# VIEWS AND PERSPECTIVES FROM RUSSIAN SIDE ON DECARBONIZATION AND ON THE EU HYDROGEN AND ENERGY SYSTEM INTEGRATION STRATEGIES

**Kirill Neuymin**
**PJSC Gazprom**

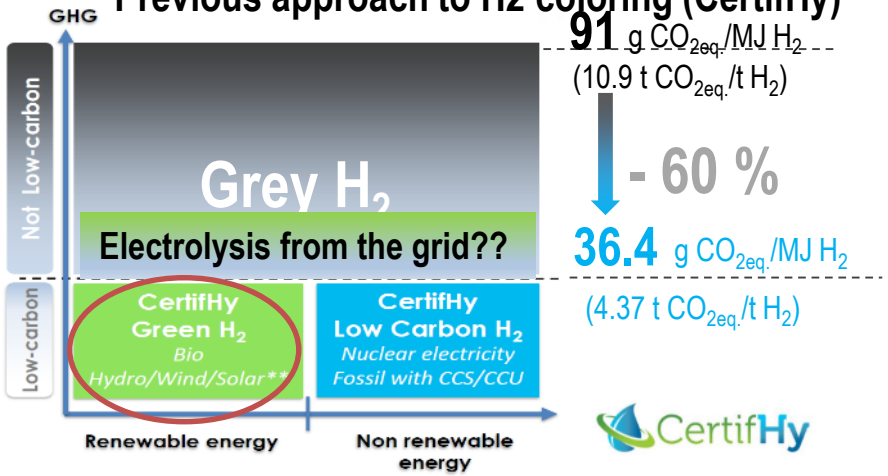
Saint-Petersburg, September 2020

# Multiple routes to decarbonization

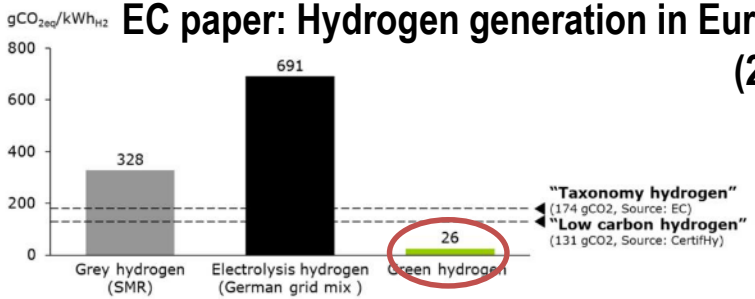
| Actual energy balance | | Decarbonization | Future energy balance |
|---|---|---|---|
| Electricity |  | | The energy mix of the future is unclear and will be determined by the technological development and regulation. It will be a combination of multiple choices and technologies. We believe that gaseous fuels will play a role, incl. methane and hydrogen. |
| Natural gas |  | | |
| Hydrogen |  | | |
| RES |  | | |
| Oil |  | | |
| Oil products |  | | |
| Coal |  | | |

# Colored hydrogen

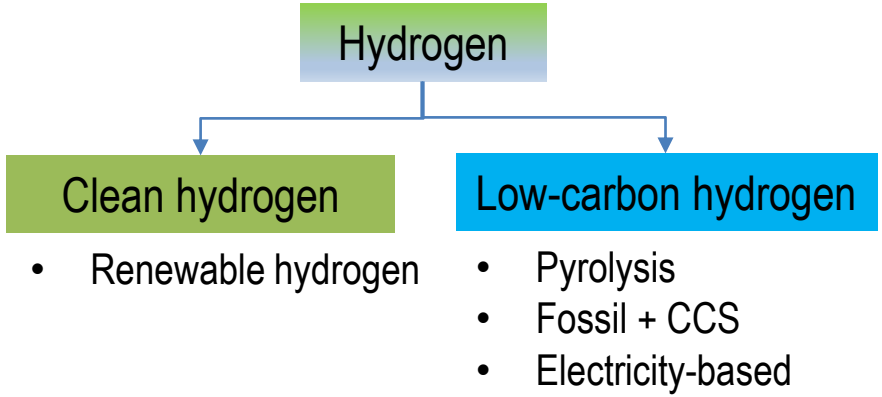
## Previous approach to H2 coloring (CertifHy)




## EC paper: Hydrogen generation in Europe (2020)




## Approach in the EU hydrogen strategy




**Role of Certification and proper regulation to foster technologically neutral development of different routes of clean and low-carbon hydrogen production**



