EU Green Deal & the prospects of Russia-EU cooperation in low-emission energy & hydrogen within interdependent "Broader Energy Europe"

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Honorary Professor's Guest lecture at the Center for Energy Law, School of Law, Aberdeen University, Scotland, UK, 24.11.2021, online

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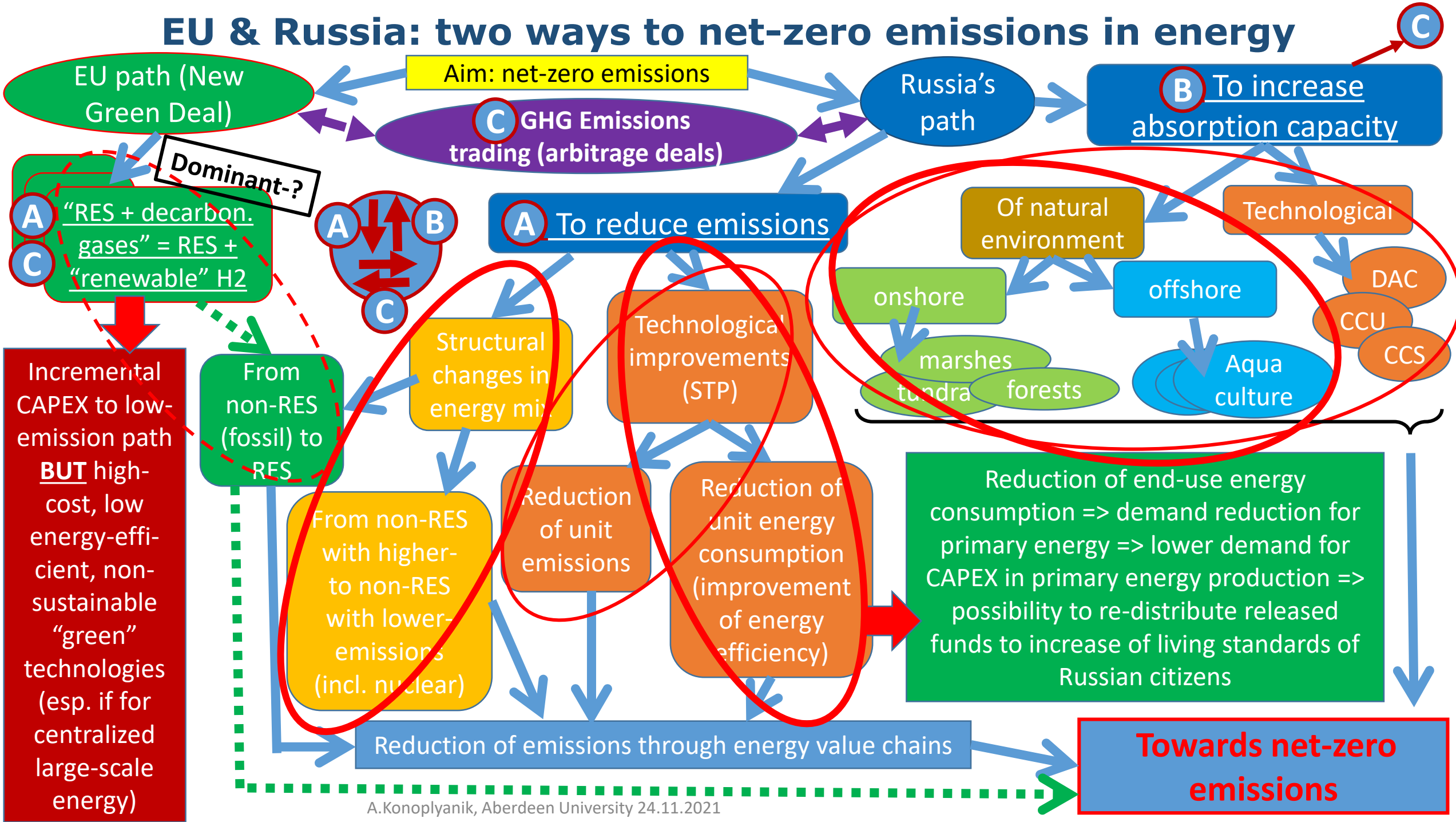
EU & Russia: two ways to net-zero emissions in energy



