

# Pyrolysis: Can it be a Pathway to a “win-win” Russia-EU collaboration in regard to decarbonisation?

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# Three global gas revolutions – and Russia's dilemma

Two revolutions came from supply-side:

- 1) **US shale** (gas & oil) revolution with global consequences (domino effects)
- 2) **LNG** revolution (formation of global LNG market => global gas market)

One revolution came from demand-side:

3) Global **“green”** revolution => decarbonisation/low-carbon development (in result of growing importance, up to aggravation, of climate agenda) => in the EU:

- Technological aspects (mostly RES) with geopolitical subtext (*domestic “green/clean” electrons vs. foreign “dirty” molecules*), but
  - EU (since 2018): from “all-electric” renewable future – to “renewable electricity plus decarbonized gases”
- Regulatory aspects:
  - from unbundling/“atomization” of markets, companies, businesses – to their reintegration (re-bundling) with growing low-carbon considerations => partial reintegration of gas & electricity
  - From one single gas (methane = CH<sub>4</sub>) in the grid to multiplicity of gases (CH<sub>4</sub>, H<sub>2</sub>, MHM, CO<sub>2</sub> etc.)
- Non-direct (non-linear) development trend: distortions & inflections (like “all-electric-RES-based” earlier EU perception or EIB decisions as of 14/11/2019) => “learning by doing” (like with Third EU Energy Package)

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 – but low-carbon – energy niche on the new competitive 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 FROM NATURAL GAS, esp. w/o CO<sub>2</sub> emissions, as one of the solutions***

# “Green revolution” is, inter alia, an attempt for a new repartition of global economy => what can be algorithm of rational economic behavior for Russia

- What we have been witnessing as (as if global rush for) “green revolution” is an attempt, inter alia, for a new – moreover accelerated – repartition (technological => political) of global economy =
  - = Formation of new technological mode (new economy) by companies of such new economic mode (RES etc)
    - To hamper it? NO (Not to repeat the mistakes of initial perception of the Third EU Energy Package)
    - To effectively fit into low-carbon economy based on maximization of national interests, **but within win-win approach!!!**
- Russia should not rush to be at the forefront within this repartition :
  - This is impossible – economy is not ready for breakthrough into new economy as it viewed on the West (technological gap),
  - This is not necessary (accelerated drive for repartition will slow-down sometime soon - since largely based on overstated miscounted perceptions - to a more balanced vision , like it was with “100%-RES-electricity” EU vision or “Russia as energy-super-power” vision)
  - BUT... it is clear that low-carbon development has been formed and set by now as a steady trend in the EU
    - In the minds, especially of Western young generation
    - Politicians who play long-term and thus aim at this young generation as growing electorate (EU New Green Deal 2019)
    - Began to be materialized in legal decisions that influence investment flows thus redistributing them in favour of “green” industries (non-dependent whether perception of “green” is fair, like based on strained interpretation EIB decision as of 14.11.2019)
- => To preserve Russia in the zone of its competitive advantages (non-renewable energy resources) in circumstances where major partners (EU) steady goes through the path of accelerated decarbonisation (low-carbon development => stated resignation from fossil fuels => **one of the win-win options: H2 from CH4**
- **BUT:** not “grey”, “blue” or “green” H2 (EU terminology which mislead) but:
  - Export-oriented decarbonisation of Russian gas (not for domestic Russia first, but first for the EU)
  - Not upstream, but downstream Russia-EU gas value chain (where 80% CO2 emissions)
  - **H2 production from CH4 without CO2 emissions => most preferential mutually-beneficial way of production and use of such decarbonized gas as H2**

# Decarbonised gas: what are key H2 production technological pathways

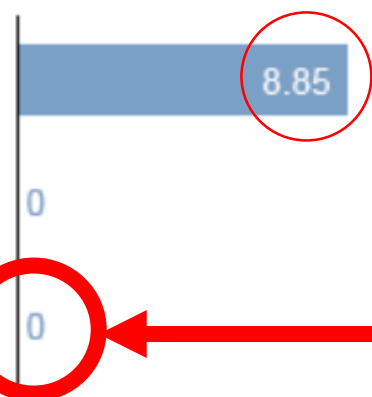
- 1) **Water electrolysis** (the only as if “**green**” H2 in the EU among three options), but:
  - Is not “green” if electricity from the grid (20% EU electricity is coal-fired power stations)
  - Is not green if full value chain (incl. manufacturing of RES-power equipment etc) is considered
  - In 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
    - If permanent (non-interruptible) RES-electricity supply: this is possible ONLY with the use of back-up generation capacities (coal and/or gas-fired угольные power station with low utilization rate => worsens their & 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 is 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 !!!**

