Hydrogen economy as one of the low-carbon paths: a new story (additional window of opportunities?) for gas? Technological vs. regulatory challenges

Prof. Dr. **Andrey A. Konoplyanik,**
Professor on International Oil & Gas Business, Russian State Gubkin Oil and Gas University;
Co-chair Work Stream 2 “Internal Markets”, Russia-EU Gas Advisory Council;
Adviser to Director General, "Gazprom export" LLC;
Member of the Academic Board of the IEC – CEC Joint Research Center

IEC – CEC Joint Research Center Annual Meeting “International Energy Charter Symposium in Beijing” jointly organized by the International Energy Charter and China Electricity Council, Beijing, China, MinZu Hotel Beijing, 28.11.2019

Three global gas revolutions => way to hydrogen?

Two revolutions came from supply-side:

1) **US shale** (gas & oil) **revolution**
   - one of the long-term man-made consequences of the oil price shocks of the 1970-ies
   - 10+ reasons why it happened in the US and not elsewhere
   - 10+ its "domino effects" which radically changed (energy) world
2) **LNG revolution** (formation of global LNG market => global gas market)
   - …as one of "domino effects" of US shale revolution
   - development on the model of global oil market (physical plus paper energy market)
   - Increasing supply flexibility at the cost of increasing risks

One revolution came from demand-side:

3) **"Green" revolution** /decarbonization/low-carbon development (in result of growing importance, up to aggravation, of climate agenda => COP-21/24):
   - Technological aspects
   - Regulatory aspects

These three revolutions have overlapped on top of long-term effect of materialized consequences of adaptation of world economy to oil prices' shocks of the 1970-ies

⇒ New more competitive energy environment is being formed; it is more difficult for producers of non-renewable energies (fossil fuels) to find its place in compressing competitive niche

⇒ ***Dilemma for Russia: to leave the area of its current competitive advantages OR to stay within non-renewable energy niche, BUT on the new competitive technological basis?***

⇒ Russia has its competitive niche which allows this country to monetize its vast non-renewable energy resource (incl. most clean – natural gas), but on the new technological basis => **Hydrogen as one of the solutions, a win-win possible option for both Russia & EU**

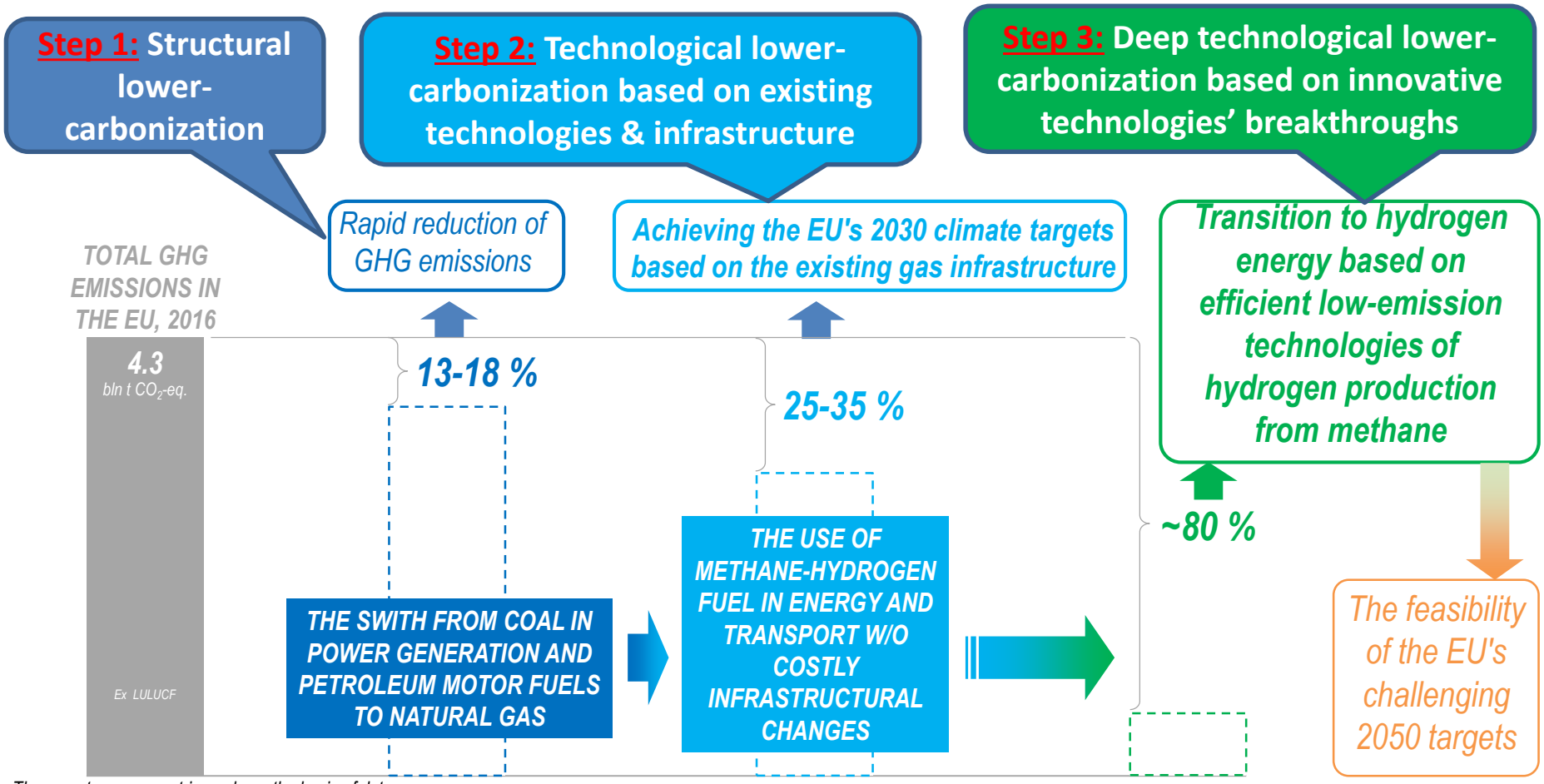
Green revolution => hydrogen: technological aspects

