On prospective role of Russian natural gas in EU decarbonisation

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How Russia can help the EU on its way to low-carbon energy future to the mutual benefit of both parties

(three-steps Gazprom's proposed pathway ("Aksyutin's path") and the role of Hydrogen produced from Methane without CO2 emissions as the potential area of Russia-EU cooperation in energy and beyond)

How high in the list of national priorities climate agenda, and thus decarbonization (*), is placed due to objective preconditions

EU (highest domestic priority)

- Accumulated negative ecological consequences since 1st industrial revolution (started much earlier => longer accumulation period)
- Smaller territory, higher population density => higher unit negative accumulated ecological effect
- Lack of forests (result of early industrialization) => lower environmental recovery capacity (ability) => GHG **emission exceeds** its natural absorption (by 4 times?) => EU is **GHG net-emitter** (like US, China, India…)

Russia (not as high domestically as in EU)

- Industrialization started much later
- Large territory, lower density of population – much lower unit negative ecological effect
- Large territories covered with forests => highest environmental recovery capacity (ability) => GHG **natural absorption exceeds** its emission (by few times?) => Russia is **GHG net-absorbent** (plus other 4-5: Canada, Brazil, Australia, New Zealand and (?) Sweden)
- Too early to switch to posterior technological steps in decarbonization chain of actions in domestic Russia – it might be counter-productive => historical lessons of almost taken wrong invest decisions:
  - **from 1980-ies: Caspian Sea level vs water transfer from Siberian Rivers proposal;**
  - from 1960-ies: Verkhneobskaya (Higher-Ob) hydro power station proposal
- **=> Export-oriented decarbonization as a balanced solution?**

(*) Decarbonisation as the process of decreasing carbon intensity of the economy

To find the balanced economically justified & mutually acceptable joint solutions

EU & Russia: two different approaches (starting positions) to gas decarbonisation shall not disunite the parties

EU approach/priority (to monetize **gas infrastructure only**)

- To convert excessive renewable electricity (when available, and thus at zero or negative price), a non-storable energy good, into storable energy commodity – hydrogen (and thus to further pay back past state subsidies for RES)
- To use available **gas infrastructure** for this purpose
- **Decarbonisation is the definite immediate target** *(R.Dickel: "We have the target – how to reach it")(*)*
- + by-product: to diminish import dependence (to substitute dirty foreign molecules by clean domestic electrons)

Russia approach/priority (to monetize **both gas resources & gas infrastructure**)

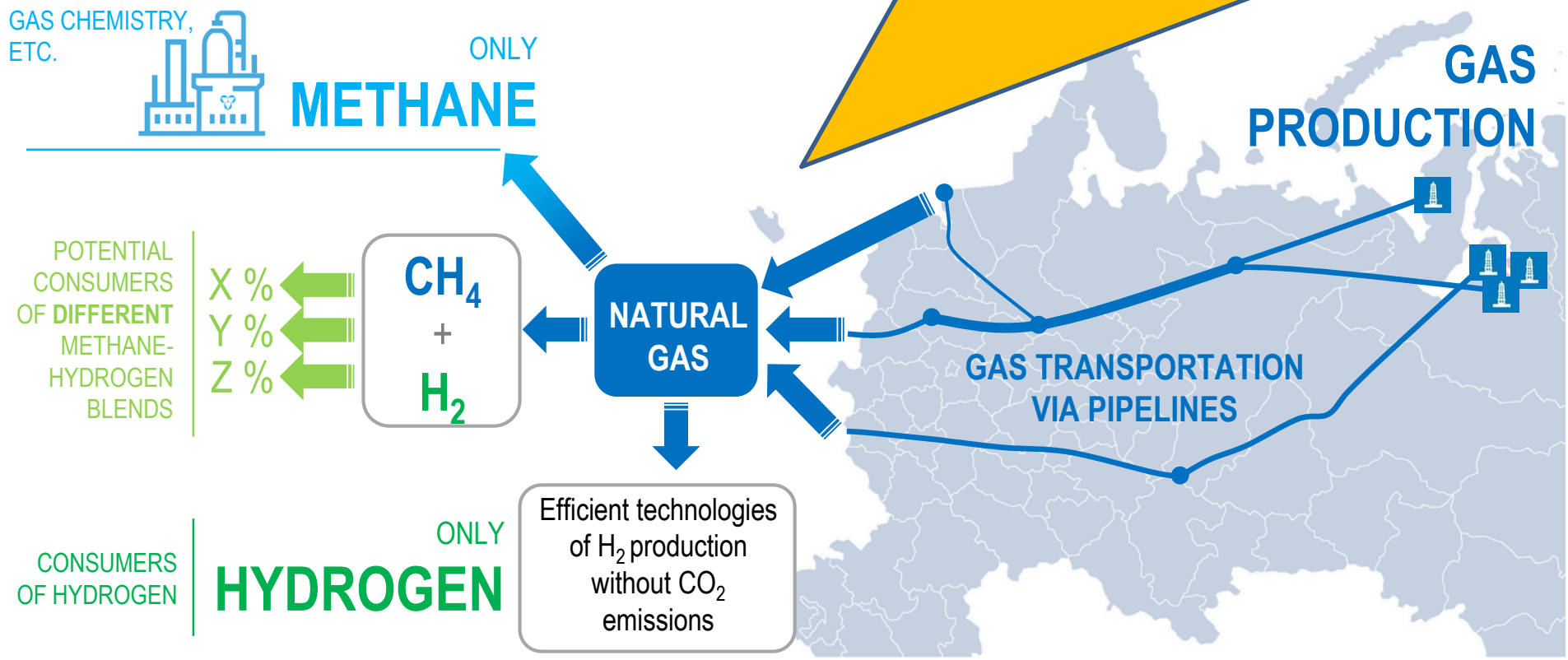
- To monetize its vast gas reserves / resources as, first, substitute for other (much more dirty) fossil fuels, secondly, as the resource for its further decarbonization within the Russia-EU cross-border gas value chain at its segment where common benefit is the highest
- To use available **gas resources & infrastructure** for this purpose
- **Decarbonisation is rather the immediate means for gas monetization than the immediate target by itself** => *(M.James / M.Hafner: "if Russia wants to help EU to build (become the first) H2-based economy…")(*)* => not at the price of loosing Russia's current competitive niches / advantages in energy sphere