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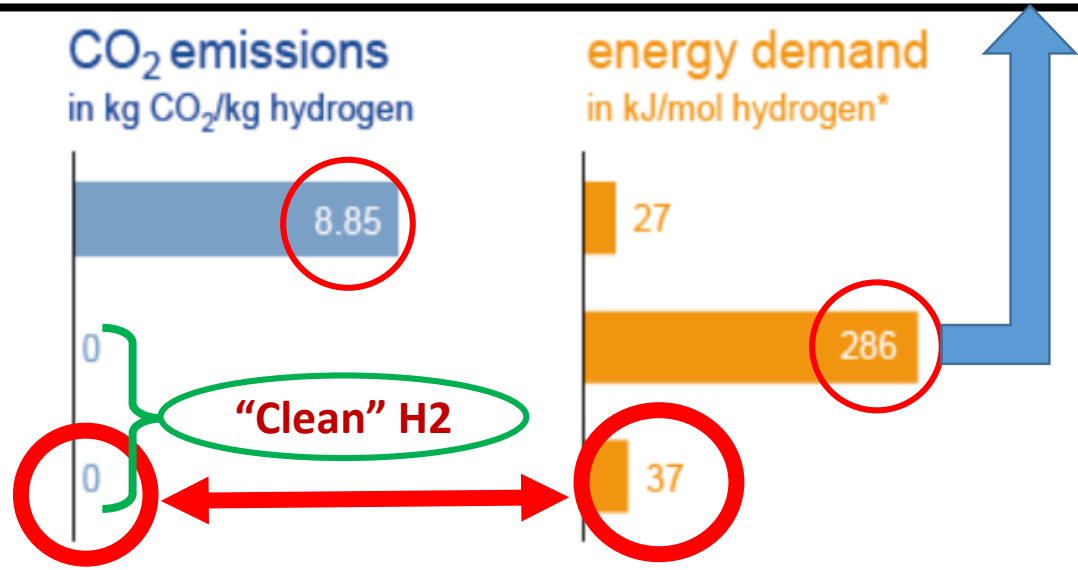
1) EU & Russia: two paths to net-zero emissions in energy
2) **EU Hydrogen Strategy: Energy Transition based on semi-truth => distorted benefits & virtual ecological/climate exclusivity of “green/renewable” H2**
3) Two development paths for external economic segment of Russian hydrogen energy economy: to follow the EU concept which suits national EU/German interests and has been softly imposed on us – or to stand for hydrogen cooperation concept based on balance of interests of the interdependent parties?
4) Russian Government’s concept for development of national hydrogen energy economy – why yet based on the EU concept?
5) Alternative concept based on balance of interests of the parties, non-distorted system of arguments, and technologic neutrality principle: it makes EU decarbonization less costly, increases monetization of Russian gas resources, leads to welfare increase of Russian & EU citizens

All other conditions being equal, methane pyrolysis (& similar technologies) have clear competitive advantages against two other key technologies in hydrogen production (MSR+CCS & electrolysis) under technologically neutral regulation

CC(U)S is needed!!! => additional imputed costs (CAPEX + OPEX) => add. 20/30+% (*) (CEC: twice as high (*)) => additional element of cost budget => WORSENS financeability

Vision to diminish high-cost energy density – to use excessive RES electricity at zero or negative prices => this leads to unstable (regularly interrupted by natural reasons) RES-based H2 production cycle => prolongation of pay-back periods (of debt-financed CAPEX) => WORSENS financeability

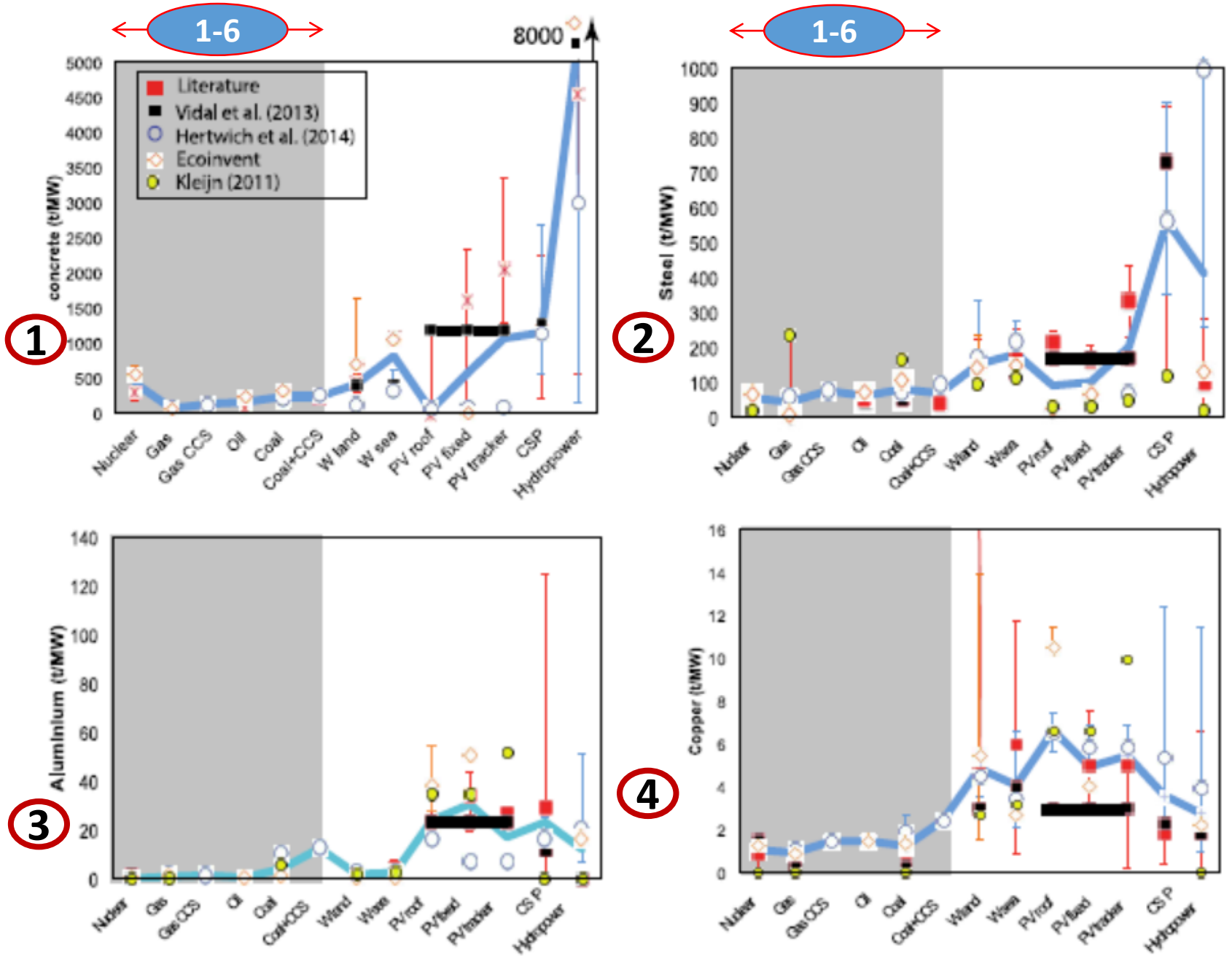
Steam reforming of natural gas	$CH_4 + 2H_2O \rightarrow 4H_2 + CO_2$
Water electrolysis	$2H_2O \rightarrow 2H_2 + O_2$
Methane pyrolysis	$CH_4 \rightarrow 2H_2 + C$