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

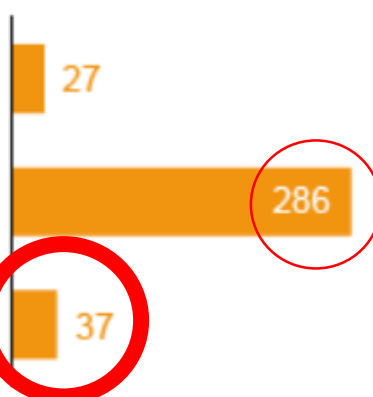
**CC(U)S is needed!!! => additional imputed costs (CAPEX + OPEX) => add. 20/30+%**

Steam reforming of natural gas	$\text{CH}_4 + 2\text{H}_2\text{O} \rightarrow 4\text{H}_2 + \text{CO}_2$
Water electrolysis	$2\text{H}_2\text{O} \rightarrow 2\text{H}_2 + \text{O}_2$
Methane pyrolysis	$\text{CH}_4 \rightarrow 2\text{H}_2 + \text{C}$

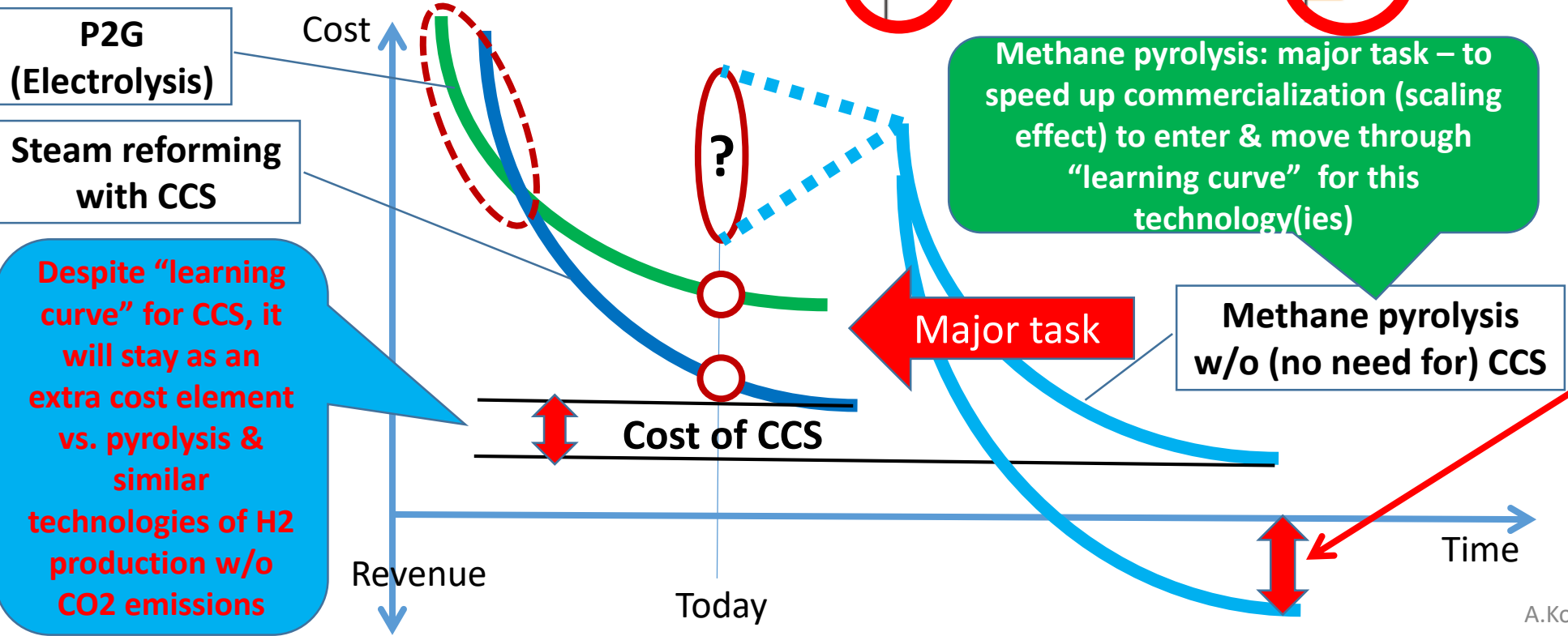
CO<sub>2</sub> emissions in kg CO<sub>2</sub>/kg hydrogen



