Decarbonization of gas industry: The Challenge or The Crisis?

Prof. Dr. **Andrey A. Konoplyanik,**
Adviser to Director General, "Gazprom export" LLC;
Co-chair Work Stream 2 “Internal Markets”, Russia-EU Gas Advisory Council

IGU Strategy Committee meeting, Tel-Aviv, Israel, 26-27.02.2020

Disclaimer: Views expressed in this presentation do not necessarily reflect (may/should reflect) and/or coincide (may/should be consistent) with official position of Gazprom Group (incl. Gazprom JSC and/or Gazprom export LLC), its stockholders and/or its/their affiliated persons, or any Russian official authority, and **are within full personal responsibility of the author of this presentation.**

Decarbonised gas: what are key H2 production technological pathways

1) **Water electrolysis** (the only as if "**green**" H2 in the EU among three options), but:
   - Is not "green" if electricity from the grid (50% of EU electricity is fossil-fuel-fired, 20% EU electricity is coal-fired power stations)
   - Is not green is full value chain is considered (incl. manufacturing of RES-power equipment etc)
   - In case RES-electricity is used:
     - If only excessive (interruptible) RES-electricity supply (with zero or negative price – which was the aim/key perception):
       - such projects of H2 production would be poorly or non-bankable (interruptible & non-predictable revenue flow) => worsening of investment pay-back
       - incremental RES generation capacities & additional H2 storage capacity are needed
     - If permanent (non-interruptible) RES-electricity supply:
       - this is possible ONLY with the use of back-up generation capacities => coal and/or gas-fired power stations with low utilization rate => worsens their (back-up electricity) & H2 project economics =>
       - CO2 emissions => such H2 is not "green" as well

2) **Methane Steam Reforming** (the only "**blue**" H2 in the EU)
   - With access of O2 => CO2 emissions => necessity for CCS, but:
     - CCS – is not "storage" but "sequestration" (big economic difference) =>
     - CO2 in such case NOT a part of (beginning of/input to) new investment cycle, but an essential incremental element in cost budget of any MSR project (not part of refundable investment but part of non-payable cost burden)

3) **Methane pyrolysis et al** (usually **not mentioned** as part of "**blue**" H2 in the EU)
   - Without access of O2 => no CO2 emissions => no need for CCS
   - Practically has not been mentioned in the EU public domain until recently (and practically are ignored today in public debate – why so?)
     - Was incorporated in active public Russia-EU informal discussion by presentation of O.Aksyutin (Gazprom) at the WS2 RF-EU GAC in SPB on 10.07.2018
   - **Economic priority for both Russia and the EU !!!**

Y-tracks of EU decarbonisation paths: mostly RES-centric (public media experience)

100% RES electricity!

100% RES electricity?

01.2018

De facto back to 100% RES electricity

"Green domestic electrons to win against dirty import molecules" (Geopolitical back-up/ perception?)

RES-electricity plus decarbonized gases!

Decarbonisation upstream (H2 production beyond EU)?

1H-2018

Decarbonisation downstream (H2 production within EU)!

1. P2G/Electrolysis (EU: "green" H2)
2. MSR (EU: "blue" H2)

2H-2018

?

2H2

Current discussion in the EU on H2 paths in a "technologically neutral" way is basically conducted within 2H2 – not 3H2 - format => this de facto pushes towards 100% RES electrification mode

!

3H2

1. P2G/Electrolysis (EU: "green" H2)
2. MSR (EU: "blue" H2)
3. Methane Pyrolysis et al (EU: "blue" - ? - H2)

Zero CO2 emission

H2 "range of colours" *(grey, blue, green…)* in EU terminology creates incorrect & negative connotations/perceptions for H2 from CH4: it is not the "colour" of the input resource which is important, but the presence or absence of emissions in result of the process and the cost of such low-carbon output => to consider CO2 output, not "C" content in original resource

List of H2 projects of different categories at the website of Hydrogen Europe (total 229 entries)

Project categories:
- Basic, Advanced
- Sub-projects categories (Demonstration, Research, Others)
- Type of funding
- Country
- Project status (Any, Started, In construction, In operation, Completed)

