Gazprom Export Global Newsletter
2018/ Issue 49

BLUE FUEL

Special Focus:
Climate Pathways to 2050

Natural Gas: Environmentally Sound Does Not Mean Expensive Page 5
Replacing More Polluting Fuels with Natural Gas Page 6
Use of Methane-Hydrogen Energy Carriers Page 7
Hydrogen Production from Natural Gas Page 8
Low-Carbon Development Scenario for the EU Page 9

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In this issue

2018/ Issue 49

Introduction.....4

Natural gas: environmentally sound does not mean expensive.....5

Replacing more polluting fuels with natural gas.....6

Use of methane-hydrogen energy carriers.....7

Hydrogen production from natural gas.....8

Possible low-carbon development scenario for the EU.....9

Independent calculations confirm the approach efficiency.....10

Consumers can afford hydrogen produced from natural gas.....11

Conclusions and recommendations 12

DISCLAIMER
Vision presented by the Gazprom Group as regards the options for future decarbonization of the European Union in view of the EU strategy for long-term GHG emissions reductions in accordance with the Paris Agreement suggests topics for further discussion. None of the parts of the present article, whether in full or in part, alone or together with any other articles and documents, contains, represents, or otherwise implies investment, legal, financial and/or other professional advice, obligation, or a recommendation. Neither PJSC Gazprom, nor any of its subsidiaries, associated or affiliated parties, partners or clients, can be held responsible for any action based on, or related to this document, or any of its part, which is for information purposes only.

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GAZPROM EXPORT

Introduction

On 28 November 2018 the European Commission presented "A Clean Planet for all - A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy", whereby the European Commission envisages the possibility to achieve up to net-zero greenhouse gas emissions in the EU by 2050 through a socially-fair transition in a cost-efficient manner.

With due regard to expected long-term demand for low-carbon fuels among major international customers, and as a reliable partner of the EU and a long-standing participant of the European energy market, the Gazprom Group is performing research and practical work in search of possible solutions to environmental and climate challenges.

Traditionally, the Gazprom Group companies have an outstanding record in public environmental ratings, and successfully reduce their greenhouse gas emissions. For example, according to the internationally acclaimed Carbon Disclosure Project (CDP) rating, Gazprom's products have the lowest carbon footprint compared with the world's 25 largest energy companies. In 2018 the Gazprom Group joined a number of leading international energy companies in signing the guiding principles on reducing methane emissions.

The possibility of decarbonizing the EU economy, subject to advancement of related technologies and regulatory framework, can be considered in what could be described as three consecutive stages, as follows:



- At the first stage, natural gas could effectively replace coal in power generation and other more polluting fuels in various sectors (which could have been done earlier at an even greater pace)

- At the second stage, more significant rates of reducing CO_2 emissions could be reached through the wider use of methane-hydrogen energy carriers

- finally, nearly complete reduction of CO_2 emissions could be achieved by 2050 and beyond due to innovative technologies of hydrogen production from methane which allow sequestrating solid carbon for further use in economy sectors

More detailed explanation of how these three stages are understood at present is given in this article below.

TODAY, PJSC GAZPROM ALREADY CARRIES OUT PRACTICAL WORK IN ALL THE ABOVE LISTED DIMENSIONS, AND EFFECTIVELY REDUCES GREENHOUSE GAS EMISSIONS IN ITS BUSINESS ACTIVITIES

* http://www.gazprom.com/press/news/2018/june/article435686/

NATURAL GAS: ENVIRONMENTALLY SOUND DOES NOT MEAN EXPENSIVE

According to statements by the European Union authorities, the EU energy policy should be based on the principle of technology neutrality taking into account competitive advantages offered by each fuel.

At the same time, natural gas needs no extra advertizing since it meets the sustainable development criteria, such as: environment friendliness, flexibility of supplies, affordability, technical, technological availability and accessibility, energy efficiency.

