

# General and Contractual Risks of Hydrogen Decarbonization

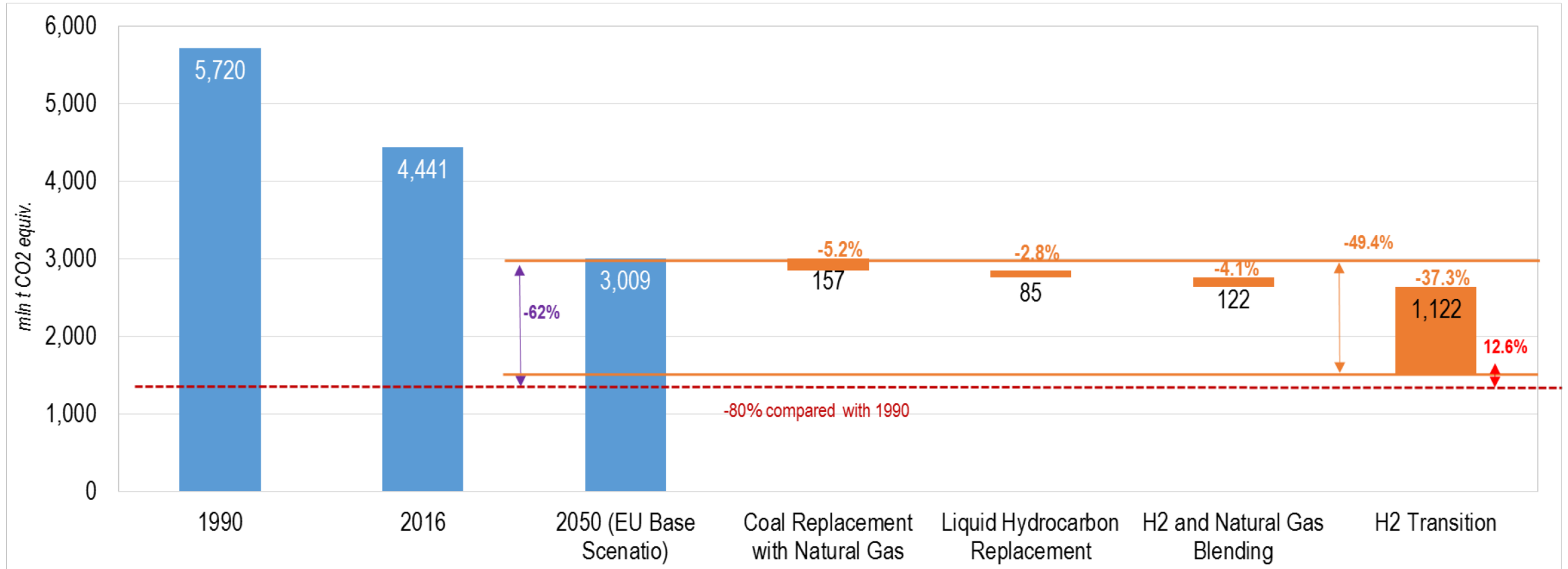
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# Hydrogen and GHG Emissions



Source: thinkstep AG

## 1 NATURAL GAS

*DECARBONISATION OF EU ENERGY AND TRANSPORT  
SECTORS BY NEARLY 2 TIMES*

## 2 MHM METHANE-HYDROGEN ENERGY SOURCE

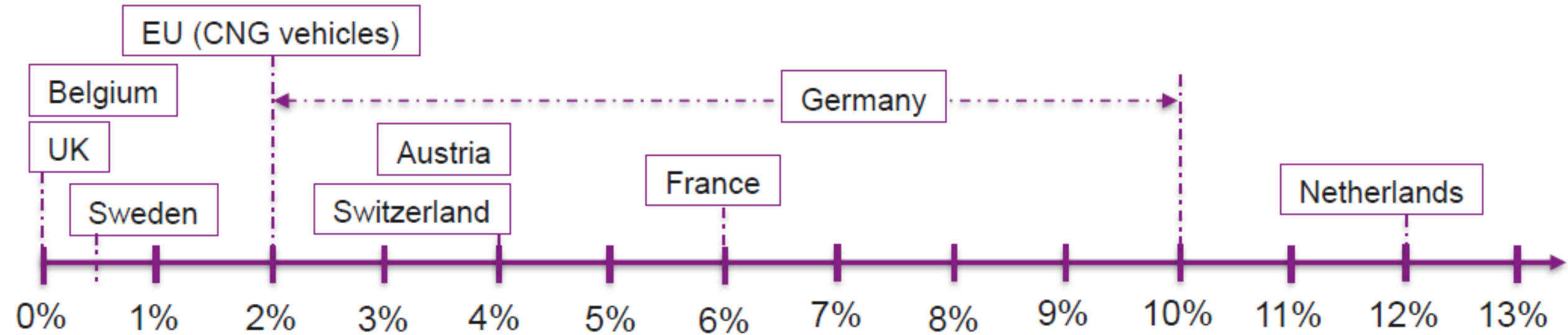
*ACHIEVMENT OF EU CLIMATE TARGETS FOR 2030*