Source: A.Konoplyanik 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 budget => start of new investment cycle(s) based on carbon black
(3) In case of storage, carbon black does not provide same negative effects as CO2 => IMPROVES financeability

(*) René Schutte, N.V. Nederlandse Gasunie. Production of Hydrogen. // Masterclass in Hydrogen, Skolkovo – Energy Delta Institute, Moscow, May 23, 2019 (https://drive.google.com/open?id=1g_4TiiKAKGaJziXG8TWjTdpncfipj9x1)
(**) Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the regions. A hydrogen strategy for a climate-neutral Europe // EUROPEAN COMMISSION, Brussels, 8.7.2020, COM(2020) 301 final, p.4-5, footnote 26 (https://ec.europa.eu/energy/sites/ener/files/hydrogen_strategy.pdf)



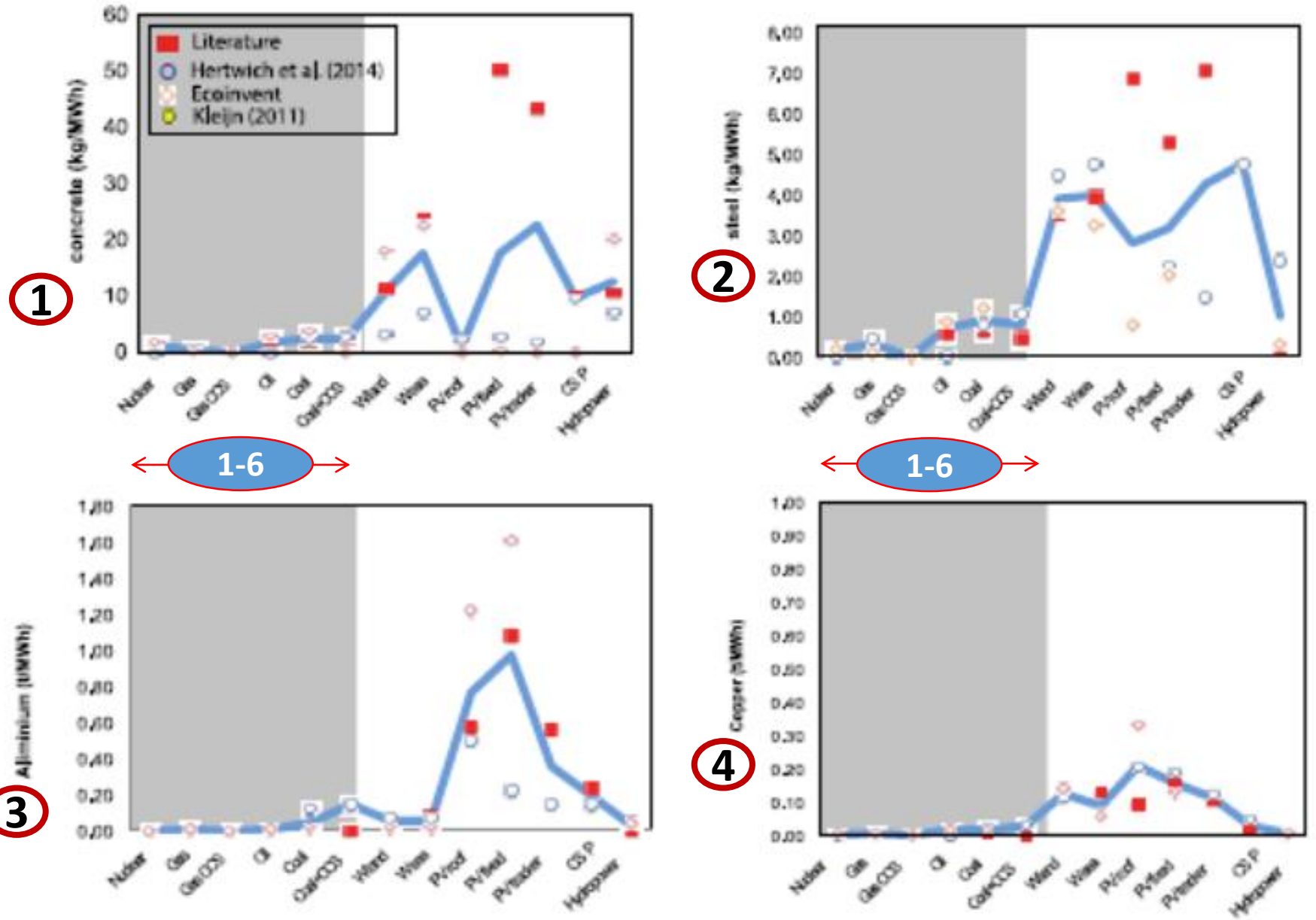
From left to right: (1) Nuclear, (2) Gas, (3) Gas+CCS, (4) Oil, (5) Coal, (6) Coal+CCS, (7) Wind land, (8) Wind sea, (9) PV roof, (10) PV fixed, (11) PV tracker, (12) CSP, (13) Hydropower