energy demand in kJ/mol hydrogen\*



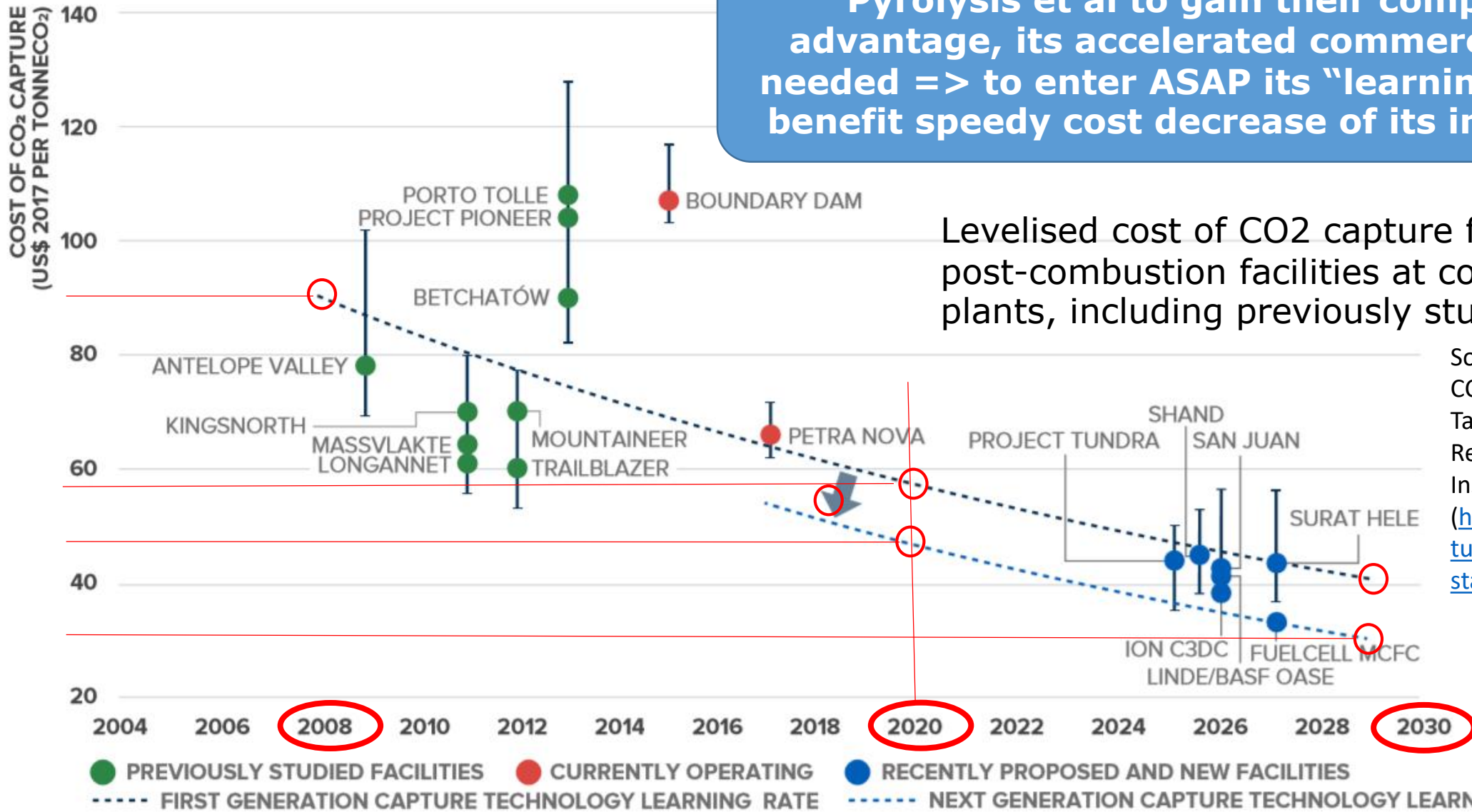
Based on: Dr. Andreas Bode (Program leader Carbon Management R&D). New process for clean hydrogen. // BASF Research Press Conference on January 10, 2019 / (<https://www.basf.com/global/en/media/events/2019/basf-research-press-conference.html>)