Decarbonisation in Russia & in EU are two different stories, **BUT common denominator** (though within different priorities): available cross-border Russia-EU capital-intensive immobile gas infrastructure NOT to be converted into stranded asset in case gas is NOT considered as just "transition (bridge)" fuel => material background for Russia-EU cooperation in decarbonisation

(*) Citations from "ENERGETIKA-XXI" conference, Saint-Petersburg, 14-16.11.2018

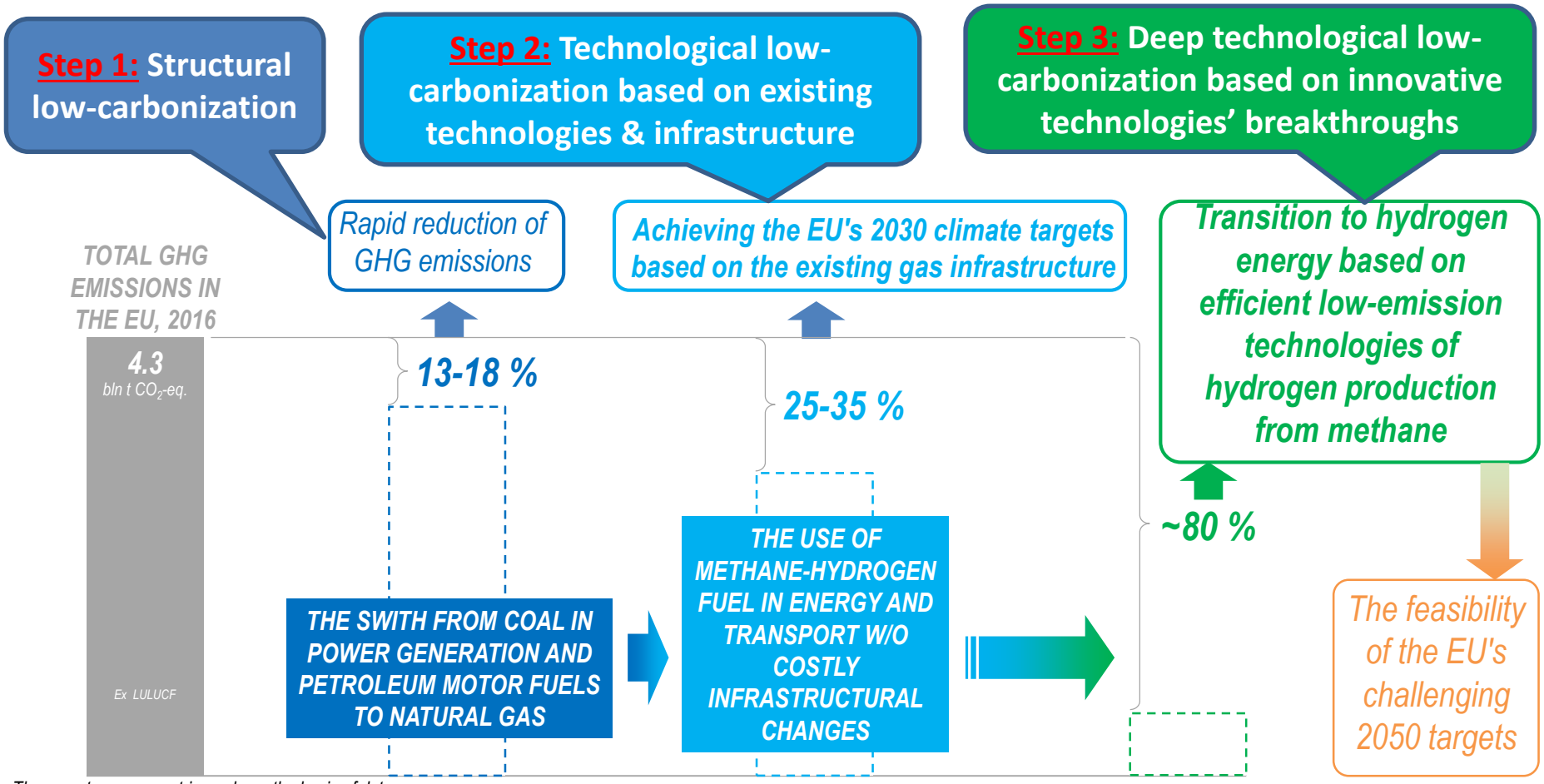
WHERE to decarbonise: selection of location for H2 production

80% CO2 emissions within Russia-EU cross-border gas value chain are downstream, at consumer end, within EU => low-carbonization downstream (at end-use, within EU) based on Russian gas export & (export of Russian, if commercialized & competitive) no-CO2 technologies of H2 production => fair competition, technological neutrality, mutual complementarity of "blue H2" technologies **with** (Norway/Equinor path => incl. CCS) & **without** (Russia/Gazprom path => no CCS) CO2 emission