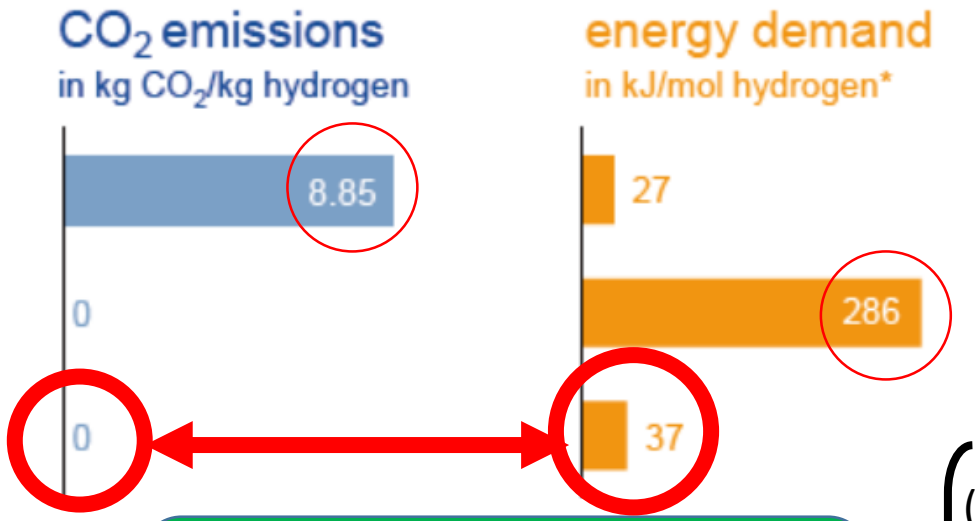
No direct identification on technological types available, incl. on most competitive gas-based H2 production technologies => Cost estimates for three main Hydrogen paths are either non-comparable or nonexistent… => to consider fundamental basics for comparison of prospective competitive advantages

Source of map: https://hydrogeneurope.eu/projects

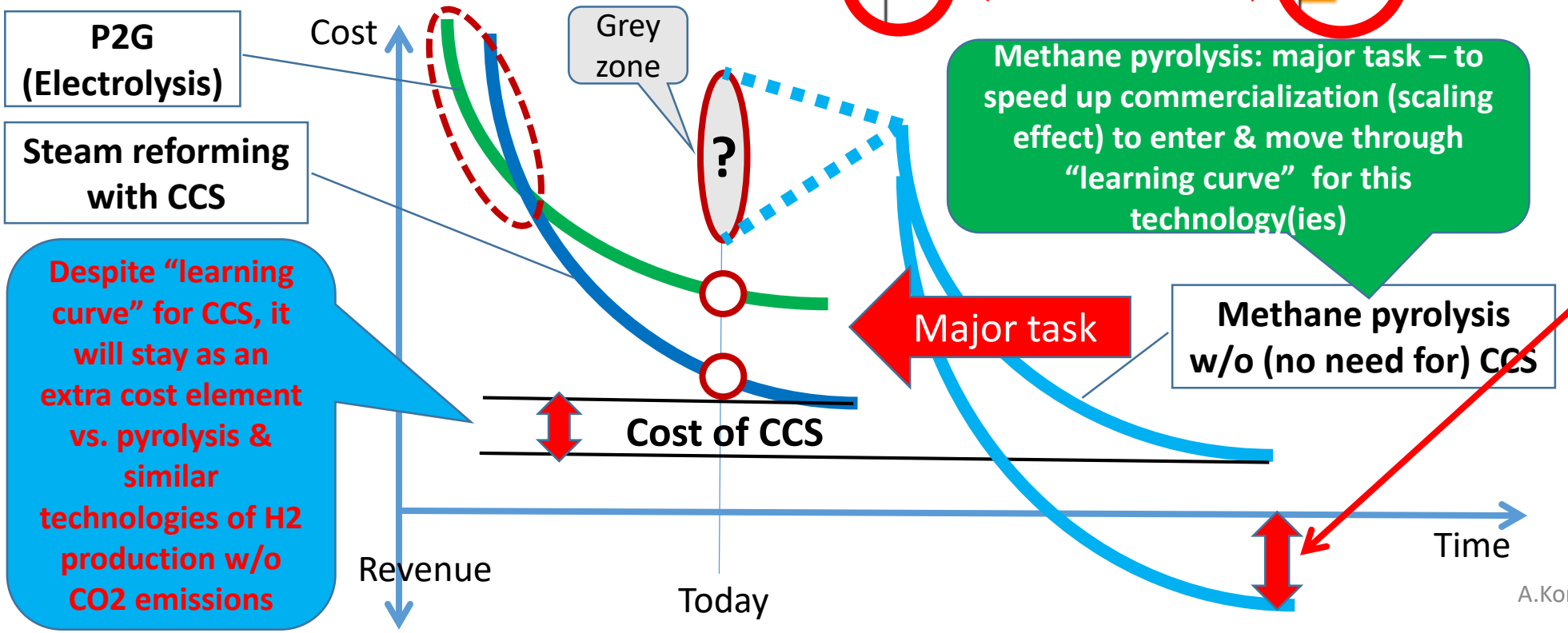
All other conditions being equal, & under technologically neutral regulation, methane pyrolysis might win competition in hydrogen production with two other key technologies