- (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 CO<sub>2</sub>

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

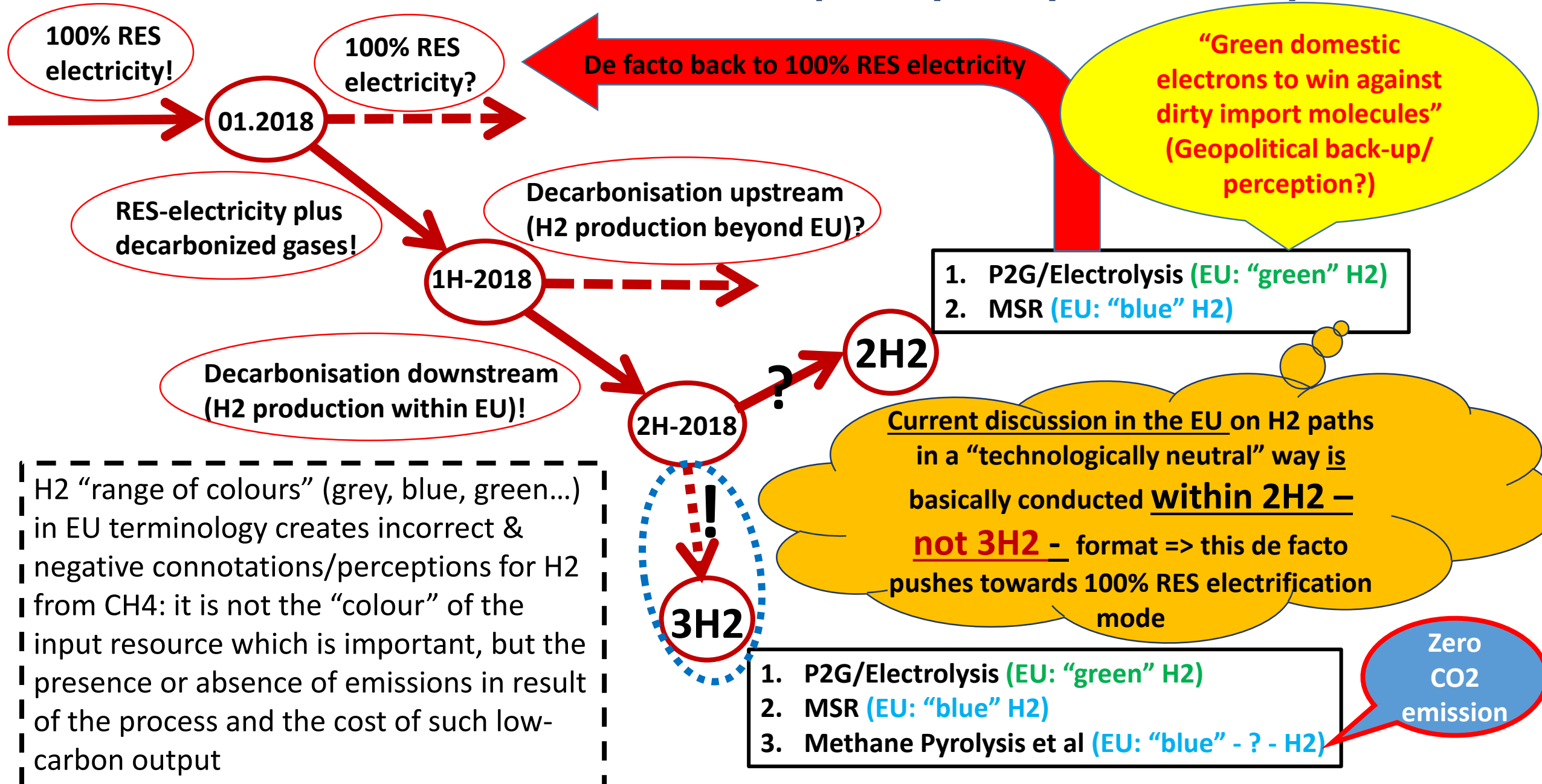
Pyrolysis et al to gain their competitive advantage, its accelerated commercialization needed => to enter ASAP its "learning curve" to benefit speedy cost decrease of its initial phase