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

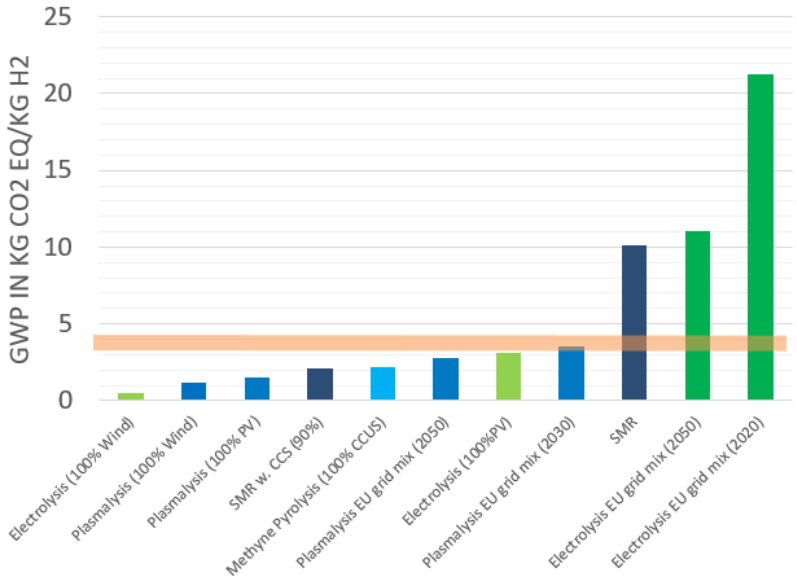
# Methane splitting

Gazprom believes that methane splitting with producing solid carbon is one of the best options for decarbonization because of its efficiency and sustainability

€ / kg

| H2 technology | Levelized production costs 2030 (incl. ETS prices, no subsidies) | Levelized production costs 2050 (incl. ETS prices, no subsidies) |
|---|---|---|
| **Electrolysis from RES** | 2,6 | 1,85 |
| **SMR + CCS** | 1,9 | 2,15 |
| **Methane pyrolysis** | 1,65 | 1,1 |

The forecasted level of GHG emissions from Pyrolysis is close to the minimal market levels




*Source: Florence school of regulation*
*Source: Own Analysis based on TUM, assuming NG supply via NSP2 and LCA analysis according to ThinkStep Gabi data*

# Gazprom perspectives for the hydrogen business

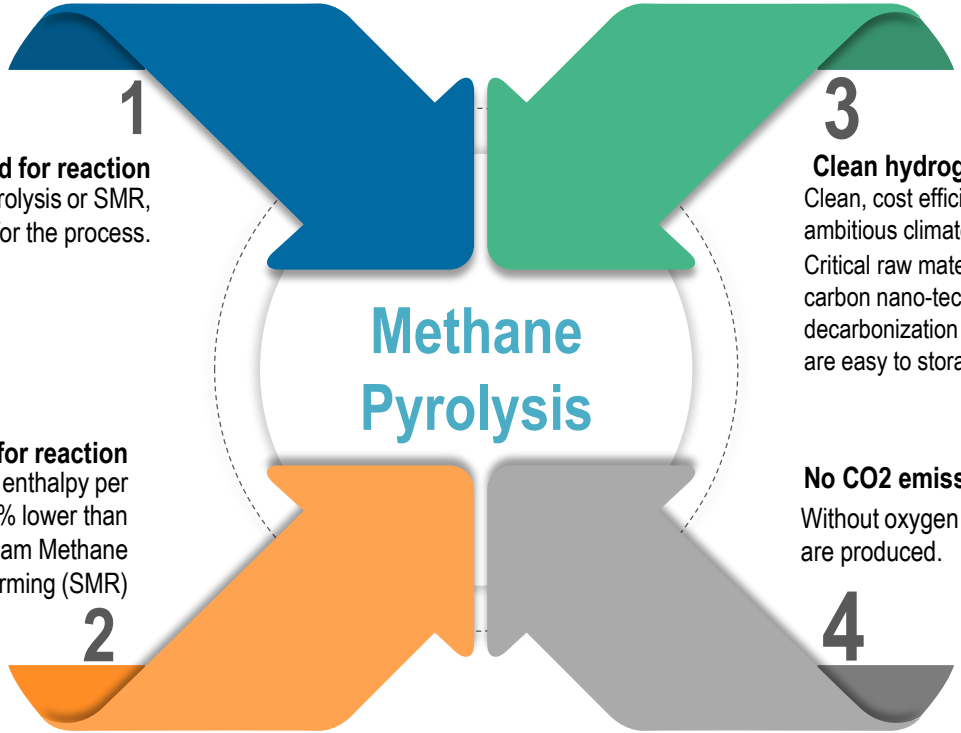
**Strategic priority is low-carbon production of hydrogen from natural gas and commercialization of vast potential of natural gas in the hydrogen economy**