## 3 HYDROGEN

*ESTABLISHING OF ACCEPTABLE CONDITIONS FOR  
THE DEVELOPMENT OF HYDROGEN ENERGY FROM  
NATURAL GAS*

# Hydrogen Admission Rates at National Gas Grids

EU DIN EN 16723: 0.5%  
Turbines: 1-5%



What are the reasons for these limitations?

Source: thinkstep AG

# Hydrogen Extension Risks

Area	“Safe” upper H <sub>2</sub> boundary	Consequences of threshold elevation
Accidents	50%	Higher frequency of failures, higher ignition probability
Explosion hazard	20%	Increased severity of explosions
GTS	20%	By more than 25% H <sub>2</sub> lower resistance to embrittlement and degradation mechanisms of pipeline material, by more than 30% - need for pipeline and compressors modification; UGSs – risk of leakage, colmatation, contamination, unclear interacting with other substances
Households	15-20% (28%)	Need for modification
Industry	4%	Need for modification
Leakage	17% (20%)	Leakage rate – not more than 0.0005% of transported H <sub>2</sub> . According to some estimates, up to 1.4%, e.g. only 60-70% of gas from Northern Africa can reach Europe
Assets integrity		Costs increase up to 10%

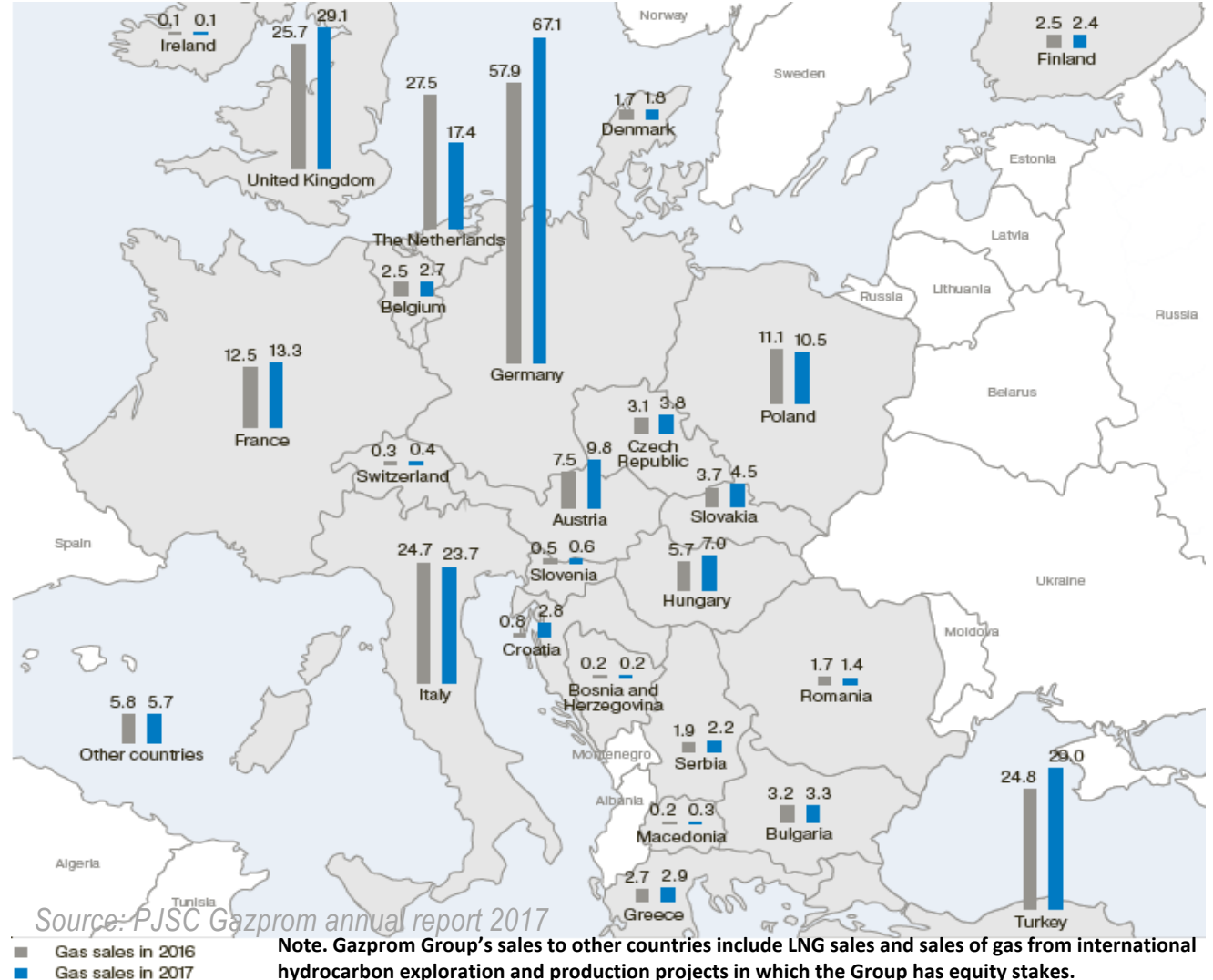
All sides (suppliers, buyers and TSO) are involved