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/>)

# Y-tracks of EU decarbonisation paths (mostly RES-centric)



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

# 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): CH<sub>4</sub> is not decarbonized gas (fossil fuel) => PtG (electrolysis) => "green" H<sub>2</sub> => monetization of gas grid (by using H<sub>2</sub>/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 CH<sub>4</sub>, H<sub>2</sub>, MHM, CO<sub>2</sub>, 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): H<sub>2</sub> from CH<sub>4</sub> without CO<sub>2</sub> 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 CH<sub>4</sub> 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





# 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
  -  MSR plus CC(U)S
  -  Methane pyrolysis et al (w/o CO2)  
*(to incorporate both Step 2 & Step 3 Cooperative measures from “Three Step Aksyutin’s Path”)*
- } Electrolysis

A.Konoplyanik,  
EGC2020, Vienna,  
29.01.2020

Based on author’s conversations with Ralf Dickel

Source of map: ENTSOE

# 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 latest WS2 meeting in Berlin on 21.10.2019 (<https://minenergo.gov.ru/node/14646>)



# Thank you for your attention!

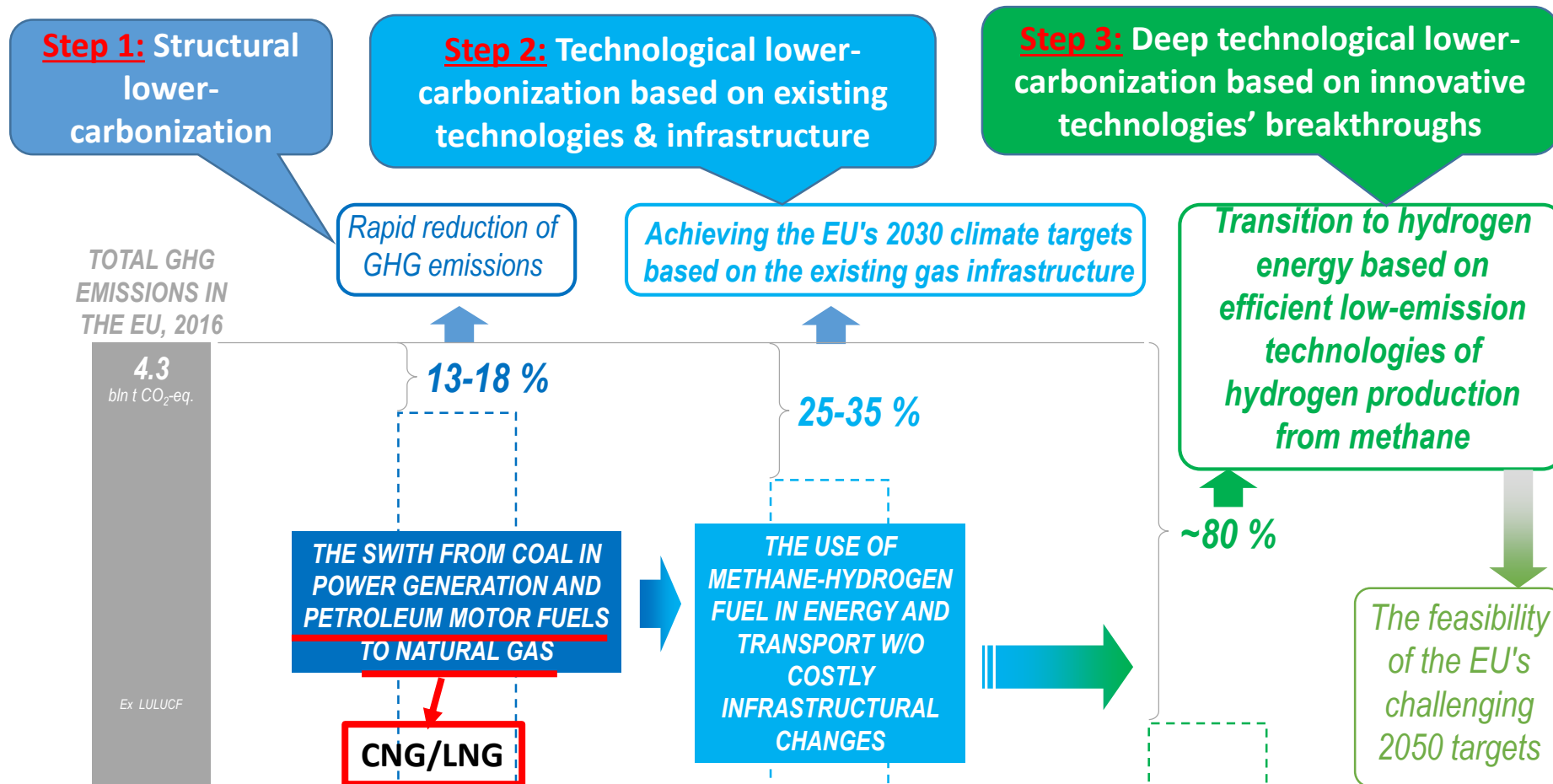
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This presentation is prepared by the author on the basis of his research undertaken, inter alia, within the research project “Influence of new technologies on global competition at the raw materials markets” (Project N 19-010-00782) which is financially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

