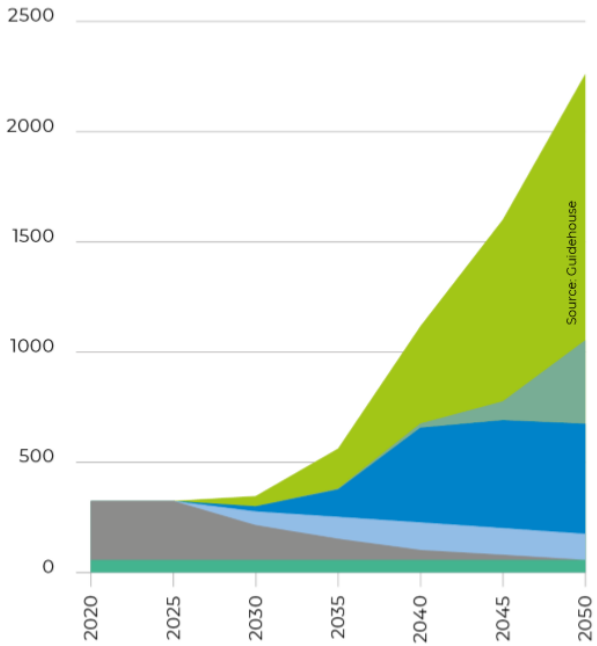
- In the technology mix scenario of Dena Leitstudie green gas (hydrogen, biomethane, synthetic methane) has a significant share of final energy consumption in all sectors in 2050
- Whereas gas plays almost no role in transport currently, green gas will be an important factor in transportation in the future

Dena: Demand for green gas will increase dynamically

Hydrogen supply 2020 to 2050

- Green hydrogen
- Hydrogen for synfuels
- Blue hydrogen - greenfield
- Blue hydrogen - existing industry
- Grey hydrogen - existing industry
- By-product hydrogen

Note that the supply in this figure exceeds the 1,710 TWh of the Gas for Climate 2050 Optimised Gas end state because supply is included from petrochemicals, which was previously out of scope, and production of synthetic fuels.