- MANY FUELS ARE EITHER ECO-FRIENDLY OR AFFORDABLE
- GAS COMBINES BOTH PROPERTIES BEING ECO-FRIENDLY AND AFFORDABLE AT THE SAME TIME

ENVIRONMENT & HEALTH	Gas contributes to the greenhouse gas emissions reduction (it is 20-30% cleaner compared to oil and 50% compared to coal in terms of CO_2 emissions) Gas allows reducing toxic emissions (NOx, SOx, particulate matter)
FLEXIBILITY	Gas-fired power generation remains indispensable for balancing renewable sources of energy Less costly and easier storage than for electric energy Worldwide access through pipelines or LNG terminals, regardless of climate and geography
ECONOMIC BENEFITS	Relatively low cost and affordability for all consumer categories Availability of proven gas reserves and possibility to increase production capacities A significant source of fiscal revenues for EU Member States (together with oil) with minimal subsidies allocated to the gas industry
MULTIPURPOSE USE	Natural gas can be effectively used in all economy sectors: heating & cooling, power generation, etc. In the transport sector not only is gas safer from environmental point, but also cheaper than other energy sources – no other type of fuel can offer this combination yet
TECHNOLOGY ADVANTAGES	Technologies related to the use of natural gas and the improvement of its environmental properties are constantly advancing Innovative research & development open prospects for the production of hydrogen fuel from natural gas and the use of gas infrastructure The existing infrastructure can be easily adapted to increasing production capacities as well as to new types of gaseous fuel (for example hydrogen) at no significant cost

STAGE I: REPLACING MORE POLLUTING FUELS WITH NATURAL GAS



Climate action in the EU: time matters

Despite large-scale investments in the renewables development, according to Eurostat data published in May 2018, CO_2 emissions in 2017 increased in many Member States, and at the EU level.

The growth of CO_2 emissions could be avoided since the EU, with its developed gas infrastructure, has favorable conditions to replace more polluting fuels with natural gas. It should be borne in mind that the ultimate goal of emissions reduction is to prevent the further rise of temperatures. Therefore, time and pace of emission reduction are of particular importance.

In this regard, natural gas offers unique advantages. For example, Germany has the potential to quickly reduce CO_2 emissions in volumes equivalent to the volumes of reduction over the past 20 years, by using natural gas.

SINCE EARLY 2000s THE GAZPROM GROUP HAS HIGHLIGHTED THE ADVANTAGES OF NATURAL GAS USE FOR THE EUROPEAN UNION, NAMELY: COMPETITIVENESS, ECO-FRIENDLINESS AND RELIABILITY. PARTICULAR ATTENTION WAS GIVEN TO THE UNIQUE PROPERTIES OF NATURAL GAS THAT ALLOW TO REDUCE GREENHOUSE GAS EMISSIONS AND TO IMPROVE AIR QUALITY BOTH IN THE ENERGY AND THE TRANSPORT SECTORS.

«Early action saves costs later. If we postpone action, we will have to reduce emissions much more drastically at a later stage.»
European Commission

- REPLACING COAL IN POWER GENERATION AND LIQUID MOTOR FUELS IN TRANSPORT BY NATURAL GAS COULD ALLOW REDUCTION OF GREENHOUSE GAS EMISSIONS IN THE EU BY 13-18% COMPARED TO CURRENT LEVELS (OR BY 35-39% COMPARED TO 1990 LEVELS)
- STRATEGY FOR LONG-TERM EU GREENHOUSE GAS EMISSIONS REDUCTIONS BY 2050 SHOULD TAKE INTO ACCOUNT THE UNTAPPED OPPORTUNITIES AS WELL AS CREATE INCENTIVES FOR RAPID REPLACEMENT OF MORE POLLUTING FUELS WITH GAS IN THE EU

