

General and Contractual Risks of Hydrogen Decarbonization

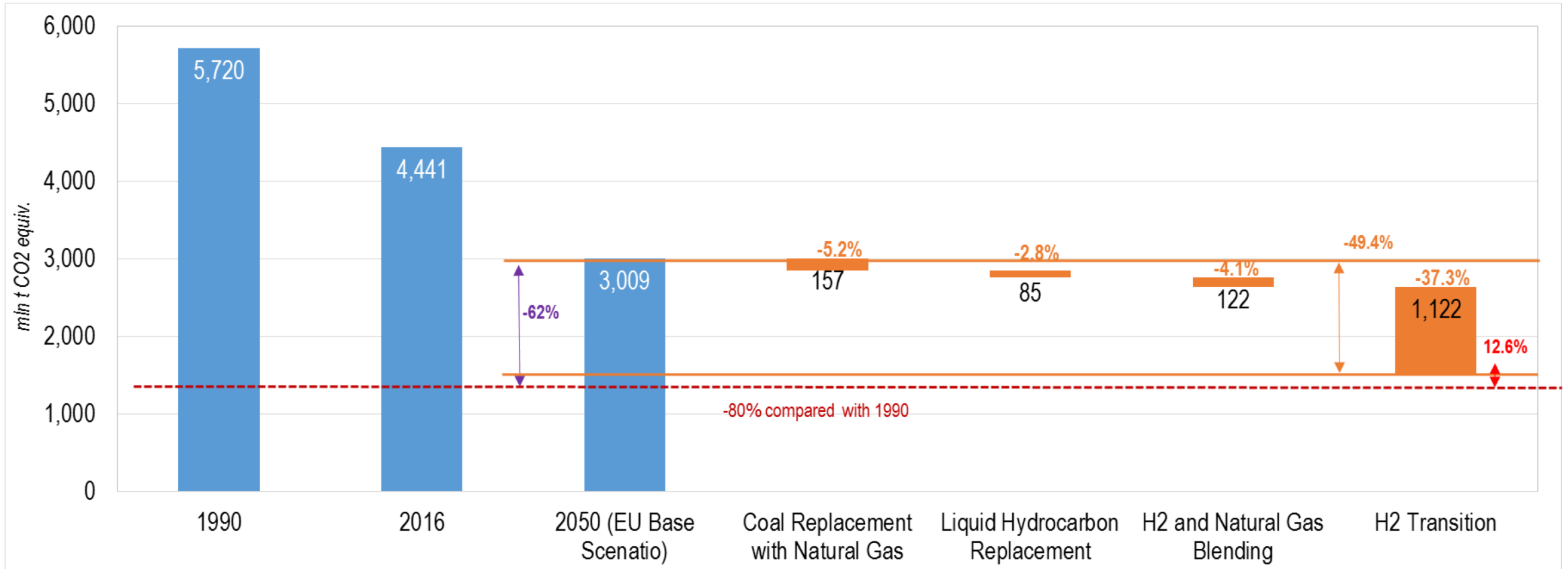
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Hydrogen and GHG Emissions



Source: thinkstep AG

1 NATURAL GAS

DECARBONISATION OF EU ENERGY AND TRANSPORT SECTORS BY NEARLY 2 TIMES

2 MHM METHANE-HYDROGEN ENERGY SOURCE

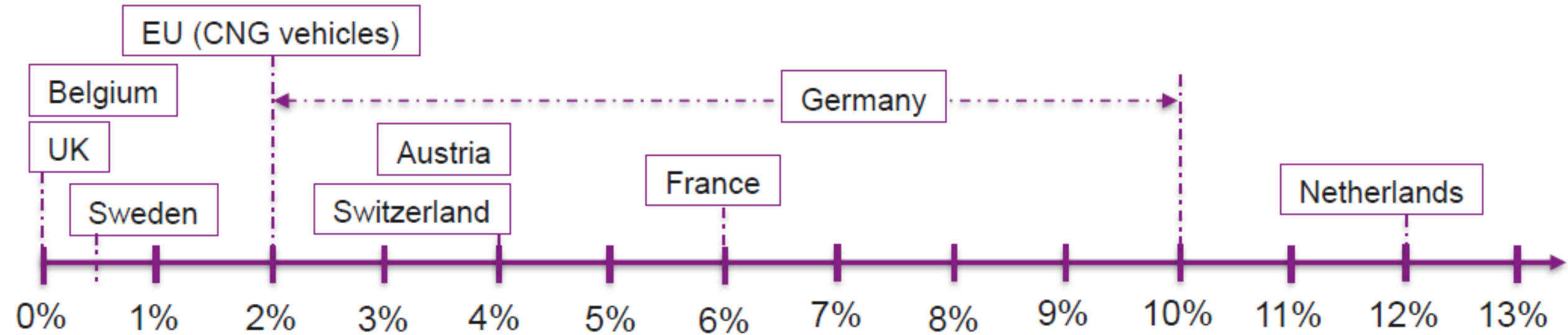
ACHIEVMENT OF EU CLIMATE TARGETS FOR 2030

