Potential of natural gas decarbonization:
Russian view of the cross-border gas value chain

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COP21 Decision
(on adoption of the Paris Agreement on Climate Change):
countries are required to prepare by 2020
2050 long-term low GHG emission development strategy

Nationally determined contributions

New regulations

Future of energy

Potential of natural gas decarbonization: Russian view of the cross-border gas value chain
METHANE-HYDROGEN SCENARIO FOR LOW-CARBON DEVELOPMENT

TOTAL GHG EMISSIONS IN THE EU, 2016

4.3 BMT CO₂ eq. (EV LULUCF)

13-18 %
THE SWITCH FROM COAL POWER GENERATION AND PETROLEUM MOTOR FUELS TO NATURAL GAS

25-35 %
THE USE OF METHANE-HYDROGEN FUEL IN ENERGY AND TRANSPORT W/O COSTLY INFRASTRUCTURAL CHANGES

Transition to hydrogen energy based on efficient low-emission technologies of hydrogen production from methane

~80 %
The feasibility of the EU’s challenging 2050 targets

Rapid reduction of GHG emissions
Achieving the EU’s 2030 climate targets based on the existing gas infrastructure

The feasibility of the EU’s challenging 2050 targets

A EUROPEAN STRATEGIC LONG-TERM VISION FOR A PROSPEROUS, MODERN, COMPETITIVE AND CLIMATE NEUTRAL ECONOMY

<table>
<thead>
<tr>
<th>Main Drivers</th>
<th>Electrification (ELEC)</th>
<th>Hydrogen (H2)</th>
<th>Power-to-X (P2X)</th>
<th>Energy Efficiency (EE)</th>
<th>Circular Economy (CIRC)</th>
<th>Combination (COMBO)</th>
<th>1.5°C Technical (1.5TECH)</th>
<th>1.5°C Sustainable Lifestyles (1.5LIFE)</th>
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<tbody>
<tr>
<td>GHG target in 2050</td>
<td>Electrification in all sectors</td>
<td>Hydrogen in industry, transport and buildings</td>
<td>E-fuels in industry, transport and buildings</td>
<td>Pursuing deep energy efficiency in all sectors</td>
<td>Increased resource and material efficiency</td>
<td>Cost-efficient combination of options from 2°C scenarios</td>
<td>Based on COMBO with more BECCS, CCS</td>
<td>Based on COMBO and CIRC with lifestyle changes</td>
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<tr>
<td>• Higher energy efficiency post 2030</td>
<td>• Market coordination for infrastructure deployment</td>
<td>• BECCS present only post-2050 in 2°C scenarios</td>
<td>• Significant learning by doing for low carbon technologies</td>
<td>• Significant improvements in the efficiency of the transport system.</td>
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<td>• Deployment of sustainable, advanced biofuels</td>
<td>• Lower CO2 emissions from transportation</td>
<td>• Higher CO2 savings from residential heating</td>
<td>• Lower CO2 emissions from industrial processes</td>
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<td>• Digitalisation</td>
<td>• Reduced CO2 emissions from manufacturing</td>
<td>• Enhanced energy efficiency in buildings</td>
<td>• Enhanced energy efficiency in transport</td>
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**Overview of Main Scenario Building Blocks**

**Power sector**

Power is nearly decarbonised by 2050. Strong penetration of RES facilitated by system optimization (demand-side response, storage, interconnections, role of prosumers). Nuclear still plays a role in the power sector and CCS deployment faces limitations.

<table>
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<tr>
<th>Industry</th>
<th>Electrification of processes</th>
<th>Use of H2 in targeted applications</th>
<th>Use of e-gas in targeted applications</th>
<th>Reducing energy demand via Energy Efficiency</th>
<th>Higher recycling rates, material substitution, circular measures</th>
<th>Combination of most Cost-efficient options from “well below 2°C” scenarios with targeted application (excluding CIRC)</th>
<th>CIRC+COMBO but stronger</th>
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<tr>
<td>Buildings</td>
<td>Increased deployment of heat pumps</td>
<td>Deployment of H2 for heating</td>
<td>Deployment of e-gas for heating</td>
<td>Increased renovation rates and depth</td>
<td>Sustainable buildings</td>
<td>COMBO but stronger</td>
<td>CIRC+COMBO but stronger</td>
</tr>
<tr>
<td>Transport sector</td>
<td>Faster electrification for all transport modes</td>
<td>H2 deployment for HDVs and some for LDVs</td>
<td>E-fuels deployment for all modes</td>
<td>Increased modal shift</td>
<td>Mobility as a service</td>
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<tr>
<td>Other Drivers</td>
<td>H2 in gas distribution grid</td>
<td>E-gas in gas distribution grid</td>
<td></td>
<td></td>
<td></td>
<td>Limited enhancement natural sink</td>
<td></td>
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</tbody>
</table>