CC(U)S is needed!!! => additional imputed costs (CAPEX + OPEX) => add. 20/30+%

Steam reforming of natural gas	$CH_4 + 2H_2O \rightarrow 4H_2 + CO_2$
Water electrolysis	$2H_2O \rightarrow 2H_2 + O_2$
Methane pyrolysis	$CH_4 \rightarrow 2H_2 + C$



Based on: Dr. Andreas Bode (Program leader Carbon Management R&D). New process for clean hydrogen. // BASF Research Press Conference on January 10, 2019 / (https://www.basf.com/global/en/media/events/2019/basf-research-press-conference.html)



Despite "learning curve" for CCS, it will stay as an extra cost element vs. pyrolysis & similar technologies of H2 production w/o CO2 emissions

(1) No need in CC(U)S => CAPEX/OPES saving
(2) Marketing of carbon black = additional element of revenue flows => start of new investment cycles based on carbon black
(3) In case of storage, carbon black does not provide same negative effects as CO2

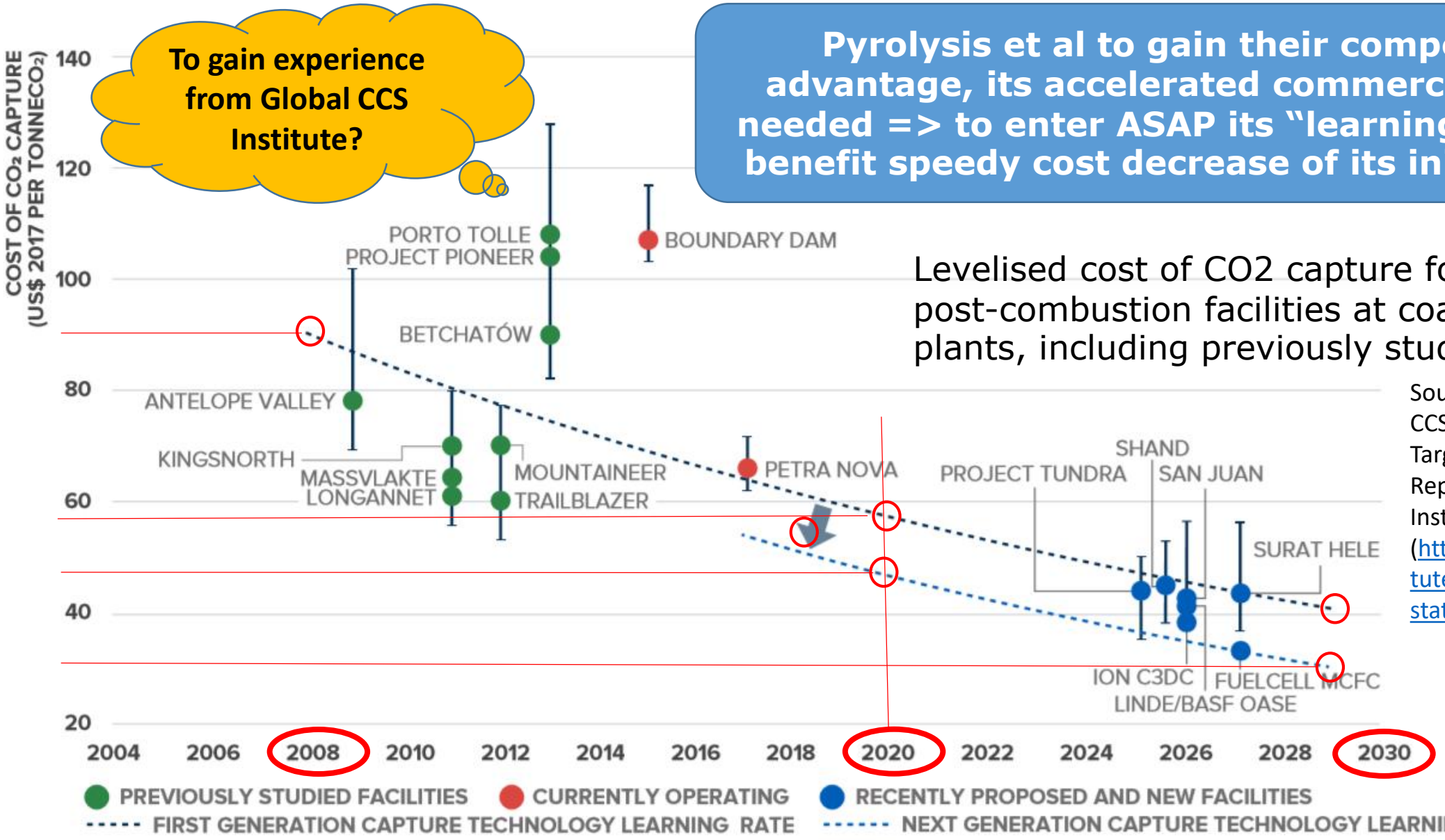
Multilateral tasks for "third technological path" in Hydrogen production (H2 production w/o access of O2 => w/o CO2 emissions => w/o CCS)