Quantities (t/MW) of four structural materials used to manufacture different power generation infrastructure (material intensity) :

1 – concrete,
2 – steel,
3 – aluminium,
4 – copper

(fossil fuel power generation technologies are in the gray shaded area;
colour version of the figure at: www.iste.co.uk/vidal/energy/zip)

Source: Olivier Vidal. Mineral Resources and Energy. Future Stakes in Energy Transition. // ISTE Press Ltd - Elsevier Ltd, UK-US, 2018, 156 pp. (Figure 5.2./p. 72)



Mass of material in kg required to produce 1 MWh electricity:

1 – concrete,
2 – steel,
3 – aluminium,
4 – copper

(calculated with the material intensities shown in Figure 5.2 and Table 5.1; the gray shaded area indicates fossil fuel-based electricity production; colour version of the picture at: www.iste.co.uk/vidal/energy.zip)

Source: Olivier Vidal. Mineral Resources and Energy. Future Stakes in Energy Transition. // ISTE Press Ltd - Elsevier Ltd, UK-US, 2018, 156 pp. (Figure 5.3./p. 74)

From left to right: (1) Nuclear, (2) Gas, (3) Gas+CCS, (4) Oil, (5) Coal, (6) Coal+CCS, (7) Wind land, (8) Wind sea, (9) PV roof, (10) PV fixed, (11) PV tracker, (12) CSP, (13) Hydropower

What is clean energy? Depends on how you calculate/consider it...

Wrong perceptions as if Ren-H2 is the only clean H2 and, moreover, that it is clean at all => Energy Transition based on semi-truth...

A hydrogen strategy for a climate-neutral Europe (Brussels, 8.7.2020 COM(2020) 301 final): '**Renewable hydrogen**' is hydrogen produced through the electrolysis of water (in an electrolyser, powered by electricity), and with the electricity stemming from renewable sources. The **full life-cycle greenhouse gas emissions of the production of renewable hydrogen are close to zero <...>** **'Clean hydrogen'** refers to renewable hydrogen.

Siemens/Gascade/Nowega (Hydrogen infrastructure – the pillar of energy transition.., Sept.2020): "If the electricity required for electrolysis comes exclusively from renewable, CO2-free sources, the **entire production process is completely CO2-free**."

?

Much higher GHG emissions in manufacturing equipment for RES electricity production compared to the same for non-RES electricity production

Carbon track of renewable H2 through the full life-cycle (acc. to EU H2 Strategy) vs. GHG Scopes 1-2-3

GHG Scope 3

Production of equipment for generation RES electricity/Ren-H2

CO2 emissions: **NOT equal to Zero**
EU H2 Strategy: **not included**
Geographical location: **beyond EU**

GHG Scope 2

Production RES electricity

GHG Scope 1

Renewable H2 production

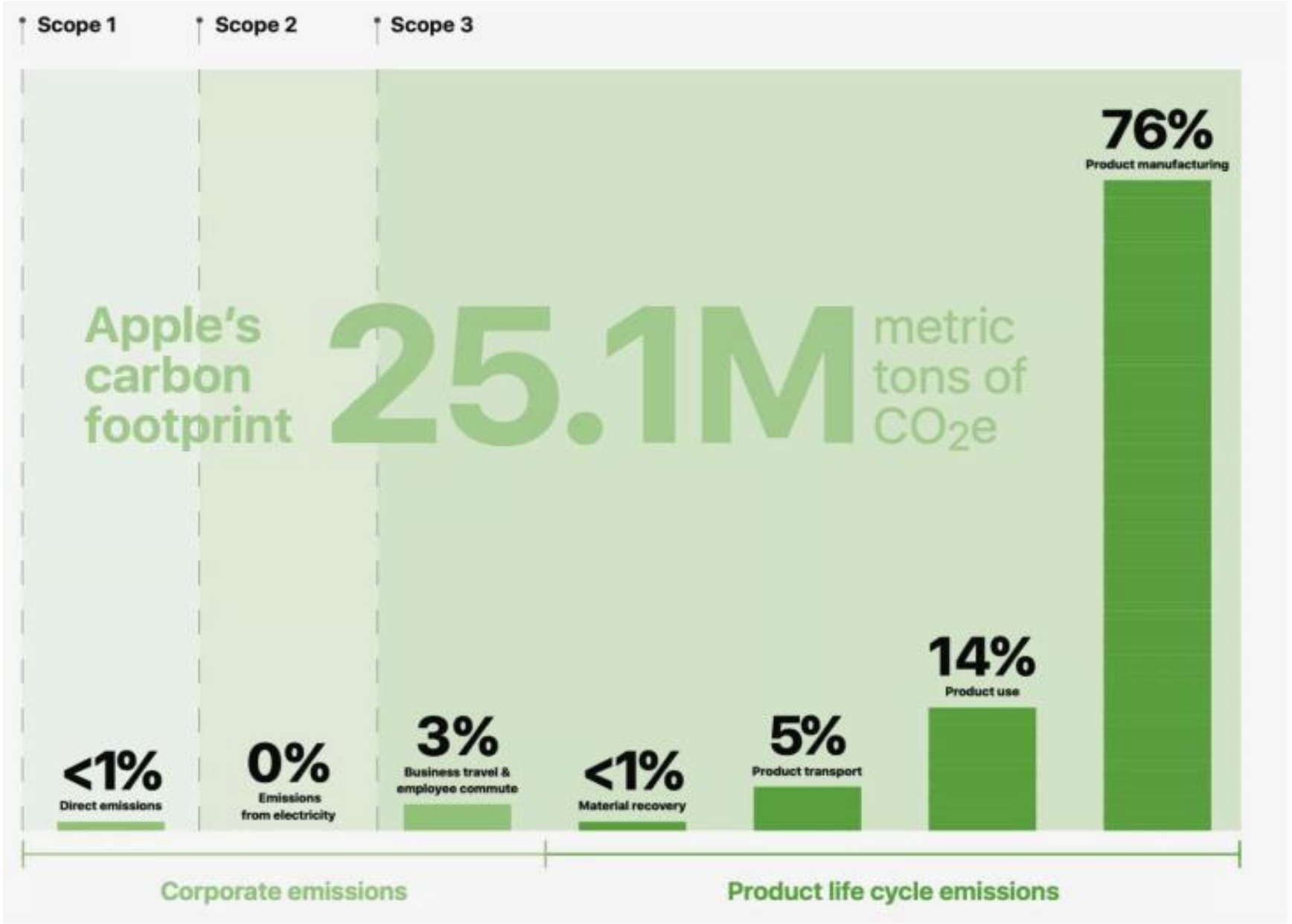
CO2 emissions: **equal to Zero**
EU H2 Strategy: **included**
Geographical location: **within EU**