Source: O.Aksyutin, A.Ishkov, K.Romanov. Potential of natural gas decarbonization: Russian view of the cross-border gas value chain. // 27th meeting of GAC WS2, Brussels, 07.12.2018 (www.fief.ru/GAC)

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

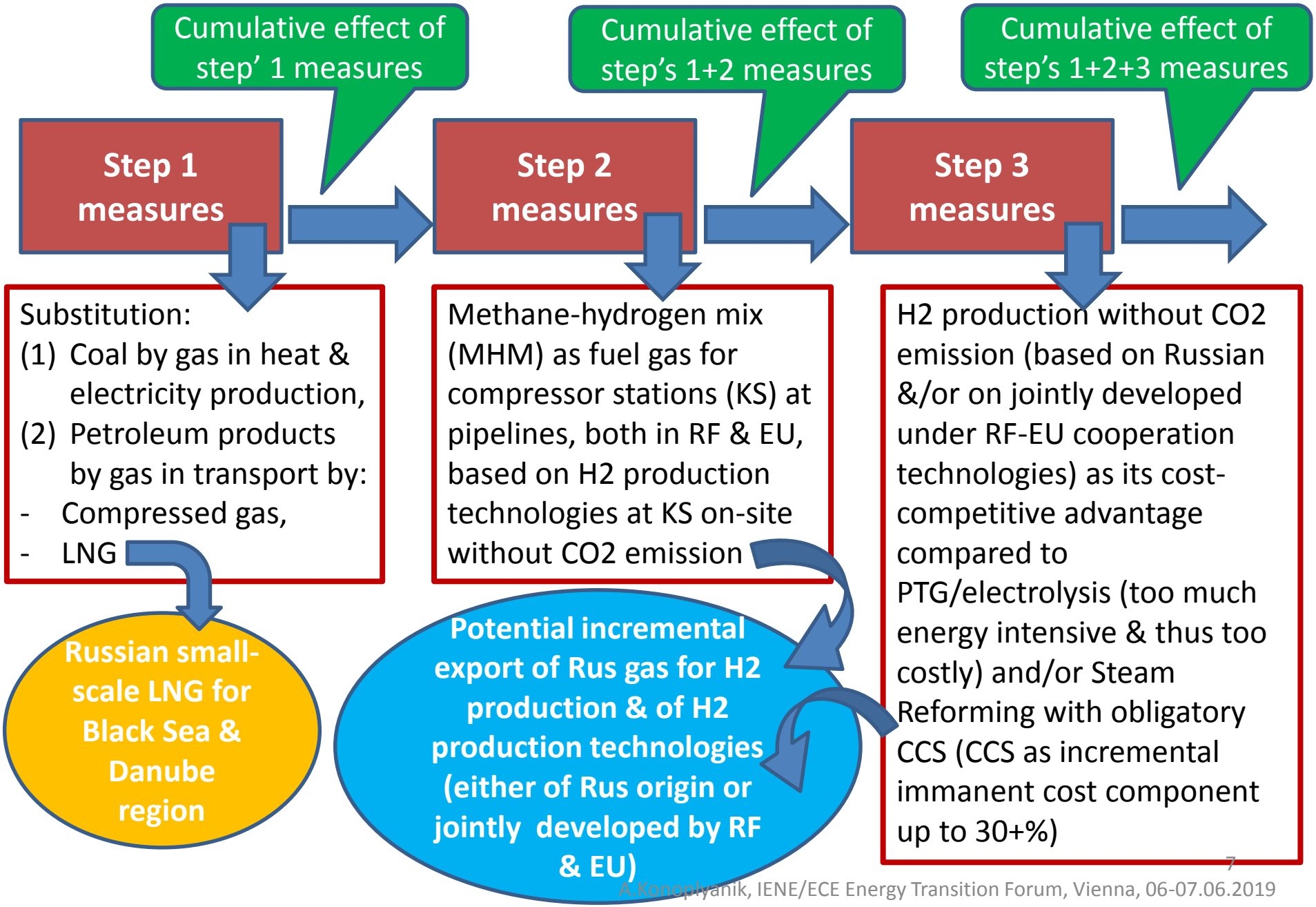


The expert assessment is made on the basis of data on:

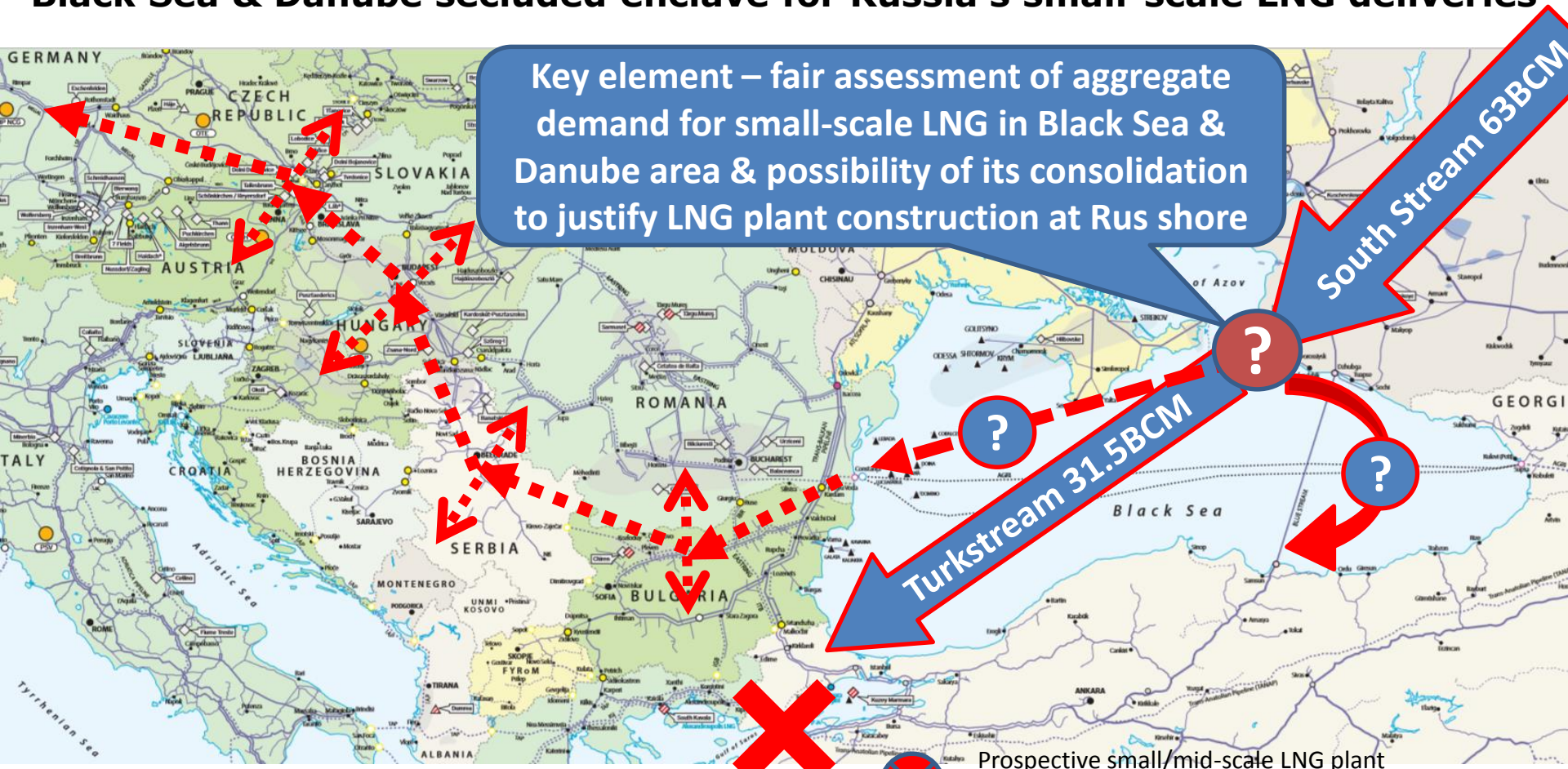
- *Carbon intensity from different fuels (U.S. Energy Information Administration estimates);*
- *Carbon footprint of various motor fuels (European Natural gas Vehicle Association report, 2014-2015);*
- *EU GHG emissions (1990 – 2016 National report on the inventory of anthropogenic emissions by sources 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 implement three-steps "Aksyutin's pathway"?



Turkey' s decision on closure of the Straits for LNG-carriers and Russia's change from South Stream to TurkStream as a precondition for forming of Black Sea & Danube secluded enclave for Russia's small-scale LNG deliveries



Turkey's prohibition for LNG-carriers to pass though the Straits in both directions

Small/mid-scale LNG supplies towards Danube

Small/mid-scale LNG supplies through Danube (LNG delivery as cassette modules to gas stations and for river ships' bunkering)

Prospective small/mid-scale LNG plant (onshore/offshore)

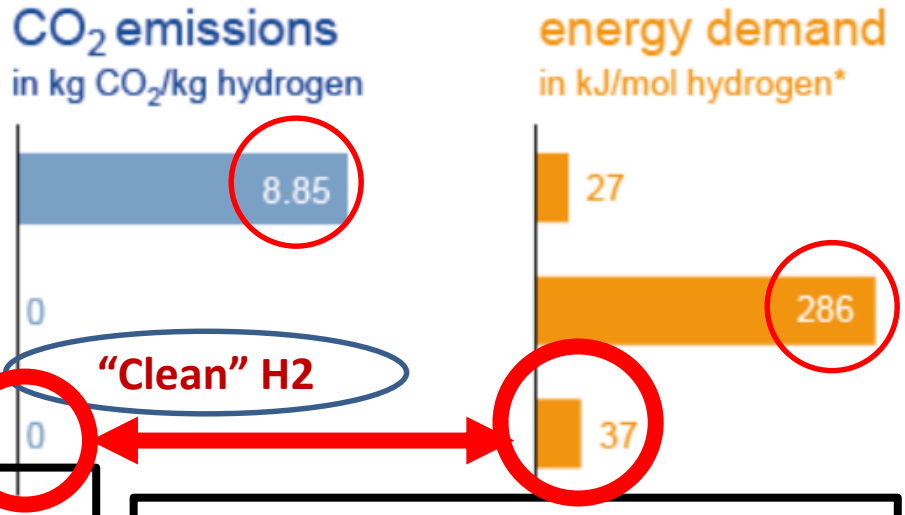
Ships bunkering (sea vessels & sea-river vessels) in Black Sea water area & for entry to Mediterranean water area & to rivers of the Black sea & Volga-Don basins; small-scale LNG supplies to littoral cities