- How best to succeed in speedy scaling of "third technological path" of H2 production and in experiencing "learning curve" cost-cutting effects for it to gain competitive advantages compared to two other key H2 production technological paths (RES PtG & MSR+CCS):
  - To identify all knowledge & technological centers dealing/experimenting with "third technological path" of H2 production
    - If in Europe – maybe under Hydrogen Europe (to select within 229 "entries")?
  - To engage them in collaboration => to join efforts for synergy effects
    - Exchange of information
    - Concentration on most promising technologies
    - Co-financing (cost-saving & scaling-up effect)
  - To create extraneous field of comparative (comparable) cost assessments of H2 production costs (to identify the starting point of cost curve for pyrolysis et al)
  - To start few pilot projects (to enter the & start moving though "learning curve" for pyrolysis et al)
  - To identify marketing opportunities for black carbon (by-product of pyrolysis et al)

CCS "Learning curve" is there, but its cost will always to be added to MSR cost

To gain experience from Global CCS Institute?

Pyrolysis et al to gain their competitive advantage, its accelerated commercialization needed => to enter ASAP its "learning curve" to benefit speedy cost decrease of its initial phase



Levelised cost of CO2 capture for large-scale post-combustion facilities at coal fired power plants, including previously studied facilities)

Source: "Global Status of CCS 2019: Targeting Climate Change Report", Global CCS Institute, p.24, Figure 8 (https://www.globalccsinstitute.com/resources/global-status-report/)

Approximate potential areas of preferential use of key H2 production technologies in Europe under state regulation based on "technological neutrality" principles

- P2G wind
- P2G solar
- P2G hydro
- P2G nuclear

Electrolysis (Group 1)

- MSR plus CC(U)S (Group 2)
- Methane pyrolysis et al (w/o CO2) ***(to incorporate both Step 2 & Step 3 Cooperative measures from "Three Step Aksyutin's Pathway")*** (Group 3)

Based on author's conversations with Ralf Dickel

Source of map: ENTSOG

International experience => for International Cooperation on Pyrolysis et al (H2 production w/o CO2 emission)

- It might be proper, timely and rational to organize (maybe, within “Hydrogen Europe” at which site today among 229 projects there is no one on Pyrolysis et al => ???) a special undertaking on set of technologies for H2 production without CO2 emissions (CH4 pyrolysis, decomposition in low-temperature non-equilibrium plasma, etc. - as the third key avenue equally important with two others: electrolysis and methane steam reforming) as a study for, demonstration, promotion and input of this H2 production path to low-carbon development of global economy
- Such cooperation was proposed for consideration by the Co-chairs of WS2 GAC at the 29th WS2 meeting in Berlin on 21.10.2019 (https://minenergo.gov.ru/node/14646)
- To be further discussed at the 30th WS2 GAC meeting in Brussels on 03.04.2020

Thank you for your attention!