GHG Scope 3

Utilization of equipment for RES/H2 production after project business life is over

CO2 emissions: **NOT equal to Zero**
EU H2 Strategy: **not included**
Geographical location: **beyond EU**

Daniel Yergin, Pulitzer Prize winner for "The Prize" book at presentation of his new book "The New Map": **"NEW SUPPLY CHAINS FOR NET-ZERO CARBON REQUIRES CARBON!!! ... They require diesel to operate shuttle in mining..."** (Source: A conversation with Pulitzer Prize winner and energy expert Daniel Yergin, Atlantic Council, 25.09.2020 (https://www.youtube.com/watch?v=hWMOU8IjRhI)



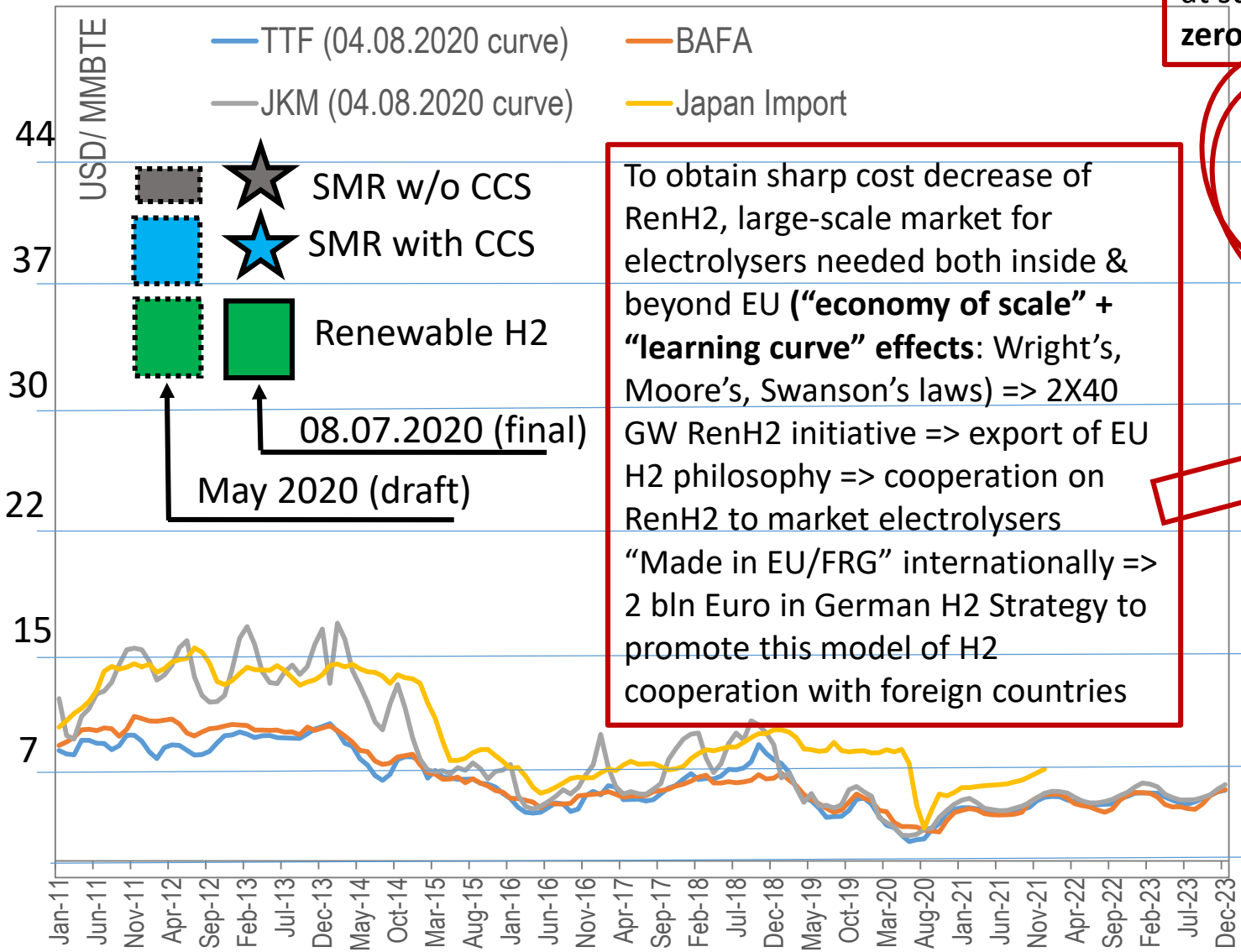
The importance of scope 3 emissions – Apple carbon footprint
Credit: Apple

Why it is important to consider GHG emissions within all THREE Scopes?