1. Technological development in Russia (vast technological and financial capacities)
2. Technological development outside Russia (strategic investments, cooperating with partners)
3. Developing mobile technologies to increase flexibility and commercial efficiency of the hydrogen business
4. Building alliances with traders for more logistic and product opportunities

**Expectations from the EU side**

1. Virtual accounting of different carbon units and credits, incl. creating clear cross-border framework, to pursue global development of the projects aimed at hydrogen projects implementation.
2. State support of the projects aimed at producing low-carbon hydrogen which helps to achieve required return of investments (e.g. CfDs seem a fare mechanism)
3. Development of the decarbonized technologies shall not be made at the expense i.a. of natural gas through cross-subsidization (in the form of increased fuel taxes, etc.).

# Advantages of using Pyrolysis




**No Water needed for reaction**
Compared to electrolysis or SMR, methane pyrolysis does not use any water for the process.

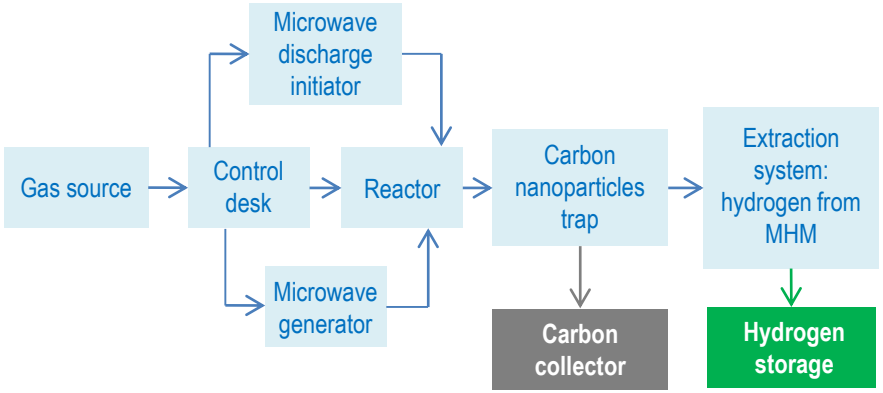
**Clean hydrogen & clean solid carbon**
Clean, cost efficient hydrogen can help Europe to achieve its ambitious climate targets for 2050.
Critical raw materials, such as Graphite, Graphene and carbon nano-technologies contributes to efficiency and decarbonization of other sectors and in form of slide carbon are easy to storage, handle and non toxic energy storages.

**Less energy needed for reaction**
The energy demand for the reaction enthalpy per hydrogen for methane pyrolysis , is -87% lower than from electrolysis and -78% lower from Steam Methane Reforming (SMR)

**No CO2 emissions**
Without oxygen in the reaction no harmful CO2 emissions are produced.

# Scheme of gas conversion in low-temperature plasma

## The impact of low-temperature non-equilibrium microwave-induced plasma on hydrocarbon gas molecules




The hydrocarbon gas conversion takes place in a closed plasma-chemical flow reactor **in the absence of oxygen** and at ambient pressure