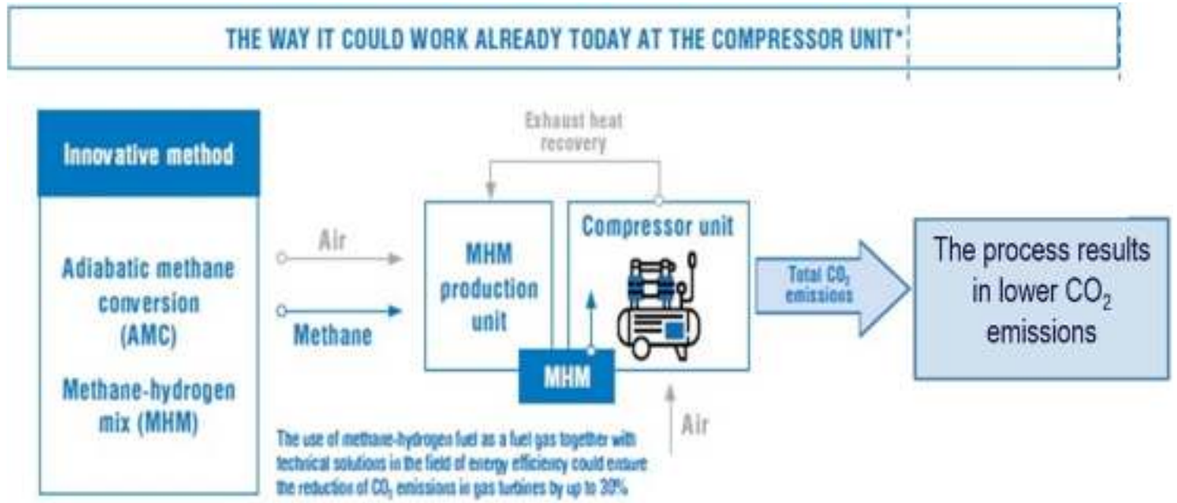
STAGE II: USE OF METHANE-HYDROGEN ENERGY CARRIERS

Gazprom Group Innovations: environment of the future

Natural gas use could contribute to the greenhouse gas emissions reduction not only in the mid-term perspective, but also in the relatively distant future – by 2050. By constantly improving and developing its scientific and research base, the Gazprom Group seeks ways to multiply competitive and environmental advantages of natural gas.

Use of methane-hydrogen mixes can help to reduce carbon footprint. Gazprom has been working on a technology of adiabatic conversion of methane which proves to have additional efficiency. The test use of methane-hydrogen mix which was produced using this technology on in a compressor unit resulted in up to 30% reduction of CO_2 emissions.

This technology is patented in Russia, Japan, China, and South Korea.



* This technology is patented in Russia, Japan, China, and South Korea

STAGE III: HYDROGEN PRODUCTION FROM NATURAL GAS



THE WAY IT COULD WORK TOMORROW (Natural gas decarbonization technology)

$$CH_4 = 2H_2 + C$$

Installation test unit



Carbon material



Solid carbon is a tangible result of experimental technologies for hydrogen production led by the Gazprom Group. This byproduct can be further used in industrial sectors

Today, innovative technologies for the decomposition of natural gas (based on cracking, methane pyrolysis) into hydrogen and valuable carbon material are being developed and deployed. These reactions proceed without any emissions of carbon dioxide. Such technologies are less energy consuming and, therefore, appear to be more economically attractive in comparison with water electrolysis.

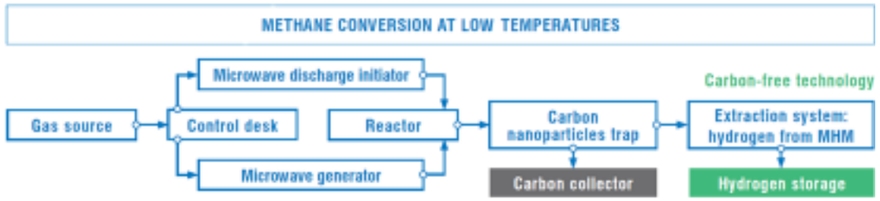
Necessary technological preconditions in this field are already in place:

- methane cracking pilot installations in Germany (Karlsruhe Institute of Technology, KIT, and Potsdam Institute for Advanced Sustainability Studies, IASS) and Russia;
- industrial production of "carbon black" in Canada for further use;
- test installation for natural gas conversion in the low-temperature non-equilibrium plasma in Russia, etc.