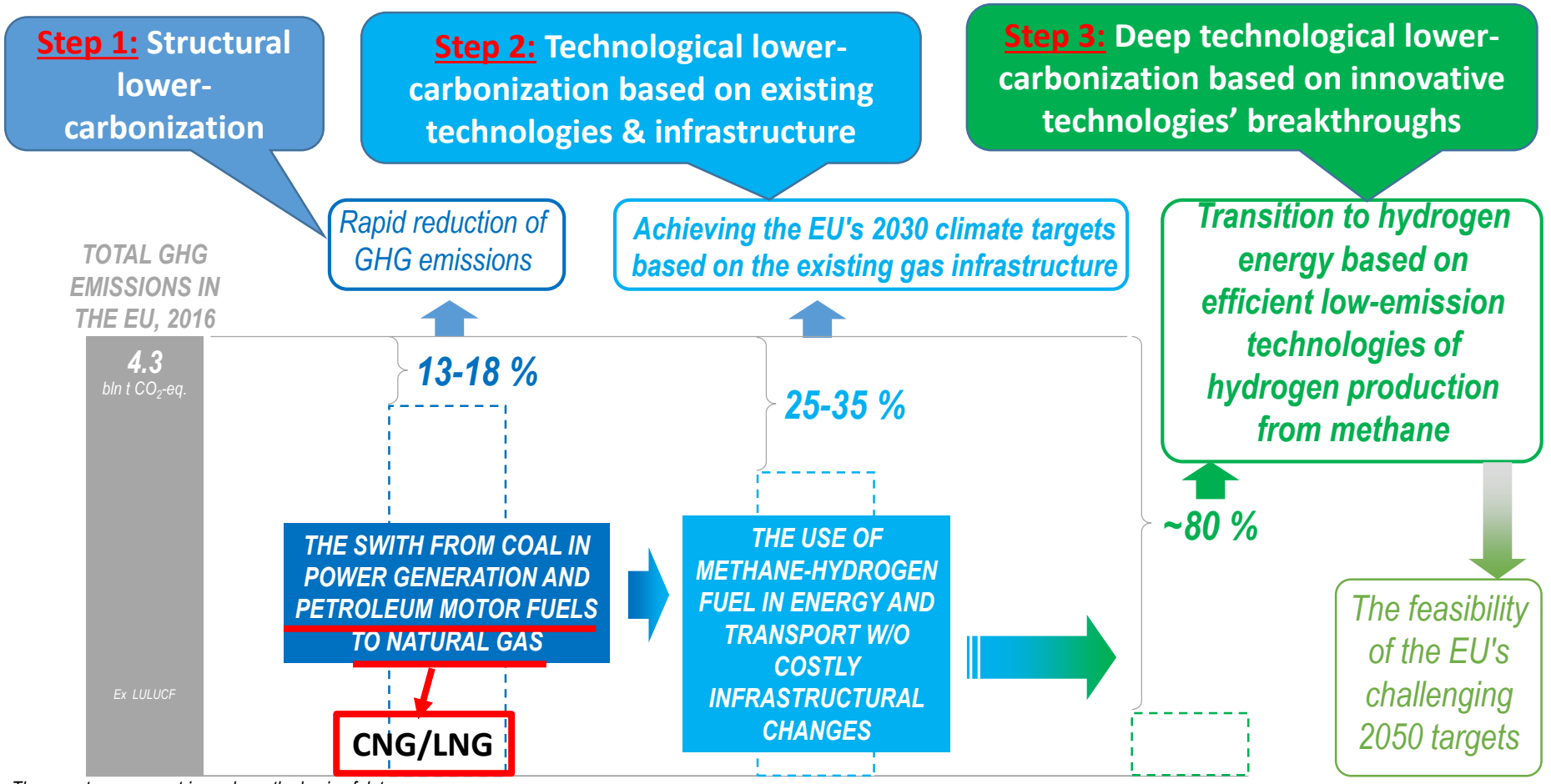
www.konoplyanik.ru
andrey@konoplyanik.ru
a.konoplyanik@gazpromexport.com

Disclaimer: Views expressed in this presentation do not necessarily reflect (may/should reflect) and/or coincide (may/should be consistent) with official position of Gazprom Group (incl. Gazprom JSC and/or Gazprom export LLC), its stockholders and/or its/their affiliated persons, or any Russian official authority, and **are within full personal responsibility of the author of this presentation.**

This presentation is prepared by the author on the basis of his research undertaken, inter alia, within the research project “Influence of new technologies on global competition at the raw materials markets” (Project N 19-010-00782) which is financially supported by the Russian Foundation for Fundamental Research.