Source: thinkstep AG

# Gazprom Group's portfolio of signed contracts

- European countries have been among the key consumers of Russian gas for over 50 years.
- Gazprom Group has highly complex and diversified portfolio of signed contracts with the main focus on European Gas Market.
- The largest amount of natural gas sales in the portfolio are under the contracts with Germany, Italy, United Kingdom, France and Austria.
- Gazprom Group's portfolio of signed contracts provides for gas sales to Europe in the amount exceeding 4 trillion cubic meters over the contract period.

**Gazprom Group's gas sales to far abroad countries, bcm**



# Contractual risks of decarbonization

Risks	Consequences
<b>Gas quality and composition changes due to hydrogen injection:</b> <ul style="list-style-type: none"> <li>Gross Calorific Value (GCV);</li> <li>Wobbe Index (WI);</li> <li>Amount of Methane (CH<sub>4</sub>);</li> <li>Amount of Ethane (C<sub>2</sub>H<sub>6</sub>).</li> </ul>	<ul style="list-style-type: none"> <li>Violation of contractual obligations regarding gas quality leading to financial penalties/deficiencies or rejection of all or part of gas by Buyer/TSO. <b>(Natural gas quality Clause) - buyers, shippers and TSOs are affected;</b></li> <li>Decreased energy content of decarbonized gases. <b>(Quantity Clause) - buyers are affected.</b></li> </ul>
<b>Operational issues due to hydrogen injection:</b> <ul style="list-style-type: none"> <li>Hydrogen embrittlement and H<sub>2</sub> effects on crack propagation;</li> <li>Degradation mechanisms of pipeline material can facilitate fatigue behavior of steel pipe;</li> <li>Compressors and gas turbines are sensitive to hydrogen fuel.</li> </ul>	<ul style="list-style-type: none"> <li>Operational accidents leading to unscheduled repair works which can cause commercial losses due to stop or decrease of deliveries. <b>(Capacity Clause, Repairs and Maintenance Clause) - buyers, shippers and TSOs are affected;</b></li> <li>Additional investments in network infrastructure which can impact established transportation tariffs. <b>(Tariffs Clause) –TSOs and shippers are affected.</b></li> </ul>
<b>Metering</b> Hydrogen concentrations of more than 10% can rise gas quality and composition measurements issues	Metering issues can cause commercial losses, reputation risks, problems with interoperability data exchange, numerous disputes and investigations. <b>(Measurement Clause) - TSOs are affected.</b>