Innovative solutions developed jointly with our international partners could allow to further improve the method of producing methane-hydrogen mix and to bring the level of emissions virtually to zero.

As these technologies advance, their costs will fall down.

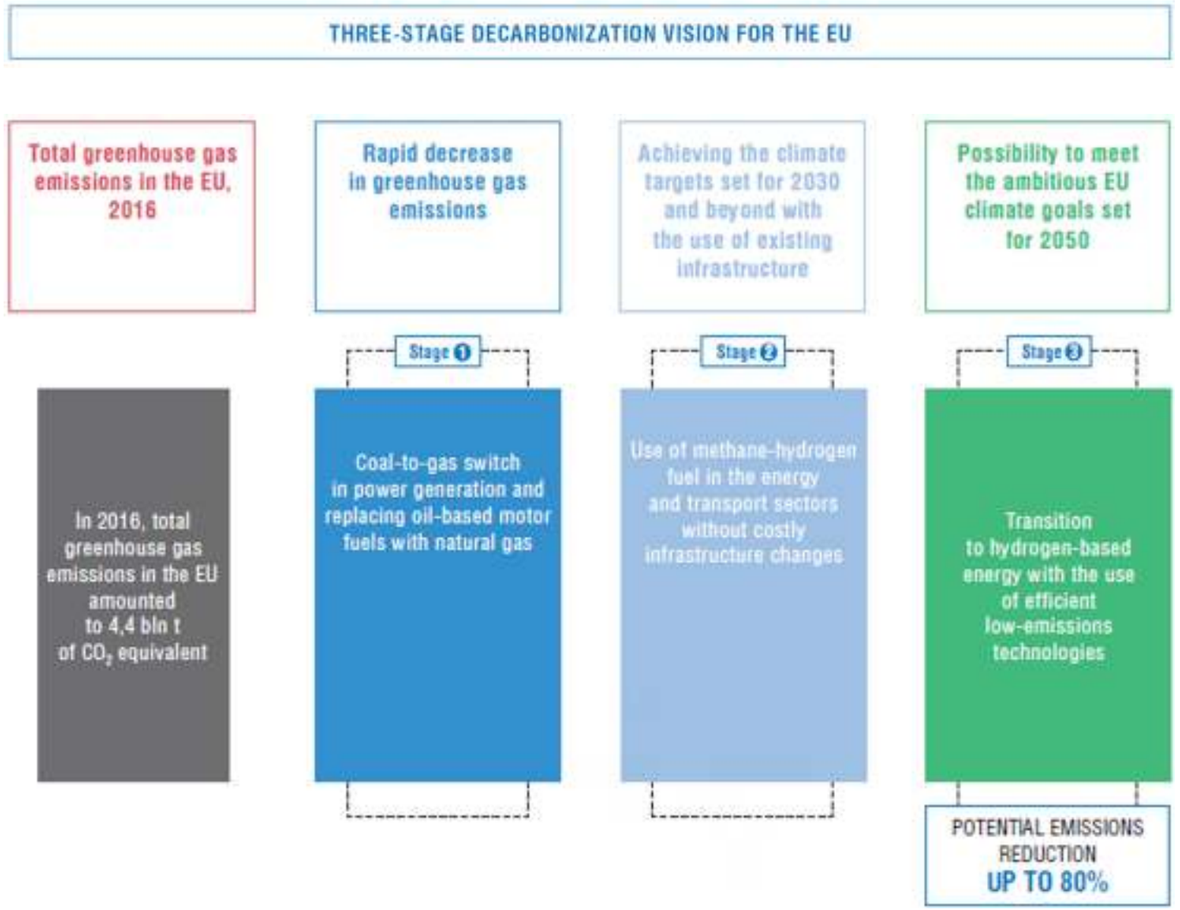
Research work led by the Gazprom Group in the field of hydrogen production from natural gas with possible solid carbon sequestration will open opportunities for cost-effective transition to a carbon-free economy in the future.