Reserve slides

HOW to decarbonize: Gazprom's three-steps cooperative vision ("Three-steps Aksyutin's pathway")

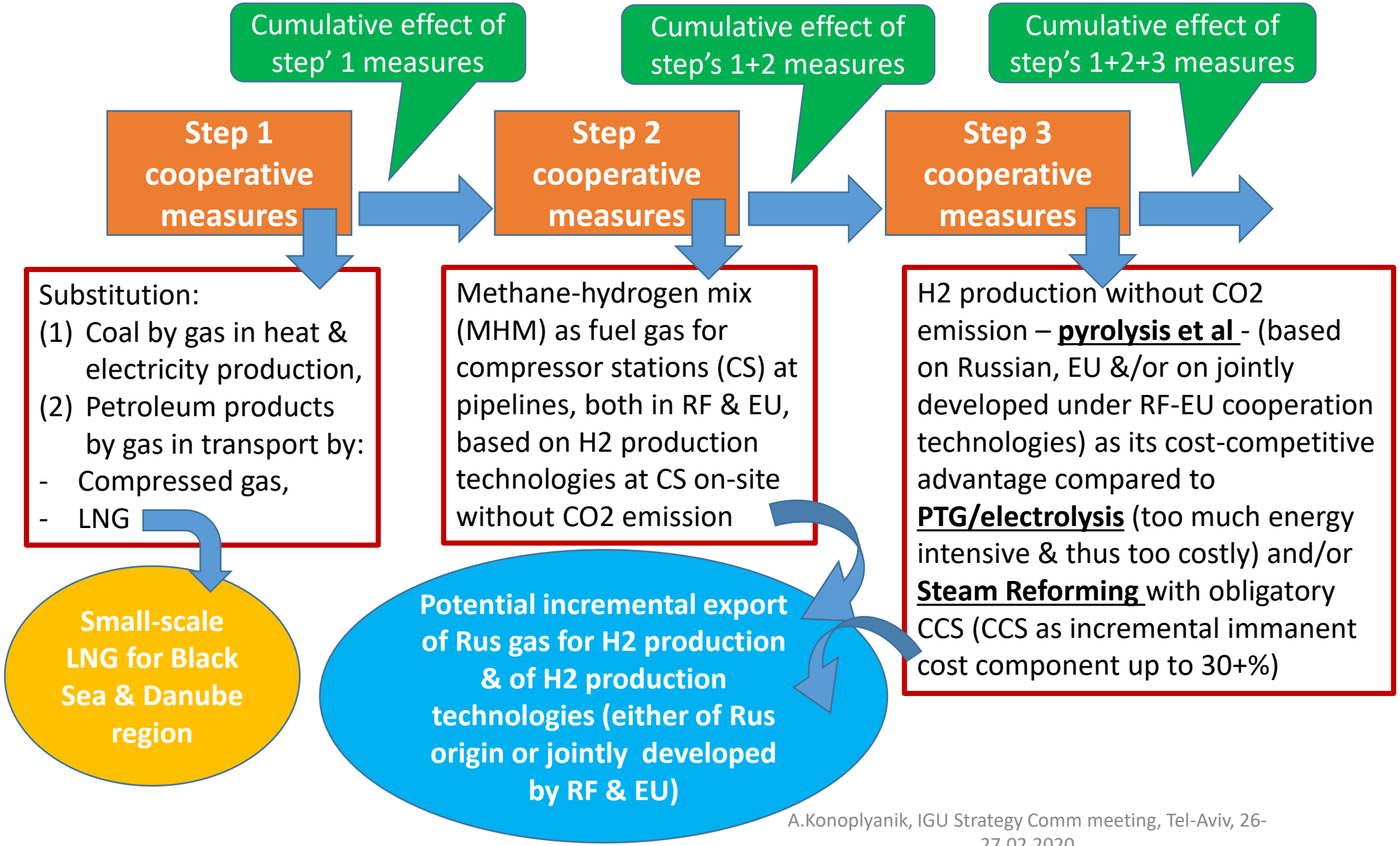


The expert assessment is made on the basis of data on:

- *Carbon intensity from different fuels (U.S. Energy Information Administration estimates);*
- *Carbon footprint of various motor fuels (European Natural gas Vehicle Association report, 2014-2015);*
- *EU GHG emissions (1990 – 2016 National report on the inventory of anthropogenic emissions by sources and GHG removals by sinks not controlled by the Montreal Protocol , IEA)*

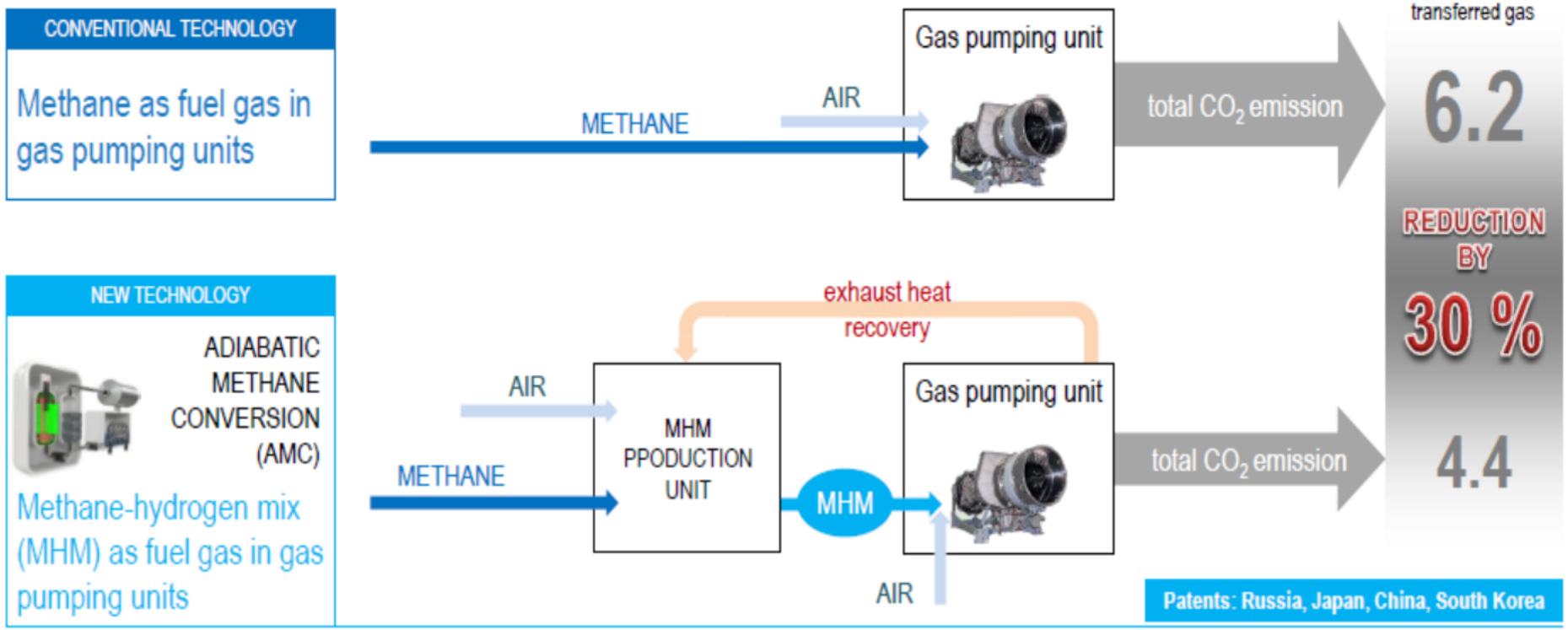
Source: O.Aksyutin. Future role of gas in the EU: Gazprom's vision of low-carbon energy future. // 26th meeting of GAC WS2, Saint-Petersburg, 10.07.2018 (www.fief.ru/GAC); PJSC Gazprom's feedback on Strategy for long-term EU greenhouse gas emissions reduction to 2050 // https://ec.europa.eu/info/law/better-regulation/initiatives/ares-2018-3742094/feedback/F13767_en?p_id=265612

How to cooperate & implement these "three-steps Aksyutin's pathway" vision ?