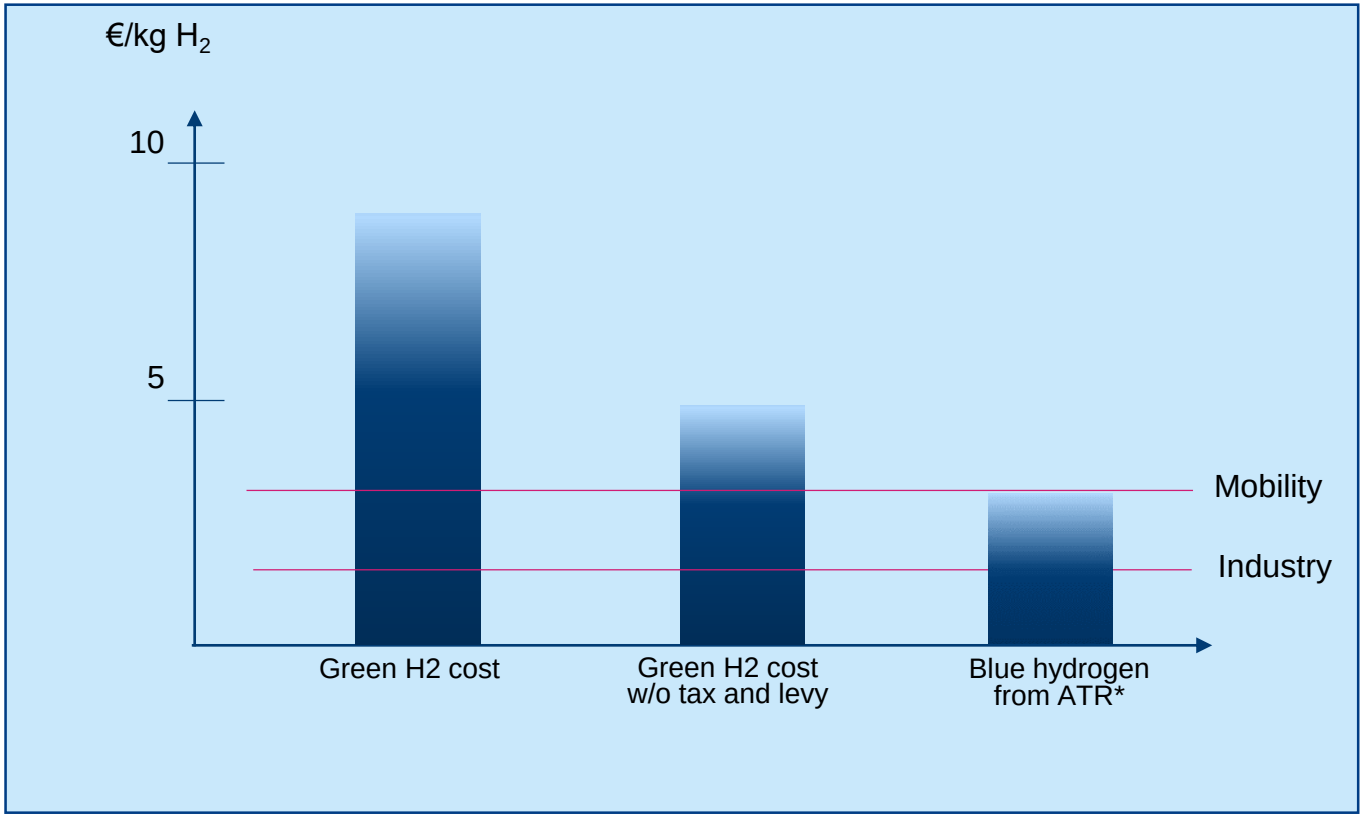


GAS FOR CLIMATE
A path to 2050

Source: Gas for Climate Pathways report 2020

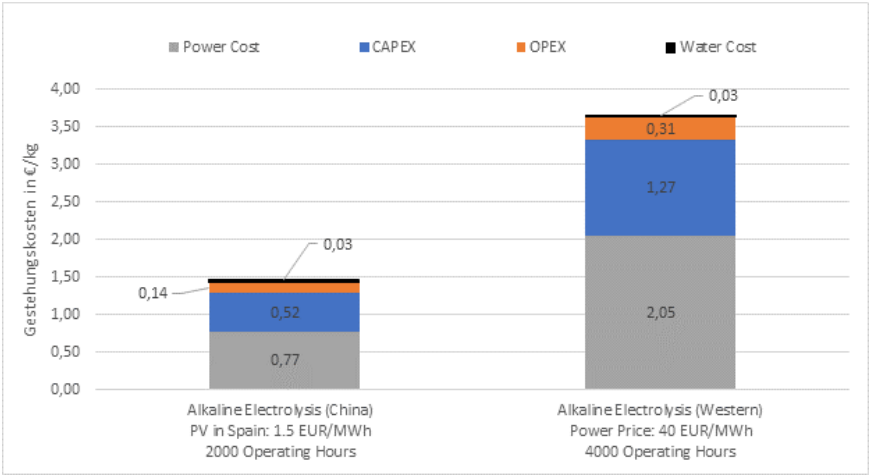
Hydrogen: Economic gap today

— Cost for green hydrogen based on baseload power cost and Western electrolysis cost



Source for green hydrogen: OGE based on Dena, IndWEDe (2018), etc./ for blue hydrogen: h2morrow; *ATR. Autothermal Reforming

Green hydrogen has the potential to become competitive and outcompete fossils



With current Chinese CAPEX for electrolyzers hydrogen production cost might fall significantly below 2 €/kg.

Assumptions

- CAPEX for bigger electrolyzers drops to Chinese levels at ~200 US$/kW vs. current West European projects @800 US$/kW.
- Elimination of levies and taxes on power for electrolysis according to action 1 of the German Hydrogen Strategy
- Renewable power price of 1.5 Eur/MWh (Spain/Portugal) vs. 4 Eur/MWh offshore wind.
- 10 years amortization period, 4% interest

Connecting Europe – The Hydrogen Backbone
TSOs join forces under Gas for Climate (new initiative)

What is it about:

— Agreement to work on vision for European Hydrogen Backbone

— Making large scale competitive hydrogen from Southern Europe and North sea available for NWE

Next steps:

— Workshop to agree „Storyline“ in March

— Identification of „blanks“ that need to be filled to complete storyline

— Target: Completion of European vision in summer 2020

* Map from Entsog. Exact route to be planned subject to capacity, availability of existing pipes, permits, anchor customers etc.

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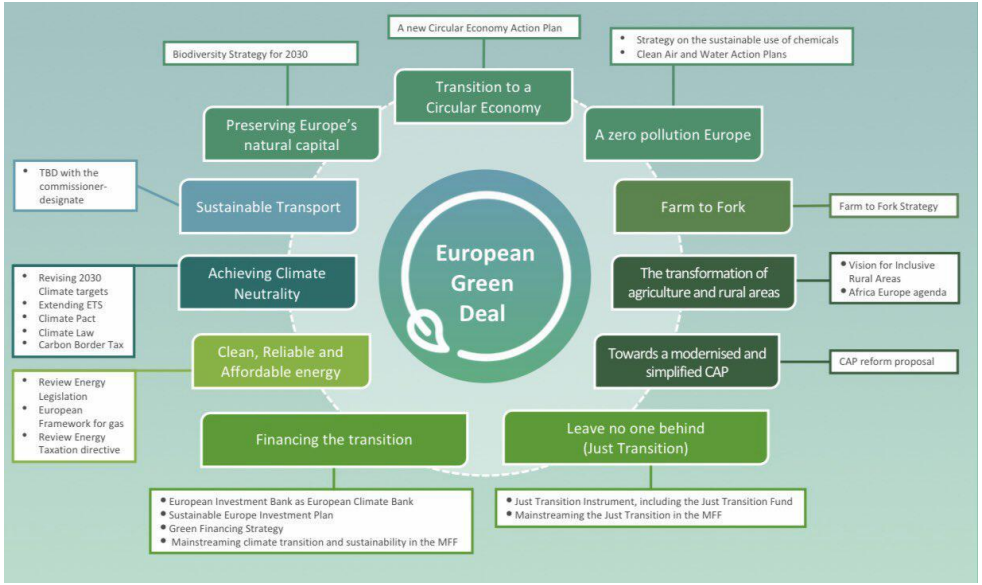
Walking the talk –
EU and Germany turn Paris targets into reality