- Decarbonization (low-carbon development) in EU vision is mostly RES (only RES considered in EU to be "green") with geopolitical subtext (domestic "green = clean" electrons vs. foreign "dirty" molecules), but
- EU future vision evolved:
  - prior to 2018: "digital, electrical, renewable" (RES electricity => all-electrical EU)
  - since 2018: from all-electric renewable future – to "renewable electricity plus decarbonized gases" => H2 is one of the "decarbonized" gases
- What are decarbonized gases? Technological options for H2 production:
  1) **PtG (electrolysis)** - considered in EU to be the only "green" H2 among three options, but:
     - Not "green" if electricity from the grid (20% EU electricity coal-fired with GHG emissions)
     - In case RES-electricity used:
       - if interruptible RES-electricity supply – financing of H2 production hardly bankable (ROI worsened – interruptible revenue flow)
       - If non-interruptible RES-electricity supply – back-up capacity is gas/coal-fired (GHG emissions)
     - "Green" only where RES-electricity is produced (EU), NOT where most of RES-electricity equipment is manufactured (China) and rare-Earth materials are extracted (China, etc.)
  2) **Steam reforming** – considered in EU to be (the only!?) "blue" H2
     - with access of O2 => CO2 => with CCS => not "storage" but "sequestration" => CO2 not an input into new investment cycle, but just an extra cost to the given project
  3) **Methane pyrolysis** (& similar technologies) – almost NOT mentioned in public debate until very recently (since mid-2018: after Gazprom presentation at WS2 GAC in SPB):
     - w/o access of O2 => w/o CO2 & CCS => **economic priority for Russia & EU !?**
- Mis-perceptions: as if "decarbonized" =

  = Green = RES = PtG => H2 by electrolysis? (EU: "green H2") – the most/only welcome path in EU,

  = w/o C = non-fossil => H2 ***not*** from methane (methane is fossil) – or at least with CCS => in result: mutually beneficial for Russia & EU technological path was not on top of (in) the agenda (until very recently)

HOW to decarbonize: Gazprom's three-steps cooperative vision



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 vision ?