(Illustrative example from Apple which it has presented to the public voluntarily – direct analogy with "green" H2)

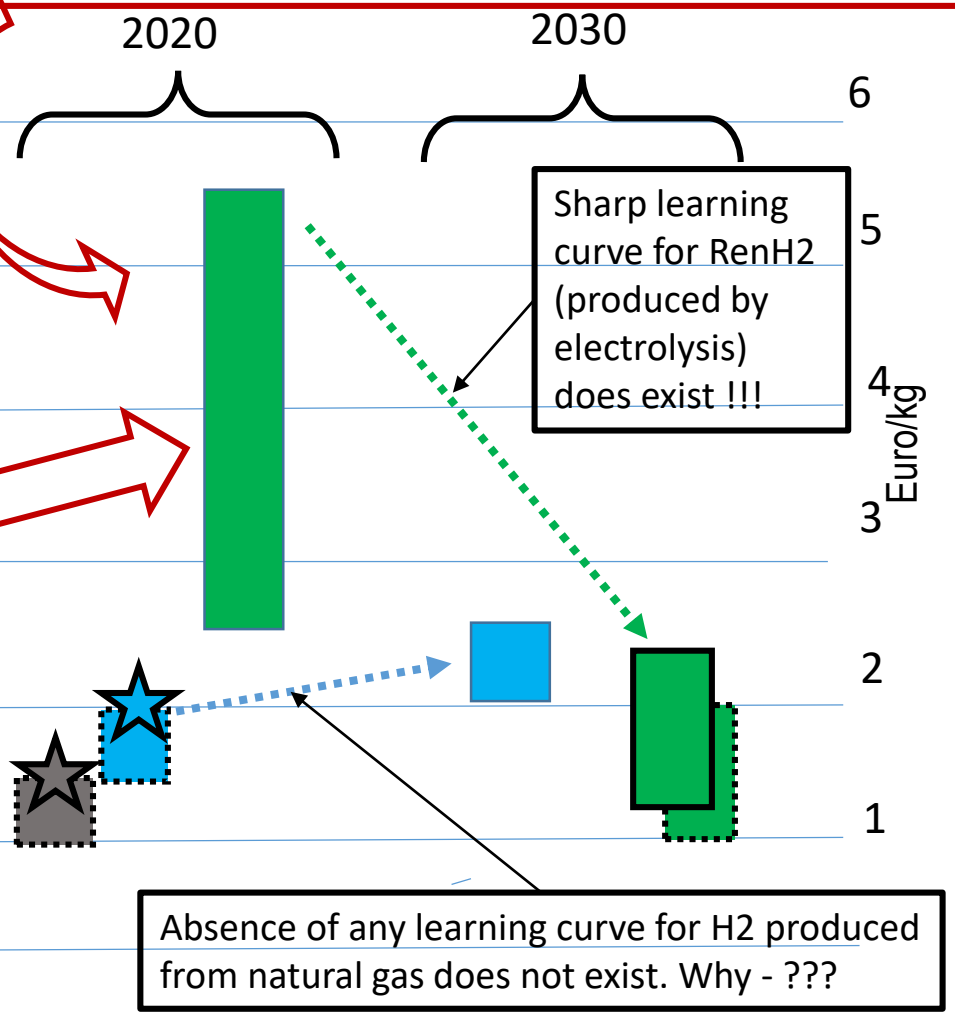
Source: What are Scopes 1, 2 and 3 of Carbon Emissions? // PlanA Academy, 12.08.2020 (https://plana.earth/academy/what-are-scope-1-2-3-emissions/)

European Commission's estimated costs of H2 production by the key technologies (as presented in the EU Hydrogen Strategy as of 08.08.2020) – and natural gas prices



To obtain sharp cost decrease of RenH2, large-scale market for electrolysers needed both inside & beyond EU **("economy of scale" + "learning curve" effects**: Wright's, Moore's, Swanson's laws) => 2X40 GW RenH2 initiative => export of EU H2 philosophy => cooperation on RenH2 to market electrolysers "Made in EU/FRG" internationally => 2 bln Euro in German H2 Strategy to promote this model of H2 cooperation with foreign countries

Germany (2019): "excessive" RES electricity = 211 from 8760 hours/y => utilization rate (UR) = 2.5% => no ever economics at such UR => to diminish production cost of RenH2 **by using zero- &/or negative-priced electricity** will not work



Source: natural gas prices – Gazprom export; H2 costs – European Commission (EU Hydrogen strategy: dotted lines – draft version, May 2020; solid - final document, 08.07.2020)

Problems of & proposed solutions for "renewable/green" H2 in the EU

Electrolysis: high costs =

= f (price of purchased electricity)

= f (cost of electrolyzers)

To buy excessive RES electricity at zero/negative price, BUT Germany (2019): excessive RES electricity = 211 from 8760 hours/y => utilization rate (UR) = 2.5% (UR wind onshore= 20%, offshore = 45%)

Internal EU market is not enough to provide economy of scale effect (Wright's, Moore's, Swanson's laws/effects) => expansion beyond EU borders needed (2X40 GW green H2) => cooperation on green H2 to market electrolyzers "Made in Germany" internationally => 2 bln Euro in German Hydrogen Strategy to promote this model of hydrogen cooperation with foreign countries

Will not work as major route for cost decrease

Corresponds with national interests of EU/Germany, does NOT correspond with Russian national interests => does NOT provide for balance of Russia-EU/German interests !