# Reserve slides

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

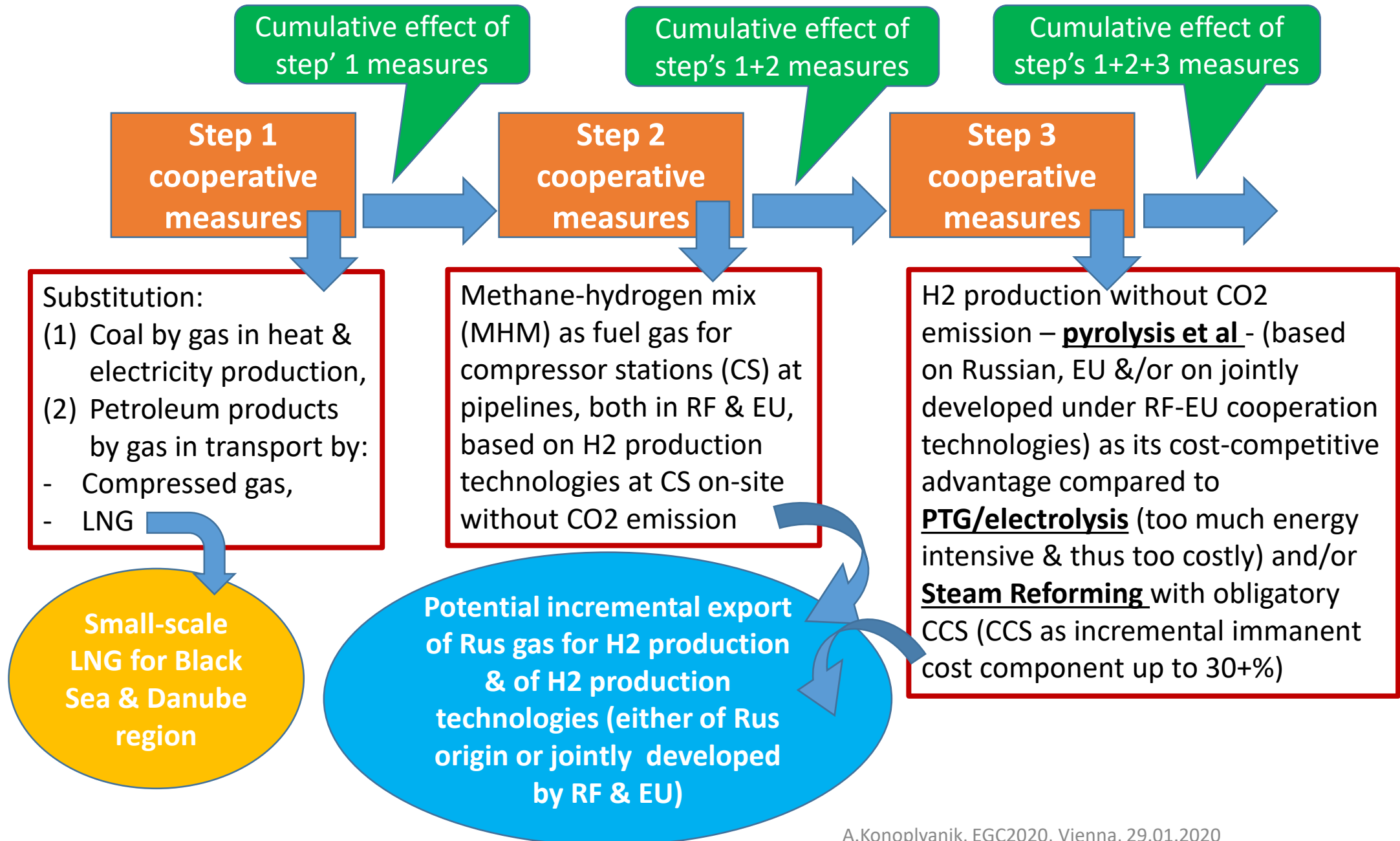


The expert assessment is made on the basis of data on:

- 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)

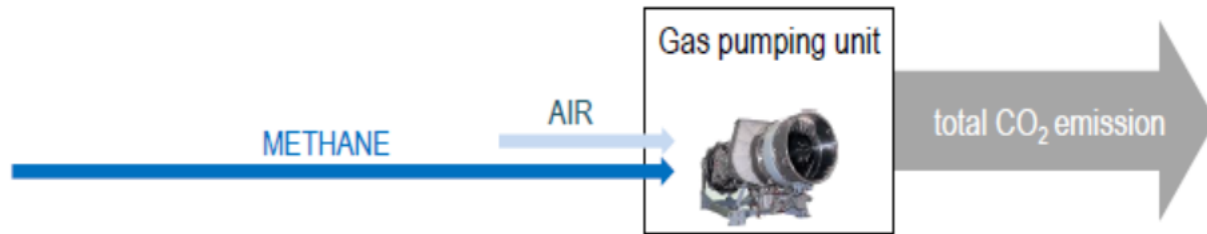
Source: O.Aksyutin. Future role of gas in the EU: Gazprom's vision of low-carbon energy future. // 26th meeting of GAC WS2, Saint-Petersburg, 10.07.2018 ([www.fief.ru/GAC](http://www.fief.ru/GAC)); PJSC Gazprom's feedback on Strategy for long-term EU greenhouse gas emissions reduction to 2050 // [https://ec.europa.eu/info/law/better-regulation/initiatives/ares-2018-3742094/feedback/F13767\\_en?p\\_id=265612](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 ?