LNG gas stations: for heavy lorries for long hauls (intercity) & intraurban transport (intracity)

3 key today's technologies of H2 production

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	$CH_4 \rightarrow 2H_2 + C$



Water electrolysis: water as feedstock => "clean" H2 (*):
- First small industrial-scale plants
- Very high energy intensity (8-10 times higher to SR/MP)

Steam reforming: Fossil fuel as feedstock => not-"clean" H2
- Main (95%) H2 production method today at global level
- Low energy intensity
- **BUT:** CO2 emissions (globally ~1% of the anthropogenic GHG emissions comes from steam reforming) =>
- CC(U)S is needed!!! => additional costs (CAPEX + OPEX)

Methane pyrolysis: NG as feedstock => "clean" H2 (*):
- First pilot plants
- Low energy intensity
- Solid carbon as 2nd product => Outlet needed for 3 kg carbon per kg hydrogen

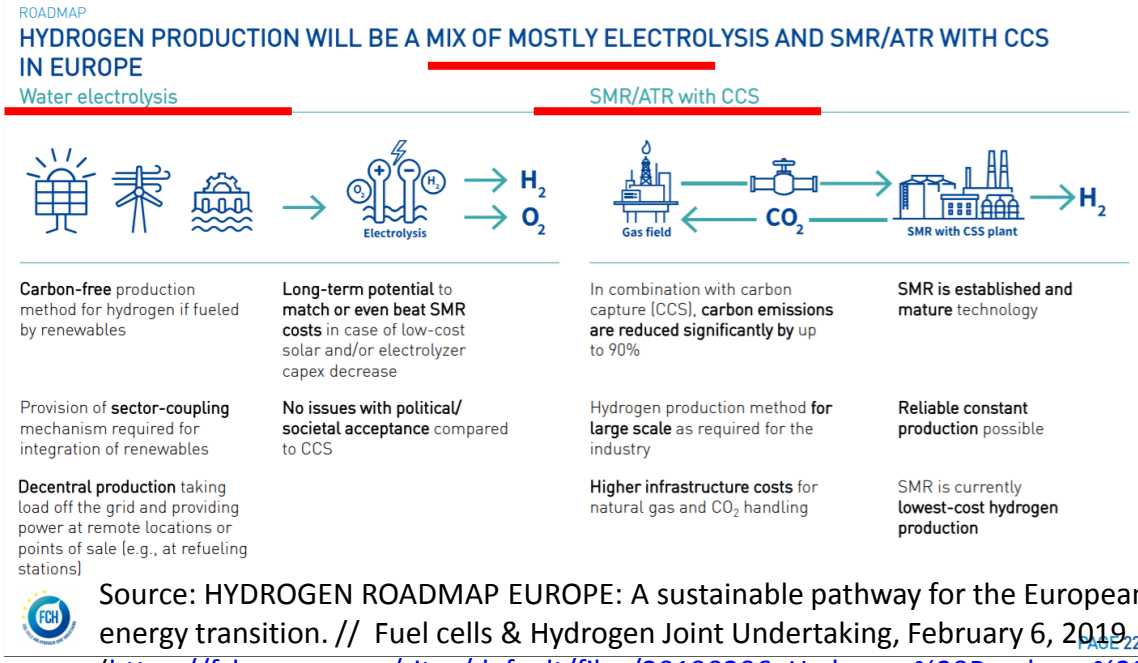
(*) "clean" – means at H2 production stage only

Options for carbon utilization and storage

1. Utilization in major carbon markets
   - Aluminum – positive tests
   - Steel – positive tests
   - Others (tires, concrete admixtures…)
2. Storage/sequestration
   - Soil improver / Terra preta
   - Filling material

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)

Why "Hydrogen Roadmap Europe" does not consider methane pyrolysis? What are consequences? Who might be interested in more costly decarbonisation paths and why so?



Source: HYDROGEN ROADMAP EUROPE: A sustainable pathway for the European energy transition. // Fuel cells & Hydrogen Joint Undertaking, February 6, 2019 (https://fch.europa.eu/sites/default/files/20190206_Hydrogen%20Roadmap%20Europe_Keynote_Final.pdf)

Major proponents of PTG & SMR/ATR with CCS might be:

- PTG: Scandinavian states (hydro-power states)
- SMR: Holders of deposits for CO2 sequestration nearby energy consuming & H2 production areas (Norway & UK),
- Developers of CCS technologies,
- Those lacking knowledge on methane pyrolysis' technologies,
- Opponents of methane-based H2 production (greens?)

-> CCS as integral element of ***as if*** the only one *(due to dominant view in the EU)* technological option for methane-based hydrogen production, predetermines permanent existence of **additional cost-element** in value chain of H2 production – **cost of CCS (up to 20-30+%).** This will permanently decrease competitiveness of H2 production from methane.