Potential of natural gas decarbonization: Russian view of the cross-border gas value chain
1. DEPENDANCE ON RARE EARTH METALS EXTRACTION
(THE SHORTAGE OF CONSIDERABLE RESERVES IN THE EU)

Monopoly position of some countries
Risks of non-compliance with environmental standards
Social conflicts in extraction areas

2. DEPENDANCE ON ENERGY STORAGE SYSTEMS

NO CONTINUITY OF ELECTRICITY GENERATION
COMPARABLE TO THE ELECTRICITY GENERATION SYSTEM

THE NEED FOR AN UNMANAGEABLE POWER GRID SYSTEM
(the refusal of land owners)

3. DEPENDANCE ON CLIMATE CHANGE

CLIMATE CHANGE – SHAKY FOUNDATIONS FOR RES
MORE EXTREME WEATHER EVENTS

MORE BLACKOUTS

Potential of natural gas decarbonization: Russian view of the cross-border gas value chain
ADVANTAGES OF NATURAL GAS OVER RESOURCES

CONSUMPTION OF MATERIALS AND VALUABLE CHEMICAL ELEMENTS

IMPACT ON ECOSYSTEMS

ENERGY RETURN ON ENERGY INVESTED

GAS-FIRED POWER GENERATION

RENEWABLE ENERGY

22% 140-353% 61-127%

21% 28 2

* over the world energy balance

Sources:
- UNEP
- International Renewable Energy Agency

Potential of natural gas decarbonization: Russian view of the cross-border gas value chain
“Hydrogen has long been used by the chemical industry as a feedstock in industrial processes. Its role is likely to become more prominent in a fully decarbonised energy system.”

“Hydrogen is also assumed to be produced in the EU. Clearly, building the necessary production assets – be it for hydrogen or e-gas production and upgrading the gas infrastructure (in case large quantities of hydrogen are to be distributed) in the light of currently high costs and nascent demand would be a challenge from the industrial policy perspective. Studies indicate that some areas within the EU could be well suited to production of hydrogen/e-gas be it because of abundant production of renewables (e.g. offshore in the North Sea or, in general, close to grids giving access to diversified and big amounts of renewables) or proximity to nuclear power stations or close to industrial buyers.”
“The decarbonisation scenarios explored in this document assume that decarbonised energy carriers (electricity, hydrogen, e-gas, e-liquids) would all be produced within the EU. However, as it is the case today for oil, natural gas and biofuels, hydrogen and e-fuels could actually be globally traded commodities and imported from regions with comparatively cheaper, abundant renewables.”
“Finally, it has to be noted that hydrogen is only marginally used in power generation (some 15 Mtoe in the H2 scenario), and that e-gas or e-liquids are virtually not used in this sector. Hydrogen provides important services as a chemical storage.”

Source: Eurostat (2000, 2015), PRIMES
GAS VS HYDROGEN CONSUMPTION

Total gas consumption per gas type

- e-gas
- biogas and waste gas
- natural gas

Note 1: e-gas does not develop in the other scenarios. In this case, e-gas is replaced by biogas and waste gas. The share of e-gas in the consumption of natural gas is also shown.

Consumption of hydrogen by sector in 2050

- Transport
- Residential & services (including agriculture)
- Industry
- Power sector (storage)

Note: «Residential & services» also includes agriculture.
THE SELECTION OF LOCATION FOR HYDROGEN PRODUCTION

GAS CHEMISTRY, ETC.