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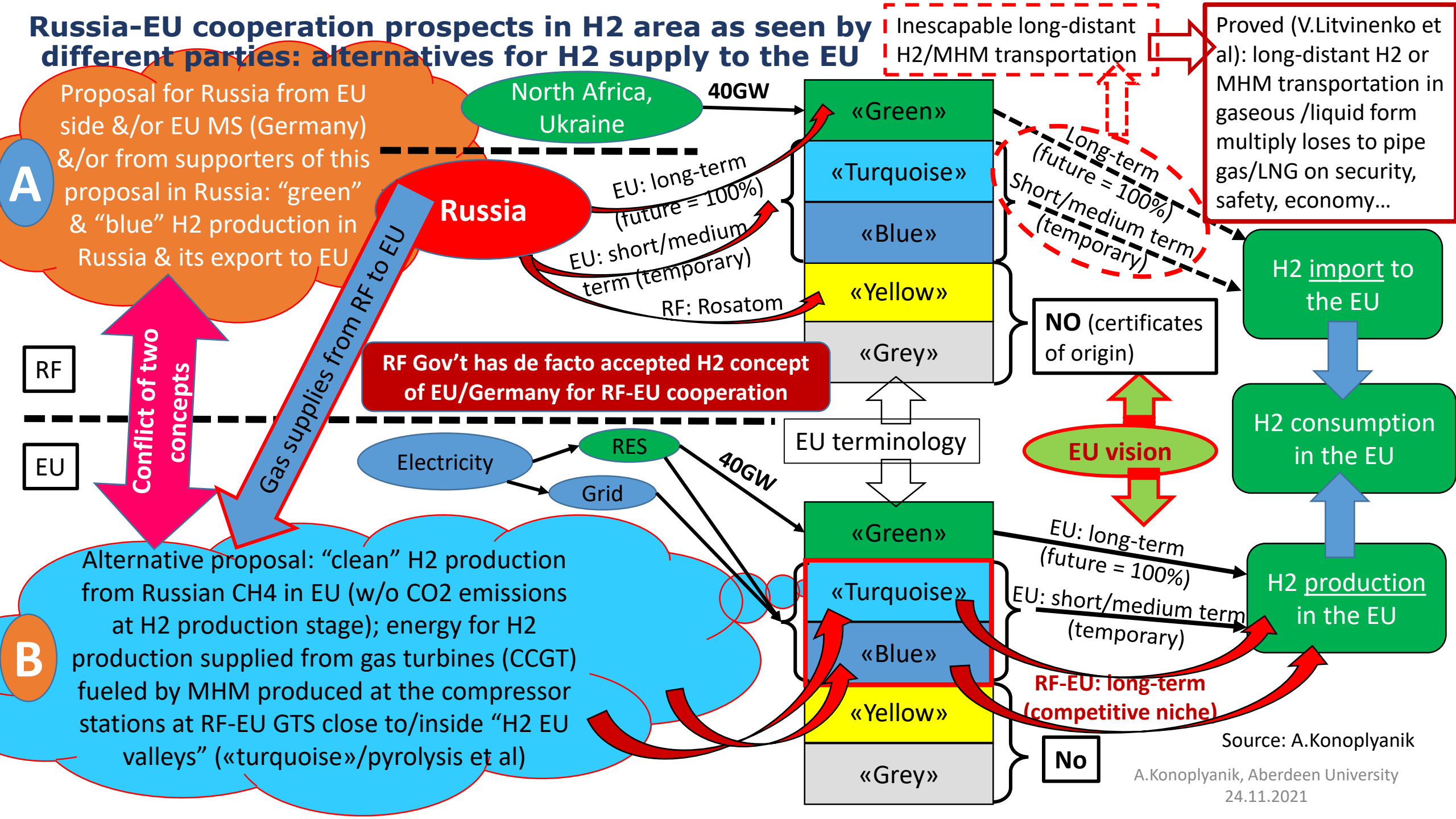
Russia-EU cooperation prospects in H2 area as seen by different parties: alternatives for H2 supply to the EU



Source: A.Konoplyanik

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24.11.2021

Decarbonisation upstream: some physical & chemical barriers to long-distant high-pressure transportation & storage of H2 (acc. to Litvinenko et al, SPB Mining University) (*)

(1) Effectiveness of gas pipeline transportation is directly contingent upon quantities of the product, and thus on the density of gas. **As concentration of H2 in MHM increases from 10 to 90 %, density of MHM decreases more than four times.**

(2) **Energy obtained from** one volume of **H2 is 3.5 times less than the energy obtained from methane.**

(3) Increase in energy required to compress 1 kg of MHM to raise the pressure by 1 MPa with increasing proportion of H2. While **H2 content in MHM rises from zero to 100%, energy costs (work) are raised by around a factor of 8.5.**