**CONVENTIONAL TECHNOLOGY**

Methane as fuel gas in gas pumping units



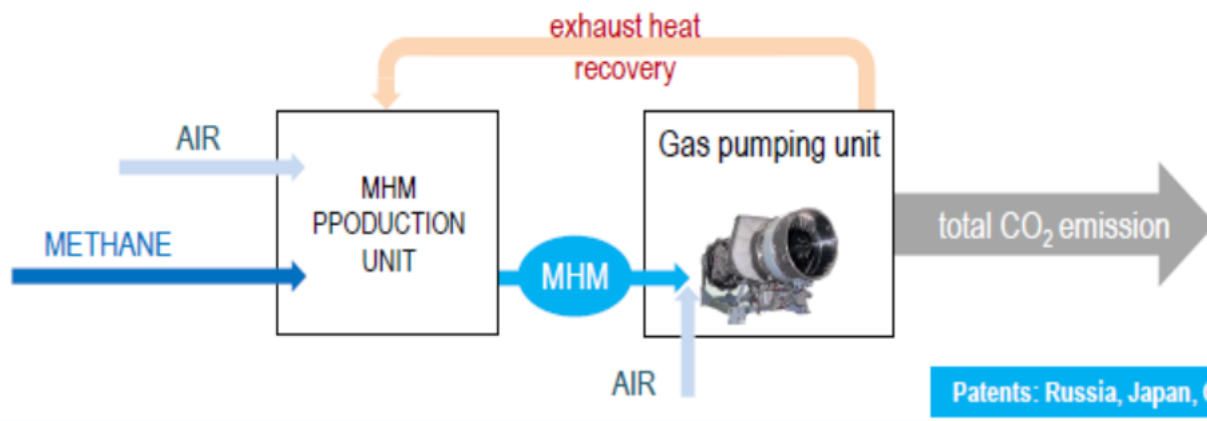
tCO<sub>2</sub>/mIn m<sup>3</sup> of transferred gas

**6.2**

**NEW TECHNOLOGY**

ADIABATIC METHANE CONVERSION (AMC)

Methane-hydrogen mix (MHM) as fuel gas in gas pumping units



REDUCTION BY

**30 %**

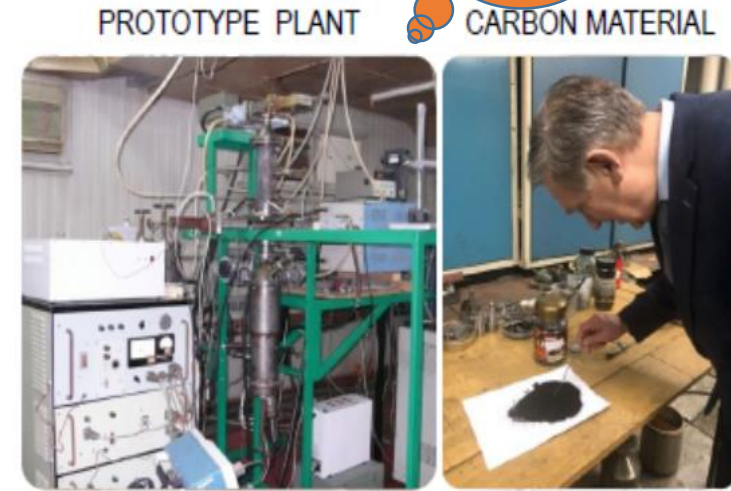
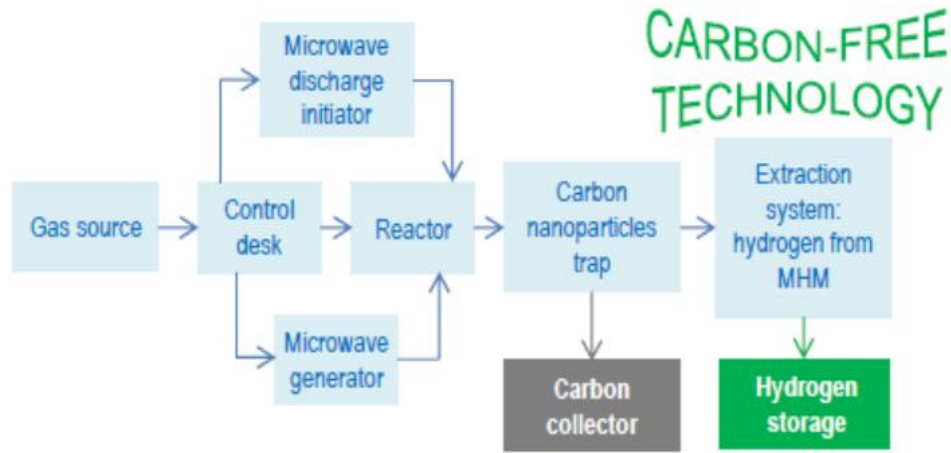
**4.4**

Patents: Russia, Japan, China, South Korea

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](http://www.fief.ru/GAC))

## Step 3 Measures

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

CAPACITY OF:  
 - hydrogen – up to 1 m<sup>3</sup>/h;  
 - carbon material – up to 80 g/h

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](http://www.fief.ru/GAC))