ADIABATIC METHANE CONVERSION

Step 2 Measures



8

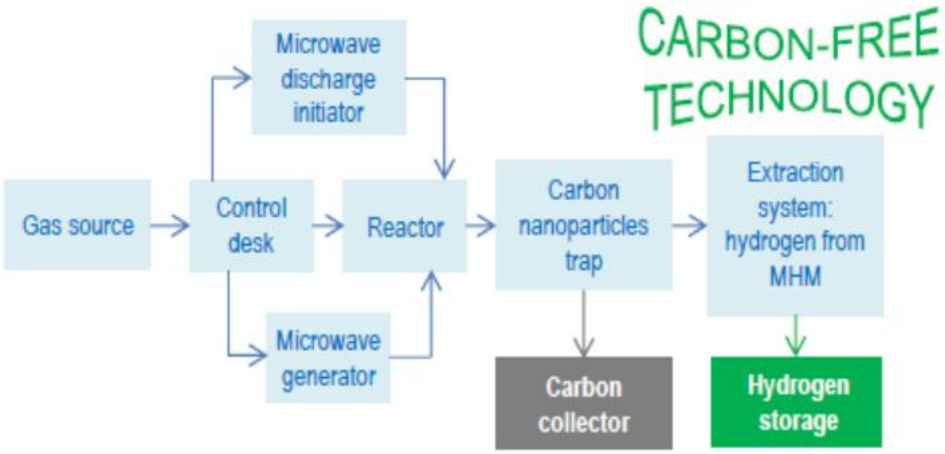
Expert review by the Center for Integrated Development of Technologies and Energy Technology Systems (KORTES Center LLC), Gazprom-Geotekhnologii LLC

Source: O.Aksyutin. Future role of gas in the EU: Gazprom's vision of low-carbon energy future. // 26th meeting of GAC WS2, Saint-Petersburg, 10.07.2018 (www.fief.ru/GAC)

HYDROGEN PRODUCTION IN A LOW-TEMPERATURE NON-EQUILIBRIUM PLASMA

Step 3 Measures

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



CARBON-FREE TECHNOLOGY

PROTOTYPE PLANT

CARBON MATERIAL

CAPACITY OF:
- hydrogen – up to 1 м3/h;
- carbon material – up to 80 g/h

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

9

Source: NATIONAL RESEARCH TOMSK POLYTECHNIC UNIVERSITY

Source: O.Aksyutin. Future role of gas in the EU: Gazprom's vision of low-carbon energy future. // 26th meeting of GAC WS2, Saint-Petersburg, 10.07.2018 (www.fief.ru/GAC)

Russia-EU balance of interests in decarbonisation is possible

Low-carbon development

To hamper it"? **NO!**

To act considering national interests of both Russia & the EU => on the basis of RF-EU mutual interests (only "win-win" approach)

More cost-effective (cheaper) way of decarbonisation for the EU; expands possibilities for incremental monetization of Russia's gas resources & RF-EU gas grid =>

win-win

EU interests/vision/perceptions – and mutual consequences:

1. Monetization of gas grid (electricity storage in the form of decarbonized gases): CH4 is not decarbonized gas (fossil fuel) => PtG (electrolysis) => "green" H2 => monetization of gas grid (by using H2/MHM)
2. Need for deep technological modernization of cross-border gas grid (esp. if to decarbonise upstream, beyond the EU) => more costly & time-consuming
3. Regulatory reform needed downstream (in EU) & upstream (in non-EU) : both between-sectors coupling (electricity & gas) and within-sector coupling (harmonization of CH4, H2, MHM, CO2, etc use within same gas grid)

Russia interests/vision/perceptions – and mutual consequences:

1. Monetization of both gas resources (increased demand for gas for further decarbonisation) & gas grid (increased throughput to domestic & export markets): H2 from CH4 without CO2 emission => preference for pyrolysis et al, not for MSR only
2. Decarbonisation downstream => direct use of gas grid for initially designed purpose (not to redesign it from original single CH4 use to multiplicity of gases) => no need in deep technological modernization (for mixture of gases) through the long transportation leg beyond export markets => less costly & time-consuming
3. Regulatory reform only downstream (in EU) => less costly & time-consuming