METHANE

\[ \text{CH}_4 + \text{H}_2 \]

NATURAL GAS

Potential of natural gas decarbonization: Russian view of the cross-border gas value chain
DECARBONISATION OF GAS SUPPLY

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Diagram showing CO2 emissions for various gas supply processes:
- Algeria: 16.9 g CO2eq / MJ (LHV)
- Australia (NWS): 20.0 g CO2eq / MJ (LHV)
- Australia (QL): 28.7 g CO2eq / MJ (LHV)
- Qatar: 14.9 g CO2eq / MJ (LHV)
- USA: 23.6 g CO2eq / MJ (LHV)
- Russia (Nord Stream 2): 6.3 g CO2eq / MJ (LHV)

Legend:
- Production & Processing
- Liquefaction
- Pipeline Transport
- LNG Transport
- Purification
- Regasification
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**NORD STREAM 2 (L > 1220)**

- BOVANENKOVO to GREIFSWALD
- L = 4166 bcm per year

**BOVANENKOVO-UZHGOROD-BAUMGARTEN**

- BOVANENKOVO to WAIDHAUS
- L = 6051

**DIFFERENCE IN GHG EMISSIONS**

- Mt of CO2-eq.
  - Annually: 8.94
  - In 25 years: 223.38

- More than ICELAND + MALTA or CYPRUS
- More than the NETHERLANDS or THE WHOLE TRANSPORT SECTOR OF GERMANY

**AMOUNTING TO ANNUAL EMISSIONS**

Calculated according to GHGenius 4.03
DECARBONISATION OF GAS SUPPLY: METHANE EMISSIONS MANAGEMENT

Guiding principles:
«Reducing methane emissions across the natural gas value chain»

- PERMITTING
- MONITORING
- FEE COLLECTION
- SUPERVISION

Greenhouse gas

Methane emissions monitoring and detection

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DECARBONISATION OF GAS SUPPLY: METHANE EMISSIONS MANAGEMENT

Gazprom methane emissions (1990-2017)

- 1899 Kt CH₄ in 1990
- 1362 Kt CH₄ in 2017
- 28% decrease

Methane emissions by main activities, Gazprom, 2017

**GAS PRODUCTION**

- 0.02% of total produced gas

**GAS TRANSPORTATION**

- 0.27% of total transported gas

**GAS STORAGE**

- 0.03% of total UGS gas

Russian Best available techniques Reference document (BREF, gas production) for permitting

- 0.06-0.18%
RENEWABLE ENERGY SOURCES (EXAMPLES)

TELEMECHANICS SYSTEM UNIT FOR THE GROUP OF WELLS AT YAMBURG GAS-OIL CONDENSATE FIELD

MODULAR PACKAGED ENERGY SAVING UNIT USING SOLAR MODULES AT GAS DISTRIBUTION STATION

ALTERNATIVE ENERGY SOURCES

THERMOELECTRIC GENERATORS AT GAS PROCESSING PLANTS

TURBO-EXPANDERS AT GAS DISTRIBUTIONS STATIONS

RENEWABLE AND ALTERNATIVE ENERGY IN GAZPROM, 2015-2017

Gazprom bank financed the construction of solar power plants and windmills in Russia:

109.6 billion rubles,
1199 MW capacity

Source: PJSC «Gazprom»
Grey H₂

Benchmark emissions intensity threshold

91 g CO₂eq./MJ H₂
(10.9 t CO₂eq./t H₂)

- 60%

36.4 g CO₂eq./MJ H₂
(4.37 t CO₂eq./t H₂)

HYDROGEN INITIATIVE
launched by the Austrian presidency and signed in Linz in September 2018

Low carbon* defined as a 60% reduction compared to a BAT emission benchmark

1 t CO₂eq./t H₂ = 8.33 g CO₂eq./MJ H₂

*Low carbon: defined as a 60% reduction compared to a BAT emission benchmark.
Supply of construction material and manufacture of power stations, electricity transmission lines, fuel production plants, and vehicles not taken into account

Electrolysis onsite: 100% renewable

SMR onsite: 100% natural gas

Greatest contribution is not taken into account

Greatest contribution is taken into account

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GUIDANCE DOCUMENT FOR PERFORMING LCA ON HYDROGEN PRODUCTION SYSTEMS

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**Thinkstep STUDY**

- **H₂** cost from small scale TDM starting at ~1.80€/kg H₂ up to 4.70€/kg H₂ (using solar energy).
- **H₂** from TDM predicted to be cheaper than **H₂** from electrolysis and close to cost from small scale SMR.
- For large scale **H₂** production via TDM only data for catalyst based process identified.
- TDM @ 1.14€/kg H₂ cost competitive with SMR, SMR+CCS and water electrolysis.
- Market size for **H₂** in 2050: ~134 Mt H₂ or 153 billion € (11.14€/kg H₂).

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October 2018
THANK YOU FOR YOUR ATTENTION!