CARBON-FREE TECHNOLOGY

PROTOTYPE PLANT

CARBON MATERIAL

CAPACITY OF:
- hydrogen – up to 0.5 м$^3$/h;
- carbon material – up to 60 g/h

*Source: NATIONAL RESEARCH TOMSK POLYTECHNIC UNIVERSITY*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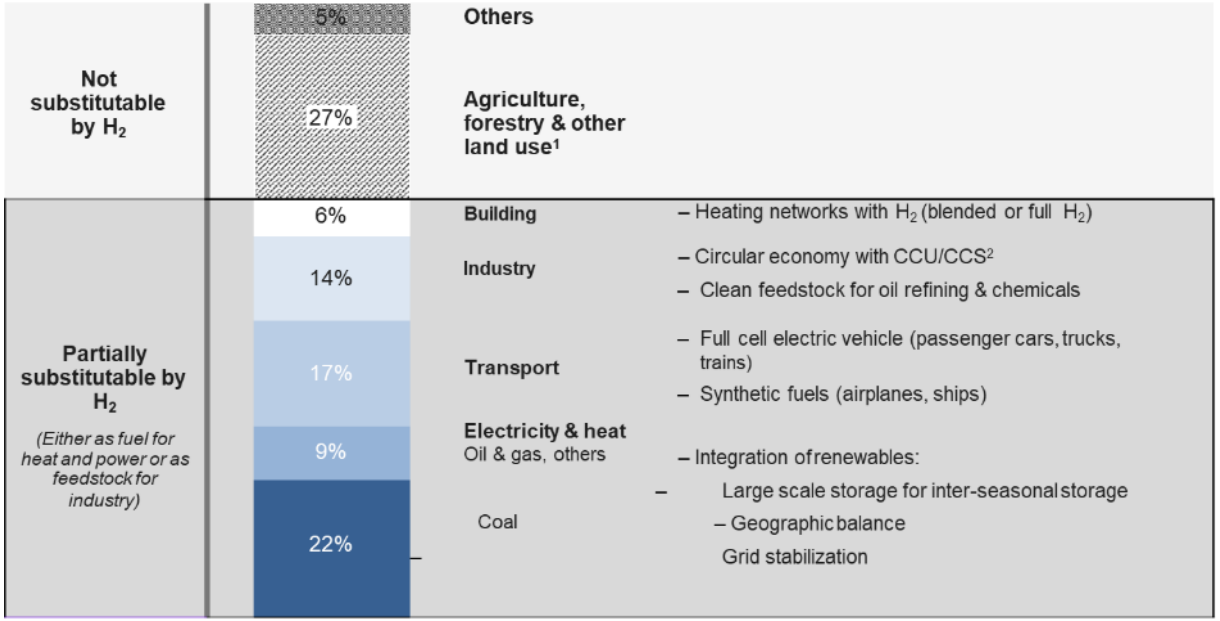
# Methane pyrolysis could address ~ 95% of GHG emissions of global emissions

Solid carbon can help reduce emission and capture CO2 via agriculture & other land use

Hydrogen could address GHG emissions as a substitute in sectors responsible for more than 65% of global emissions, solid carbon can replace energy intensive materials and .

## Current GHG emissions by segment

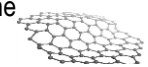
## Hydrogen potential use cases for decarbonization






1. Includes land use, emissions from cattle, etc.; 2. Carbon Capture Utilisation/ Carbon Capture Storage Sources: IEA; FAO; Kearney Energy Transition Institute analysis

# Different types of solid carbon and their application

| Type of Carbon | Types of Applications | Expected Price for Carbon |
|---|---|---|
| Carbon Black  | Tires, printing inks, high perfomance coating and plastics | $0.4-2+/kg depending on product requirements |
| Graphite  | Lithium-ion batteries; Graphite electrodes used in steel furnaces, | $10+/kg |
| Carbon Fiber  | 3D printing, Aerospace, automobiles, sports and leisure, construction, wind turbines, carbonreinforced composite materials and textiles | $25-113kg depending on product requirements |
| Carbon nanotubes  | Polymers, plastics, electronics, lithium-ion batteries | $0.10-600.00 per gram depending on application requirements |
| Needle coke  | Graphite electrodes for electric arc steel furnaces | ~$1.5/kg |
| Graphene  | Graphene used in flexible electronics, batteries, solar cells | ~ $50 -85$ / kg |

Solid carbon family consists of a few types of carbon of different structure, price, application sphere and level of penetration.
The development of the methane splitting technologies will mean also producing more expensive type of solid carbon which will allow better commercialization of the technology as well as technological break-throughs aimed at decarbonization

Source: Dagle, Dagle, Bearden, Holladay, Krause. "An overview of natural gas conversion technologies for co-production of hydrogen and value added solid carbon products." November 2017.