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 ₂ 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 ₂ 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 ₂ . 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%

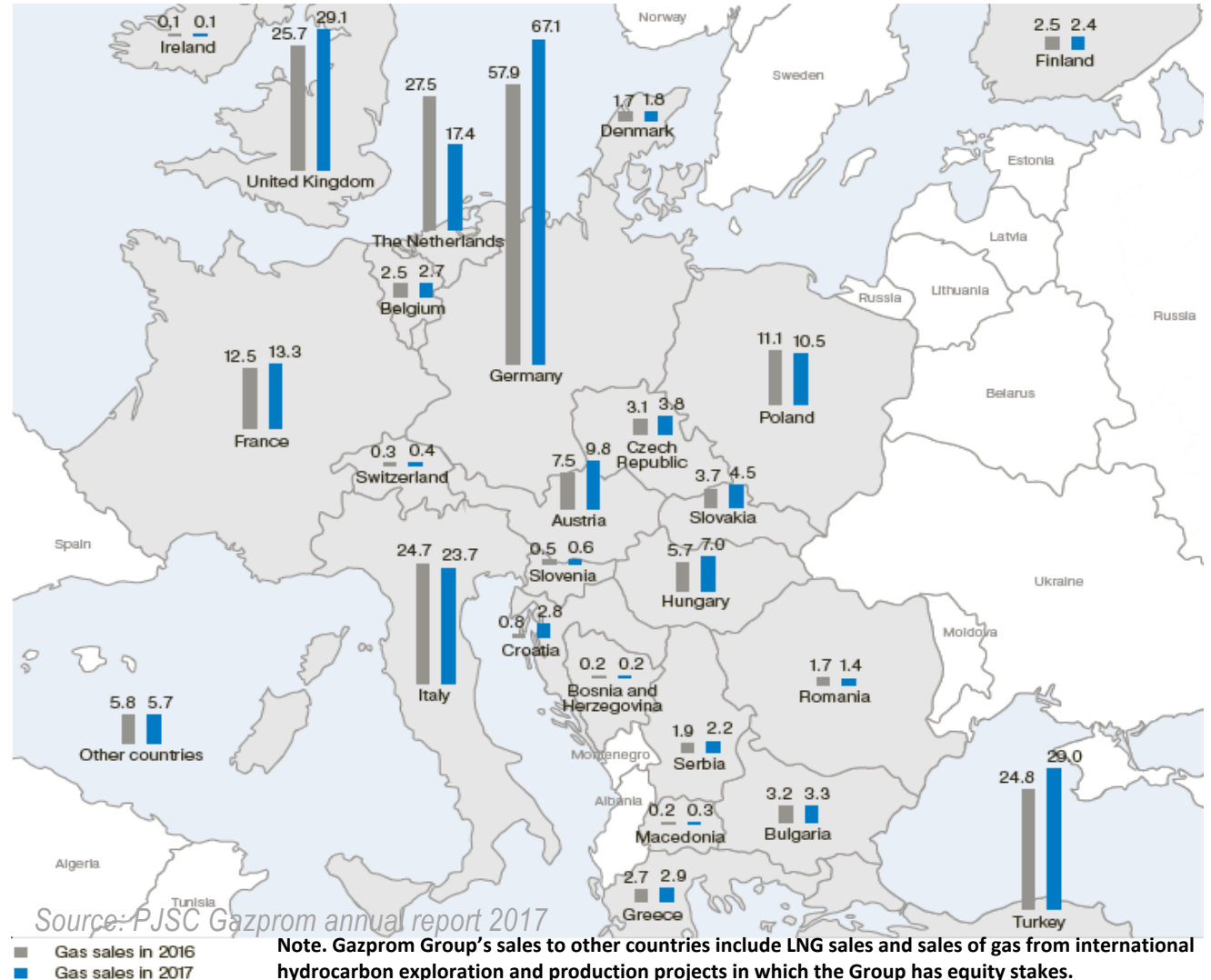
All sides (suppliers, buyers and TSO) are involved