The gas conversion to hydrogen takes place in the low-temperature non-equilibrium plasma in the absence of oxygen and under atmospheric pressure

POSSIBLE LOW-CARBON DEVELOPMENT SCENARIO FOR THE EU

The three-stage approach to CO_2 emissions reduction is distinguished by efficiency, predictability and high cost effectiveness backed up by the possibility to use and modernize the existing infrastructure.



INDEPENDENT CALCULATIONS CONFIRM THE APPROACH EFFICIENCY

The research study "**GHG emissions in the EU Energy Market today and in 2050**" by **thinkstep AG** experts was used to verify the assumptions made by PJSC Gazprom[1].

This company analyzed how the use of natural gas in various forms would impact the GHG emissions level by 2050, namely through:

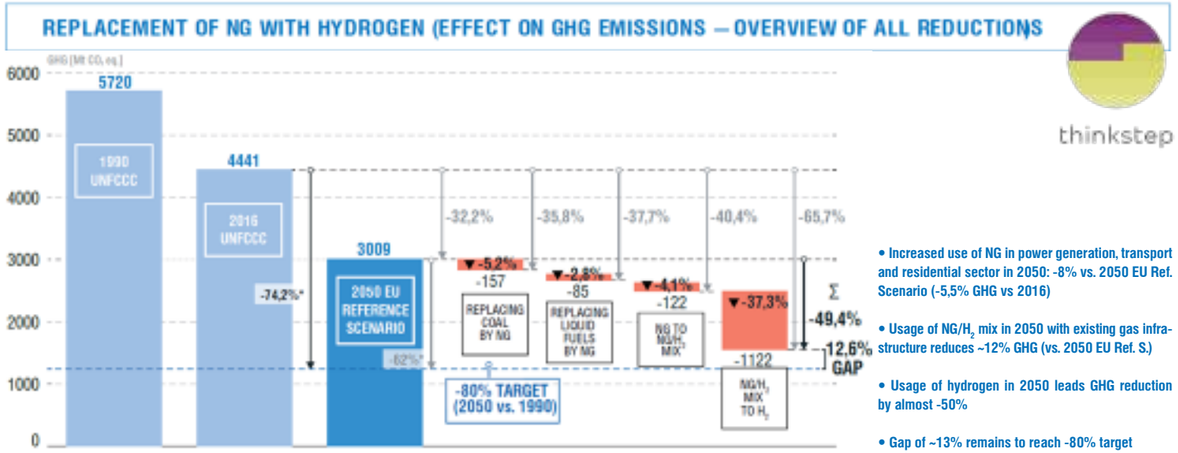
- **replacement of more polluting fuels (such as coal in power generation and liquid fuels in the transport sector) with gas**
- **use of methane-hydrogen fuel**
- **transition to hydrogen fuel produced from natural gas**

The analysis of the emissions reduction potential was based not on the 2016 level, but on the level forecasted by 2050 in the European Commission's EU Reference Scenario 2016, i.e. the additional effect resulting from the natural gas use was analyzed in comparison with the outcome expected by the European Commission by 2050.

Besides, consideration was taken of conservative estimates of the GHG emissions reduction resulting from the methane-hydrogen mix use (7-8% depending on a segment), while a number of studies refers to an effect of 15% or even higher[2] .

Calculations led to the conclusion that the emissions level may decrease by 49,4-53,7% from the level forecasted by 2050, depending on the source of power required to produce hydrogen from natural gas.

The further reduction of emissions by 8,6-12,6%, as required to achieve a cut of 80% compared to 1990 levels, could be achieved through the reduction of emissions in sectors not included into the scope of this study, as well as through additional increase in energy efficiency and other mitigation measures.