All sides (suppliers, buyers and TSO) are involved

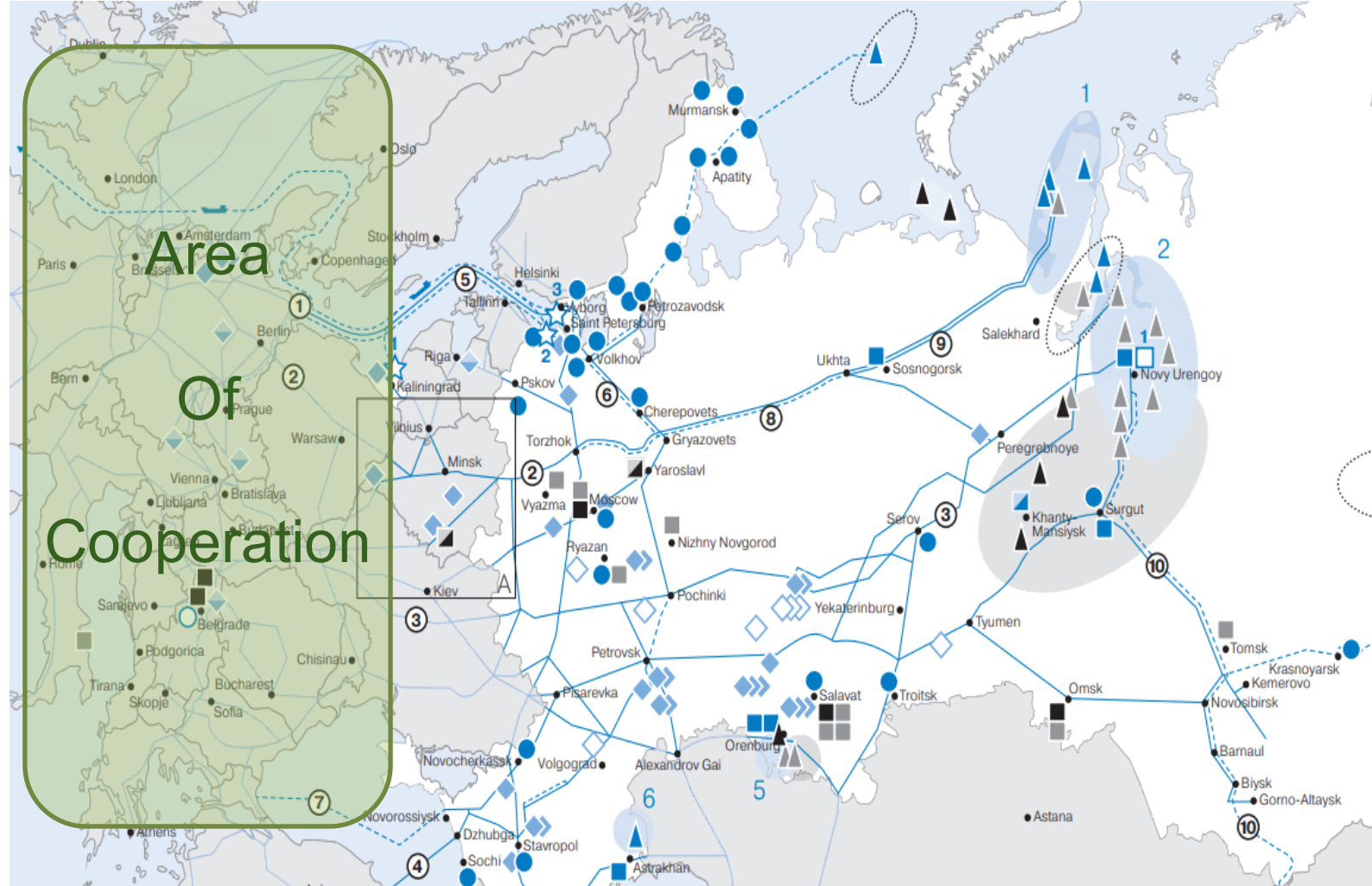


# The Rational Decarbonization Solution

- Decarbonization downstream at consumers side
- Hydrogen production by methane cracking technology at end-users



Only by joint efforts we can find a rational solution that satisfies all the stakeholders



Thank you for your attention!