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
Gas quality and composition changes due to hydrogen injection: <ul style="list-style-type: none"> Gross Calorific Value (GCV); Wobbe Index (WI); Amount of Methane (CH₄); Amount of Ethane (C₂H₆). 	<ul style="list-style-type: none"> Violation of contractual obligations regarding gas quality leading to financial penalties/deficiencies or rejection of all or part of gas by Buyer/TSO. (Natural gas quality Clause) - buyers, shippers and TSOs are affected; Decreased energy content of decarbonized gases. (Quantity Clause) - buyers are affected.
Operational issues due to hydrogen injection: <ul style="list-style-type: none"> Hydrogen embrittlement and H₂ effects on crack propagation; Degradation mechanisms of pipeline material can facilitate fatigue behavior of steel pipe; Compressors and gas turbines are sensitive to hydrogen fuel. 	<ul style="list-style-type: none"> Operational accidents leading to unscheduled repair works which can cause commercial losses due to stop or decrease of deliveries. (Capacity Clause, Repairs and Maintenance Clause) - buyers, shippers and TSOs are affected; Additional investments in network infrastructure which can impact established transportation tariffs. (Tariffs Clause) –TSOs and shippers are affected.
Metering 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. (Measurement Clause) - TSOs are affected.

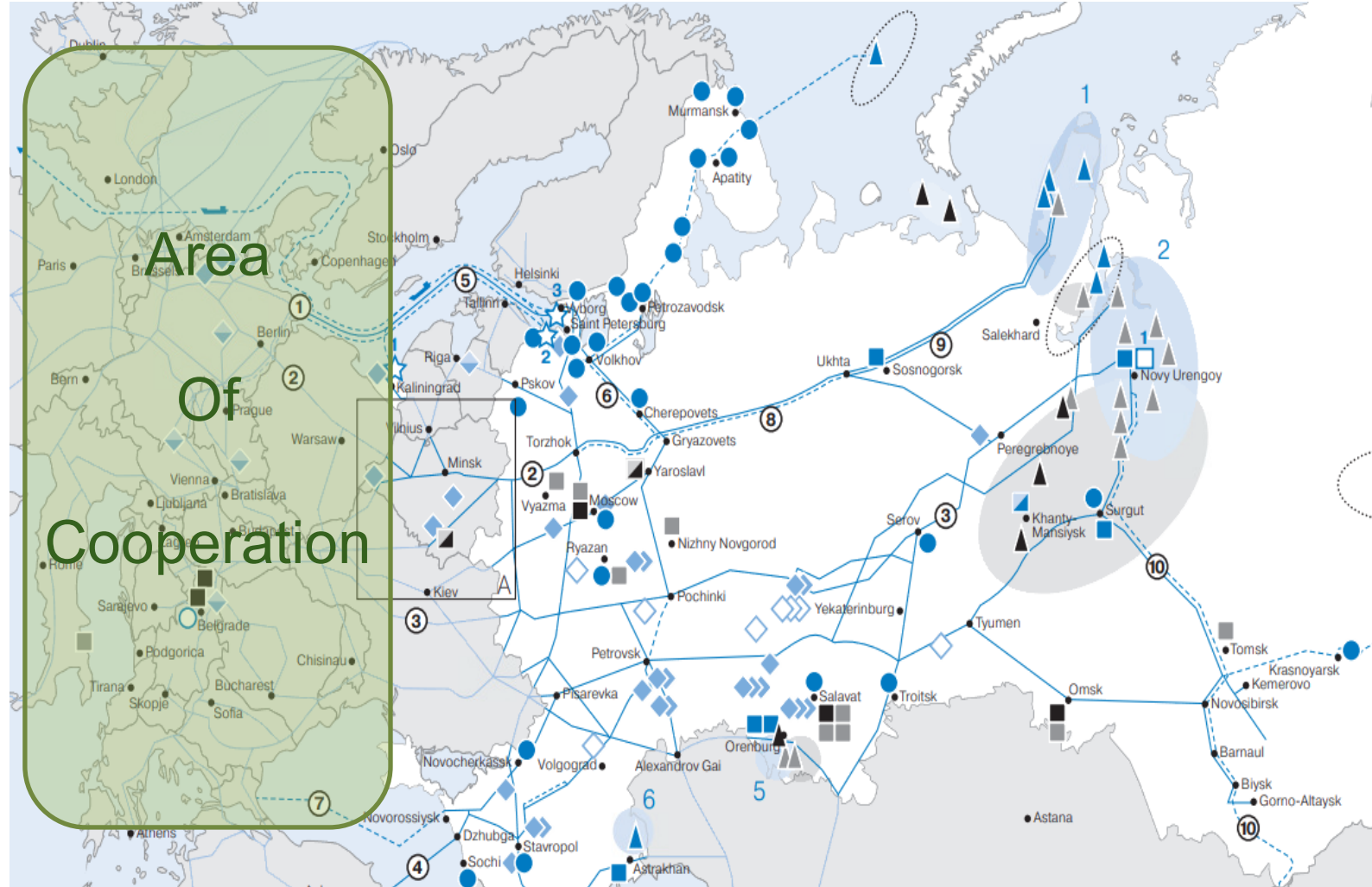
All sides (suppliers, buyers and TSO) are involved

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!