- **Increased use of NG in power generation, transport and residential sector in 2050: -8% vs. 2050 EU Ref. Scenario (-5,5% GHG vs 2016)**
- **Usage of NG/H_2 mix in 2050 with existing gas infra-structure reduces ~12% GHG (vs. 2050 EU Ref. S.)**
- **Usage of hydrogen in 2050 leads GHG reduction by almost -50%**
- **Gap of ~13% remains to reach -80% target**

* Reduction needed to reach 2050 GHG target (-80%)

1 The calculations were made only for the EU road transportation and domestic navigation segments, as well as for the following segments: power and heat generation, household energy consumption. Other segments related to consumption of significant energy volumes were not included into the scope of the study.

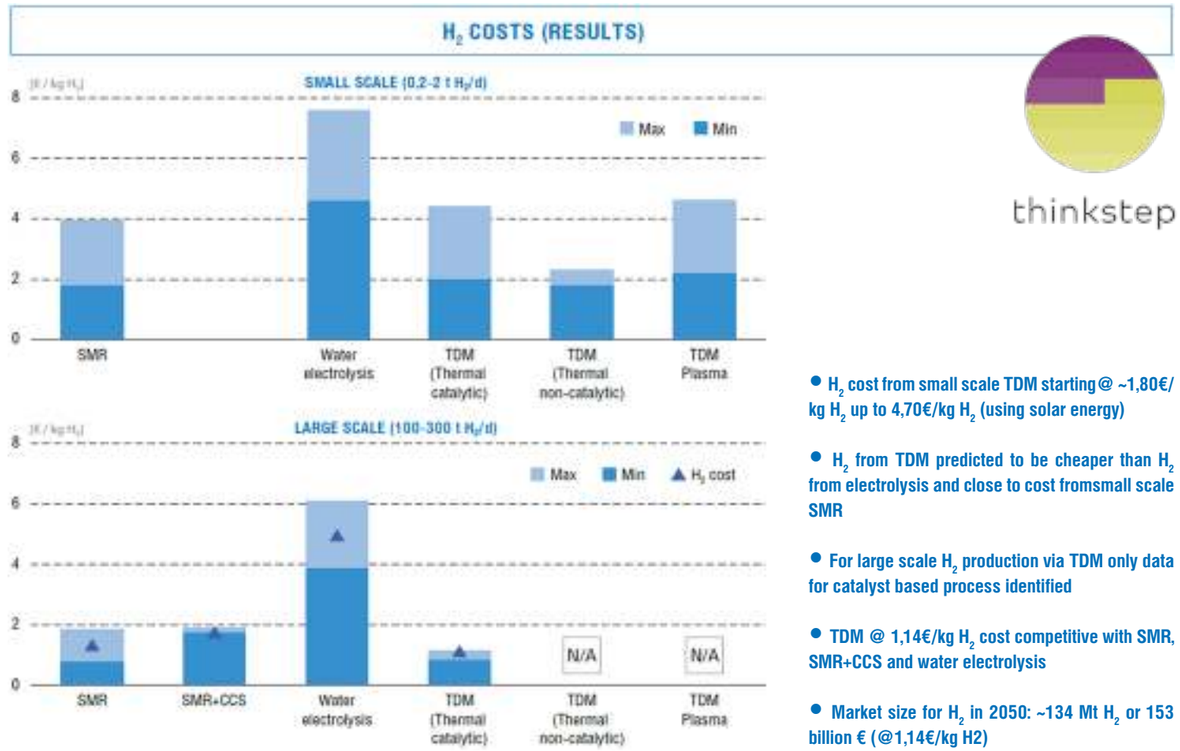
2 Sustainable Energy Fuels 2018, 710-723.

THE STUDY OUTCOME: CONSUMERS CAN AFFORD HYDROGEN PRODUCED FROM NATURAL GAS

It should be noted that the study carried out by the **thinkstep AG** research center also points out significant economic benefits of hydrogen production from natural gas at small-scale and especially large-scale installations.