1,5°C

- Clean Energy Package
- Green Deal
- EU Climate Law
- EU Hydrogen Strategy
- Reallabore
- Climate Protection Plan
- Climate Law
- Gas Dialogue & Hydrogen Strategy

EU climate neutral by 2050: „Green Deal“ likely to push hydrogen development

- Green Deal focus point of Ursula von der Leyen‘s presidency
- Mobilising >1 trillion € over next 10 years
- Hydrogen with important role



“I see a pivotal role for hydrogen”
“Hydrogen could be applied using a lot of infrastructure we already have”

Frans Timmermans, Executive VP of the Commission, leading the Commission’s work on the **European Green Deal** and its first **European Climate Law**

National Hydrogen Strategy (NWS) sets the course for hydrogen in Germany

5 GW until 2030

Green and blue hydrogen

Role of infrastructure confirmed

Funding with 7 bn €

Focus on industry and mobility

OGE CEO member of the national hydrogen council

- National H2 Strategy important first milestone
- In many European countries hydrogen strategies are being formulated, inter alia NL and UK
- There is a focus in Northwestern Europe so far, but Spain and Italy seem to follow

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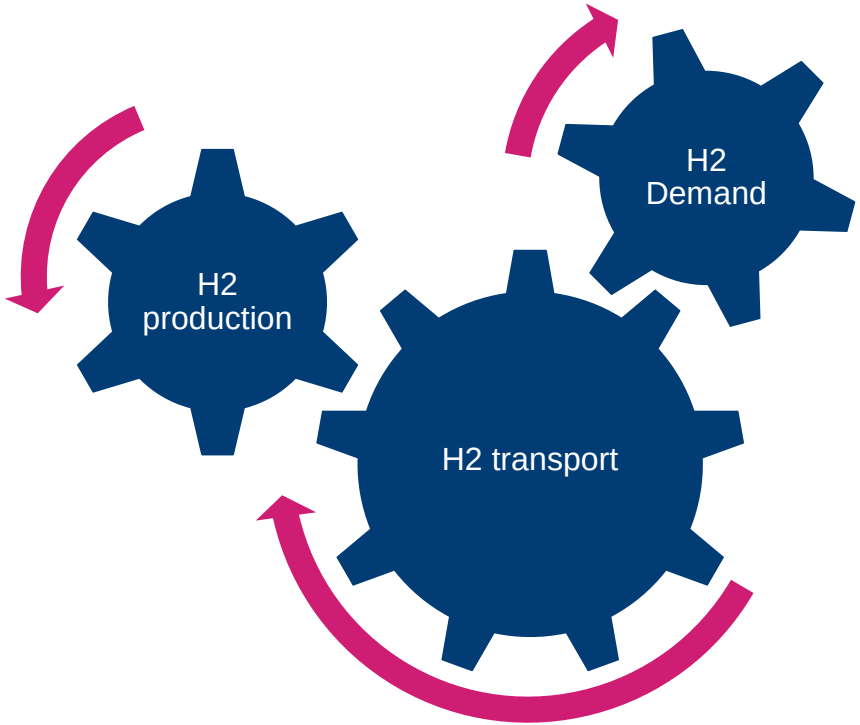
Alignment of value chain is key – cooperation is the only way, regulatory frameworks essential



- Manageable challenges along the value chain
- Topics are of technical, economic, political and cultural nature
- Numerous „chicken-and-egg“ hurdles
- Knowledge how to build long-term value chains still around

Things to look out for in the hydrogen debate

- Blending vs. pure hydrogen philosophies
- Methanation vs. pure hydrogen
- The „colour“ of hydrogen
- Parallel Infrastructure(s)
- Sector integration / sector coupling
- Political incentives and framworks
- Cost- and Access Regulation
- Security of demand to stimulate large investments
- Large & long-term investment potential
- Green hydrogen can outcompete fossils within 20 years

We are at the beginning of a new phase of energy transition

We enable energy supply.
Today and in the energy mix of the future.

OGE