-> Since "S" in CCS means not "storage" but "sequestration" (injected CO2 cannot be re-used within given project cycle), cost of CCS (CAPEX + OPEX) can not act as "investment", but just as additional element in cost budget

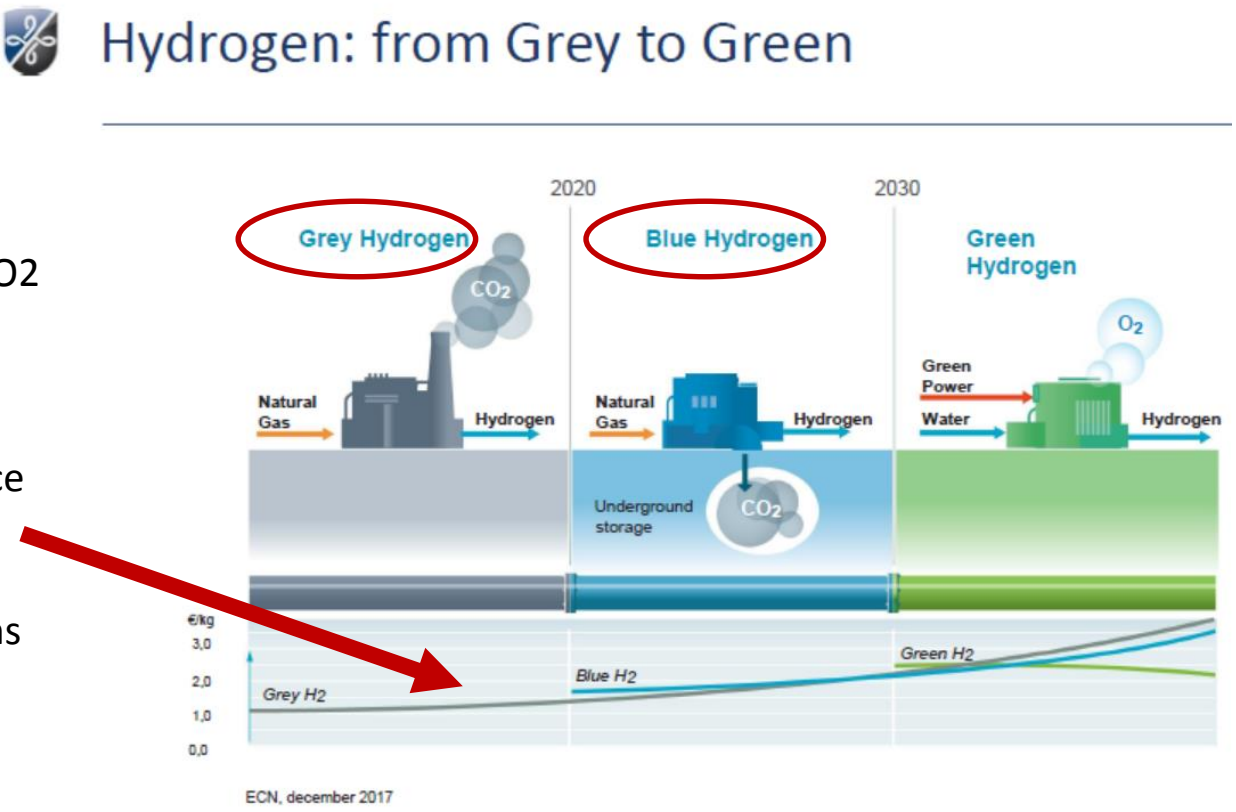
How public opinion within & beyond the EU is being formed in favour of "green" H2, electrolysis, "RES only EU energy future" – *or how wrong perceptions are created*

Questions:

(1) Why technologies to produce H2 without CO2 emissions are not indicated? This excludes from comparison potentially most competitive technology(ies) of "clean H2" production (without CO2 emissions),

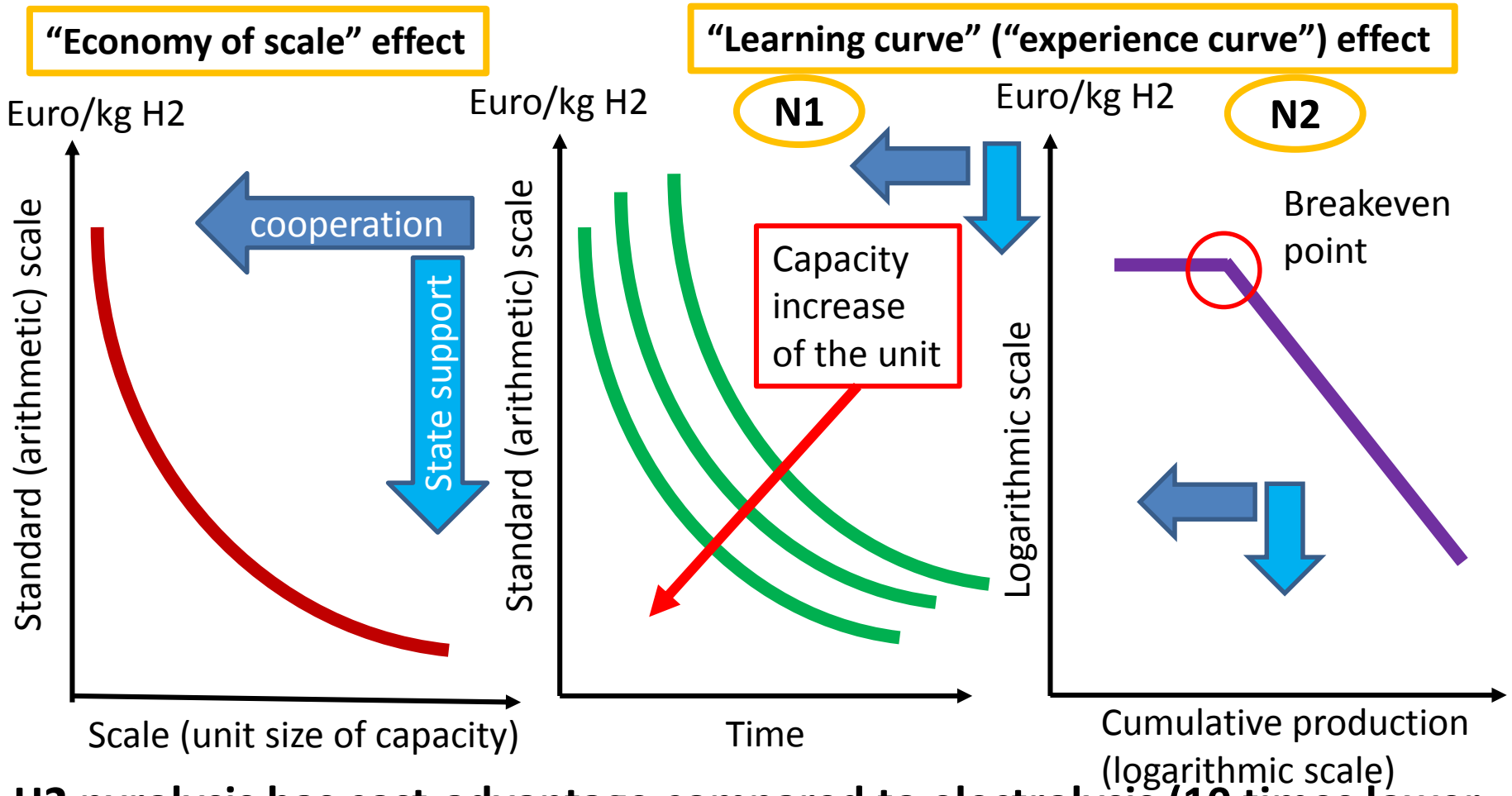
(2) The curves of Euro/kg H2 within time-frame are perceived as "cost curves" (learning curve, experience curve), but in reality it is not "cost curve", but a "wholesale H2 price curve" which includes assumptions on taxes (probably different for different technologies of H2 production), gas price (that it will grow due to "gas production decline in the EU" - ?),