Cumulative effect of step' 1 measures

Cumulative effect of step's 1+2 measures

Cumulative effect of step's 1+2+3 measures

Step 1 cooperative measures

Step 2 cooperative measures

Step 3 cooperative measures

Substitution:
(1) Coal by gas in heat & electricity production,
(2) Petroleum products by gas in transport by:
- Compressed gas,
- LNG

Methane-hydrogen mix (MHM) as fuel gas for compressor stations (CS) in pipeline systems, both in RF & EU, based on H2 production at CS on-site (AMC)

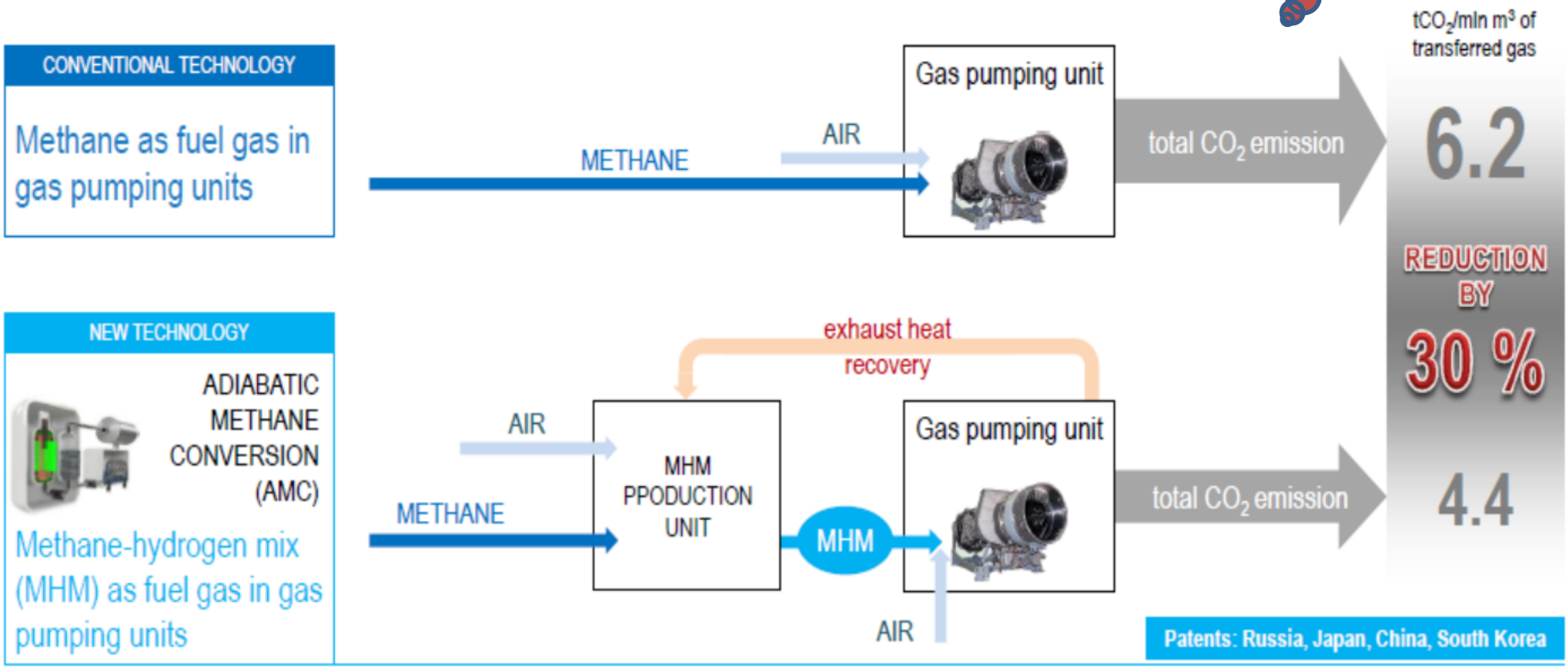
H2 production without CO2 emission (based on Russian, EU &/or jointly developed under RF-EU cooperation technologies) as its cost-competitive advantage (pyrolysis etc.) compared to PTG/electrolysis (too much energy intensive & thus too costly) and/or Steam Reforming with obligatory CCS (CCS as incremental immanent cost component up to 30+%)