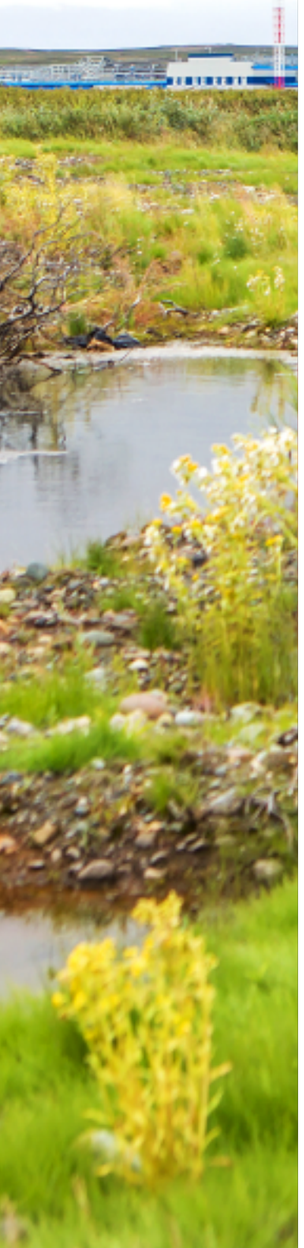
With the use of innovative technologies of the hydrogen production from natural gas, total costs appear to be lower than the net cost of all oil products consumed annually by the EU road transport alone.

Therefore, natural gas provides additional benefits in the course of transition to the hydrogen economy.



- **H_2 cost from small scale TDM starting@ ~1,80€/kg H_2 up to 4,70€/kg H_2 (using solar energy)**
- **H_2 from TDM predicted to be cheaper than H_2 from electrolysis and close to cost fromsmall scale SMR**
- **For large scale H_2 production via TDM only data for catalyst based process identified**
- **TDM @ 1,14€/kg H_2 cost competitive with SMR, SMR+CCS and water electrolysis**
- **Market size for H_2 in 2050: ~134 Mt H_2 or 153 billion € (@1,14€/kg H2)**

CONCLUSIONS AND RECOMMENDATIONS



Conclusions and Recommendations

There have been instances of emissions levels growth in the EU member states in recent years; this concerns not only CO_2 but also toxic emissions and air quality issues, which is a special cause for concern for many EU Member States.

Natural gas could play a twofold role in decarbonizing the EU economy by ensuring GHG emissions reduction and at the same time serving as a raw material for hydrogen production. Notably, the time and rates, at which emissions may be reduced, are critical. In this regard natural gas provides unique advantages by allowing to significantly reduce emissions within a short period of time as well struggle against energy poverty which rates are high within the EU. At the same time gradual increase in hydrogen use could allow an unhampered and smooth transition to the low-carbon economy employing the advantages of the existing infrastructure.

It should be noted that not only the Gazprom Group but a number of European partners carries out research in the field of hydrogen production from natural gas, which contributes to the advanced development of this technology as well as ensures competition in this sector. In its turn, availability of various technologies of hydrogen production promotes economic efficiency and diversification of hydrogen supply sources.

It should be recognized that so far not all types of alternative fuels are able to demonstrate progress, including in terms of cost reduction, also taking into account the negative environmental impact caused by the growing consumption of rare earth metals and other components required for the use of a number of environmentally friendly solutions.

The EU energy regulatory framework should embrace the declared principle of technology neutrality and further pursue the approach involving a comprehensive full life-cycle analysis of greenhouse gas emissions for all types of energy sources.

Research findings confirm that the methane emissions issue could be solved for the energy sector, which was proven by Gazprom Group's experience in methane emissions reduction, while the problem of much higher methane emissions in other sectors, including agriculture, is being addressed at a less advanced level.

It is therefore suggested that space should be left for innovative technologies to develop without any restrictions whatsoever and with the possibility to explore all potential ways to achieve low level emissions.

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* Data sources: Gazprom, thinkstep AG

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