(3) Reflection of dominant philosophy «domestic electrons to substitute imported molecules» (the end of "gas era" after 2030)?



Source of base chart: René Schutte (N.V. Nederlandse Gasunie). Production of Hydrogen. // Masterclass in Hydrogen, May 2019, Moscow, Energy Center of Moscow Skolkovo School of Management jointly with the Energy Delta Institute Energy Business School, 23.05.2019)

What is the current placement of three key H2 production technologies at three types of cost curves? A key possible area of RF-EU research cooperation in decarbonization sphere => WS2 GAC?

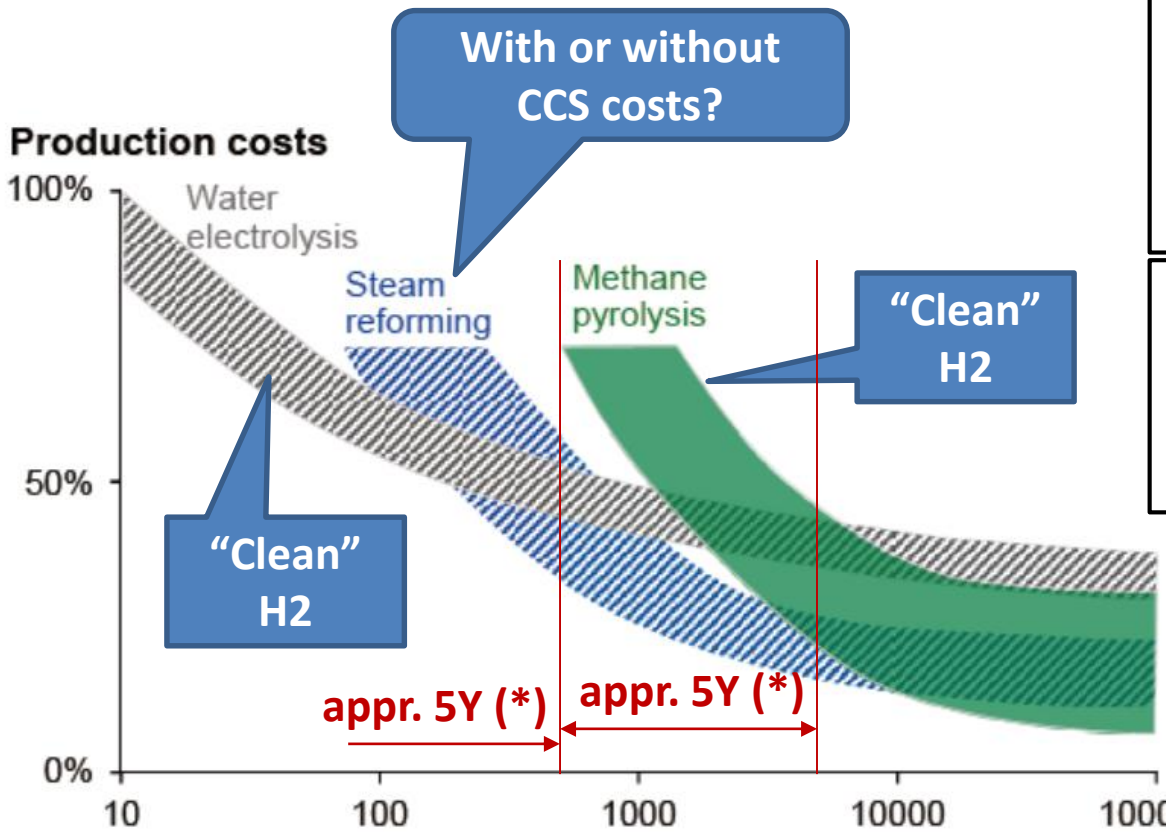


H2 pyrolysis has cost-advantage compared to electrolysis (10 times lower energy intensity) and to steam reforming (no need in CCS –> 20-30+% saving), but it seems to be placed today at the earlier stage of the cost curves or even not yet been placed at the cost curves

BASF: "Load curves" (economy of scale effect) for three key H2 production technologies

BASF Research Press Conference 2019

Is methane pyrolysis cost competitive?