Small-scale LNG for Black Sea & Danube region

Potential incremental export of Rus gas for H2 production & of H2 production technologies (either of Rus origin or jointly developed by RF & EU)

ADIABATIC METHANE CONVERSION

Step 2 Measures



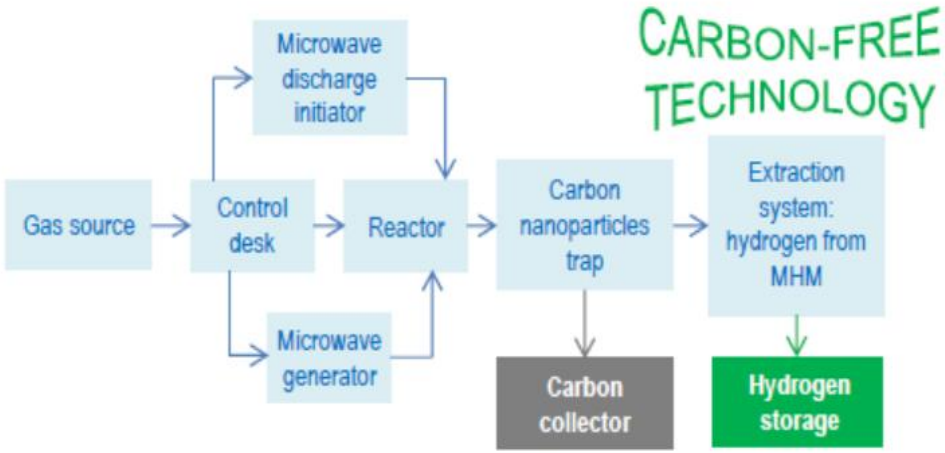
Expert review by the Center for Integrated Development of Technologies and Energy Technology Systems (KORTES Center LLC), Gazprom-Geotekhnologii LLC

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

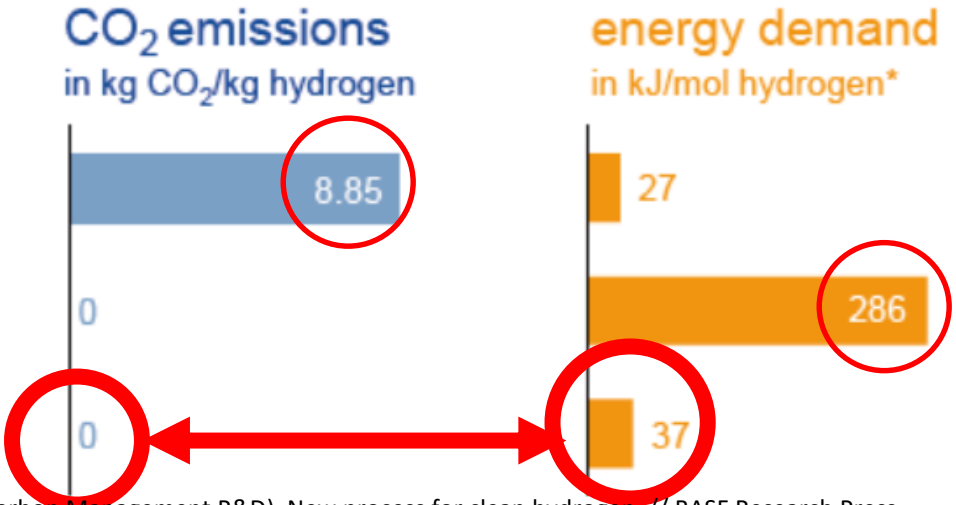
Source: NATIONAL RESEARCH TOMSK POLYTECHNIC UNIVERSITY

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)