# Large market growth for 3-D printing (based on carbon)

**3D-Printing**

**½ manufactured products 3D printed by 2060**

*Printing is used in top industries from Industrial machinery, Aerospace, Automotive, Consumer products, and medical devices.*

**Case: 3D printed gas turbines**

**High volume composite materials on a global basis**

*Reinforced carbon applications range from aircraft construction, corrosion prevention, flame retardancy, spinning of macro-carbon fibres, etc.*

**Case: 3D printing House**

**High volume impact for construction materials**

- *Composite materials (cement, concrete)*
- *Raw polymer or adjustable conductive compounds*
- *3D printable composite*

**Case: Automotive**

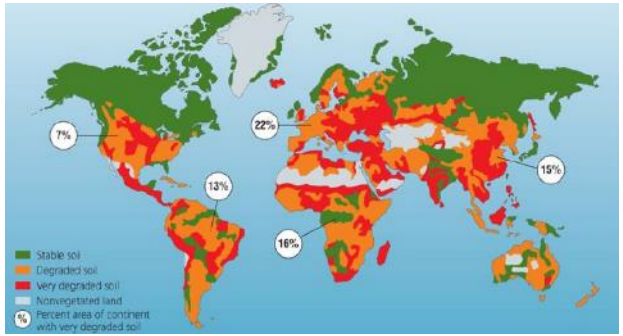
**Replacing all steel used in cars approx. 200-300MT**

- *Battery production*
- *Replacing metal components*
- *Electronic conductor*

# Carbon soil enhancement

**Soils hold three times the amount of carbon dioxide (CO2) currently in the atmosphere** or almost four times the amount held in living matter. Many cultivated soils have lost 50–70% of their original organic carbon.

Expert assessment estimates that **soil carbon sequestration** could be scaled up to **sequester 2–5 billion metrics tons of CO2 (GtCO2) per year by 2050**, with a **cumulative potential of 104–130 GtCO2 by the end of the century**.




**Millions of hectares of degraded or very degraded soils worldwide**

- Greatly increases the health of soils and the plants that grow in them. It also contributes to CO2 emission reduction in agriculture (fertile soils require fewer inputs and produce more biomass).
- Accelerated and stronger plant growth






Source: Novihum https://novihum.com/
CarbonRemoval Fact Sheet https://www.american.edu/sis/centers/carbon-removal/upload/icrlp_fact_sheet_soil_carbon_biochar_181006.pdf
Sabine Fuss et al., "Negative emissions—Part 2: Costs, Potentials and Side Effects," Environmental Research Letters 13, no. 6 (2018): 063002, https://doi.org/10.1088/1748-9326/aabf9f
Pete Smith, "Soil carbon sequestration and biochar as negative emission technologies." Global Change Biology 22, no. 3 (2016):1315–24. https://doi.org/10.1111/gcb.13178

# CO2 vs Solid Carbon *

## SMR – CO2

Weight: **70 million MT** @80 bar
Volume: **117 million m3** (738 million barrels)

## Methan Pyrolysis – Solid Carbon

Weight: **~ 20 million MT**
Volume: **~ 10- 40 million m3**

**CO2 versus Carbon**

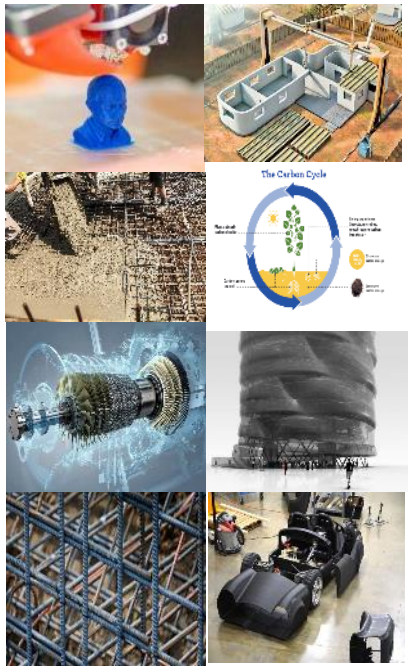
- At „room temperature“ and 1 atmosphere of pressure CO2 is a gas and 1kg of it has a volume of 505.8 litres
- At „room temperature“ and 1 atmosphere of pressure Carbon is a solid (graphite) and 1kg of it has a volume of 2 - 0.441 litres
- Consequently this means that at „room temperature“ and 1 atmosphere of pressure **„storing“ 1kg of CO2 requires 1147 times** as much space **as „storing“ 1 kg of carbon**.



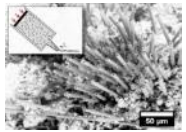
** from producing 1 Quad of Hydrogen ($10^{15}$ BTU or 293 TWh)* *Source: APRA*

# Decarbondioxidization – a new name for the policy

**Carbon is not a problem – carbon is an opportunity**




Key task is not decarbonization




Key task is

**! decarbondioxidization !**

GAZPROM

# Thank you for your attention