BASF: 2013 – 2017 Basic, ambitious R&D

- Theoretical and experimental assessment of various reactor concepts
- Carbon sample production on 100 kg scale

Results

- Successful operation on lab scale
- Identification of promising reactor concepts

Successful carbon sample production and application testing

- But: reactor was ruined during sample production

A number of other technical solutions available. See, f.i.: Alberto Abánades. Direct decarbonization of natural gas: A key technology into the energy transition. // GAC WS2, Brussels, 29.03.2019 (https://www.fief.ru/img/files/6_190329_Direct_decarbonization_of_natural_gas.pdf)

Cost estimates for methane pyrolysis depend on value of pyrolysis carbon.

(*) acc. to author's discussion with Alberto Abánades at GAC WS2 meeting, Brussels, 29.03.2019

Carbon sales price or cost for storage is critical

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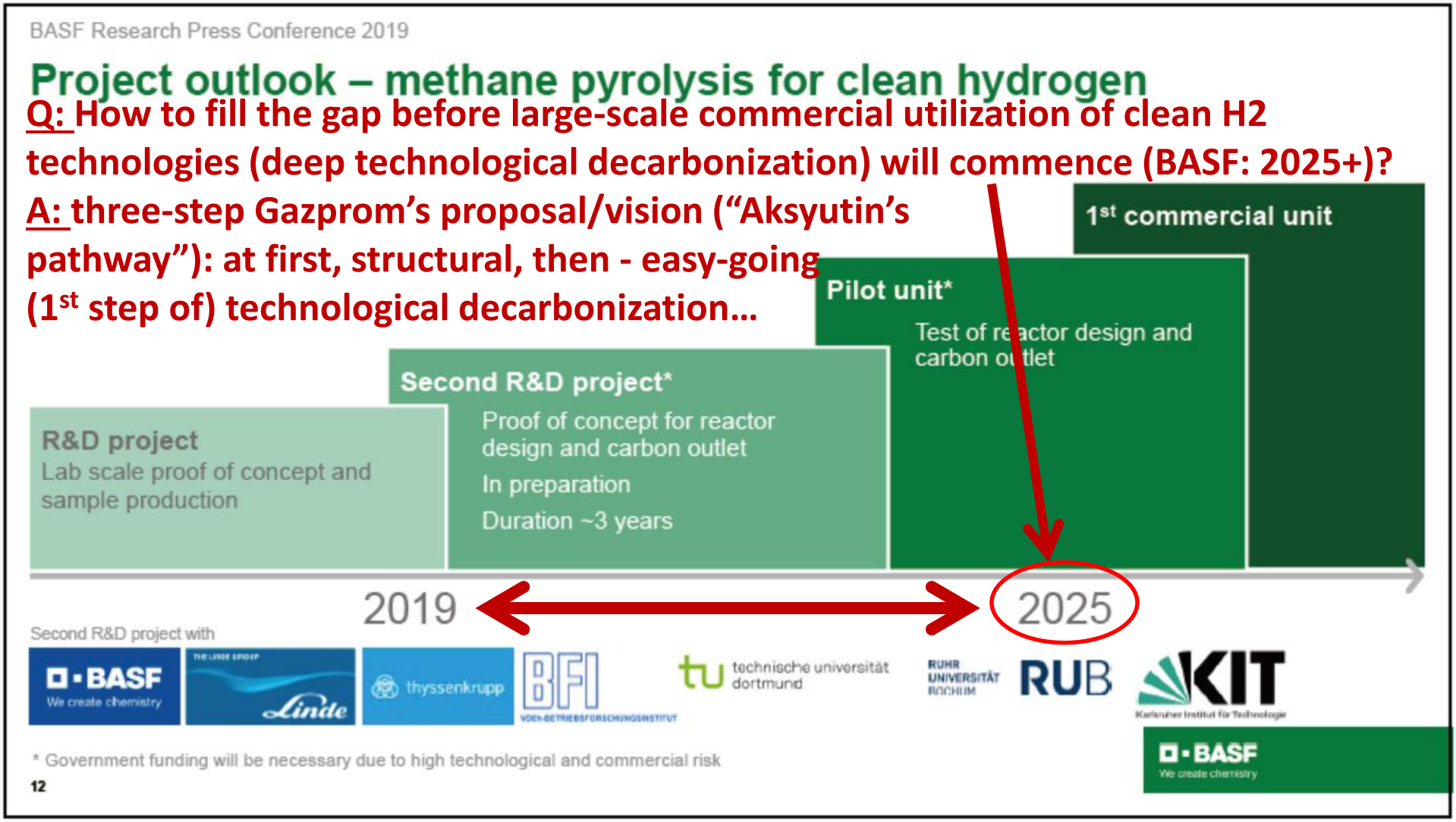
Based on: Dr. Andreas Bode (Program leader Carbon Management R&D). New process for clean hydrogen. // BASF Research Press Conference on January 10, 2019 / (https://www.basf.com/global/en/media/events/2019/basf-research-press-conference.html)



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Thank you for your attention!

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