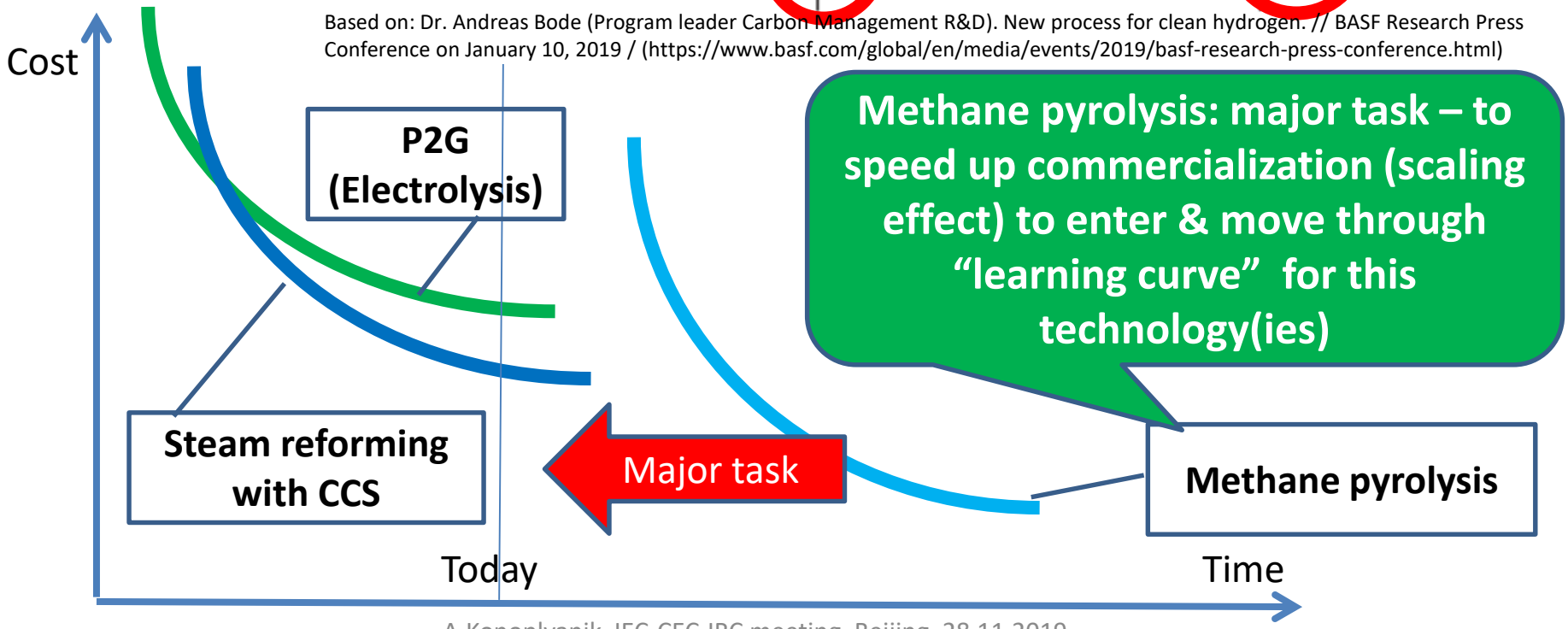
All other conditions being equal, & under technologically neutral regulation, methane pyrolysis might win competition in hydrogen production with two other key technologies

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)



Methane pyrolysis: major task – to speed up commercialization (scaling effect) to enter & move through "learning curve" for this technology(ies)

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
- Steam reforming plus CC(U)S
- Methane pyrolysis & similar (w/o CO2)

Based on author's conversations with Ralf Dickel

Source of map: ENTSOG

Green revolution - hydrogen: regulatory aspects

- From unbundling & ”atomization” (markets, companies) under 2nd-3rd EU Energy Packages – to *de facto* re-bundling (reintegration) of markets & companies under new EU Green (decarbonization) packages
- From gas to gases: from single product (NatGas = methane) to multiplicity of gases (methane, MHM, H2, CO2, etc.)
  - From fixed standard quality (deviations penalized – contractual provisions) - to multiple products with different qualities in the same integrated highly-meshed system
    - Different standards for MHM in different countries: from 0 (UK, Belgium) to 12% (Netherlands)
    - Different users need different gases (1/3 of EU gas consumed in chemistry, no gas-mix permitted)
- Within “Broader Energy Europe” (& within emerging Eurasian energy market) with cross-border immobile grids:
  - Integration of electricity & gas grids => cross-market regulation
  - Multinational character of regulation (level playing field for all)

  => IEC as a possible best available option to address common cross-border & cross-energy-markets regulatory challenges?
    - IEC Task Force on H2 as “testing water” exercise?

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.