(4) Increasing proportion of H2 in MHM increases explosion risks of the MHM

(5) Export/storage of *liquid* H2: **CH4** liquefies at atmospheric pressure and temperature below - 161.5 °C, LNG volume is 600 times less than its gaseous form. **H2** liquefies at atmospheric pressure and temperature below -252.87 °C, it reduces in volume by 848 times. **(ii)** The closer temperature of a substance to absolute zero, the more **quantum properties** (superfluidity, superconductivity, etc.) begin to appear. **(iii)** Under same conditions and tank capacity it is **possible to store or transport almost 5.9 times more LNG than liquid H2.**

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(6) H2 has extremely high penetrating ability, its molecules spread faster than molecules of all the other gases in the media of another substance and penetrate through almost any metal. **Pressurized H2 is capable to escape even from airtight tanks during long-term storage.**

(7) Research into effect of H2 on metals has been carried out for decades. Back in 1967 in USSR scientific discovery "Depreciative effect of hydrogen on metals“ was made (N 378), however, the reactivity of hydrogen is still not sufficiently studied, whereas its negative effects have already become a substantial technical issue (**stress corrosion**). Due to stress corrosion Gazprom replaced over 5,000 km of large-diameter pipelines.

*(*) Within **43** items of RF Gov't Action plan on H2 Saint Petersburg Mining University is mentioned as co-participant in **42** items*

Source: Litvinenko V.S., Tsvetkov P.S., Dvoynikov M.V., Buslaev G.V., Eichlseder W. Barriers to implementation of hydrogen initiatives in the context of global energy sustainable development. Journal of Mining Institute. 2020. Vol. 244, p. 428-438. DOI: 10.31897/PMI.2020.4.5

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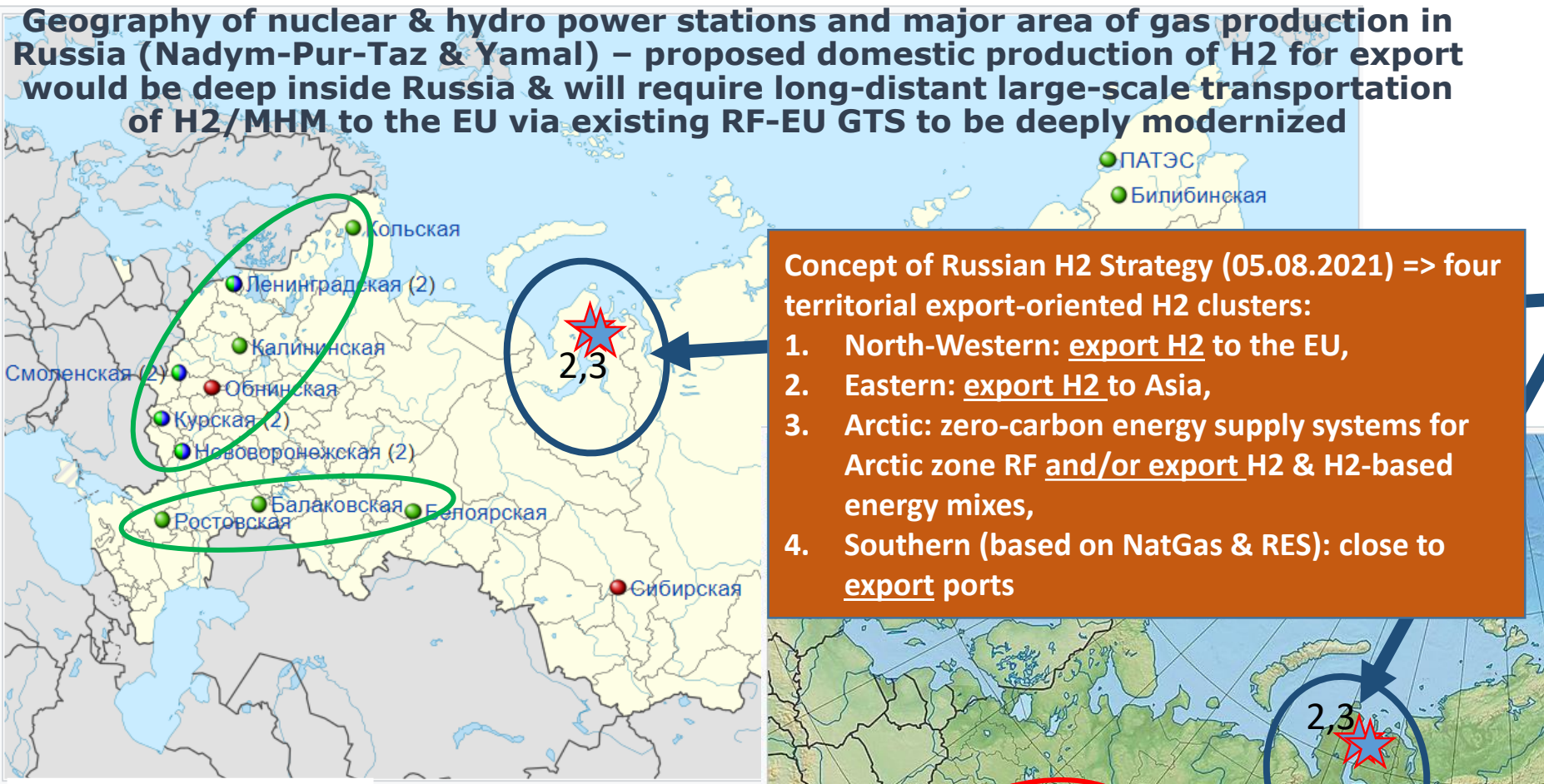
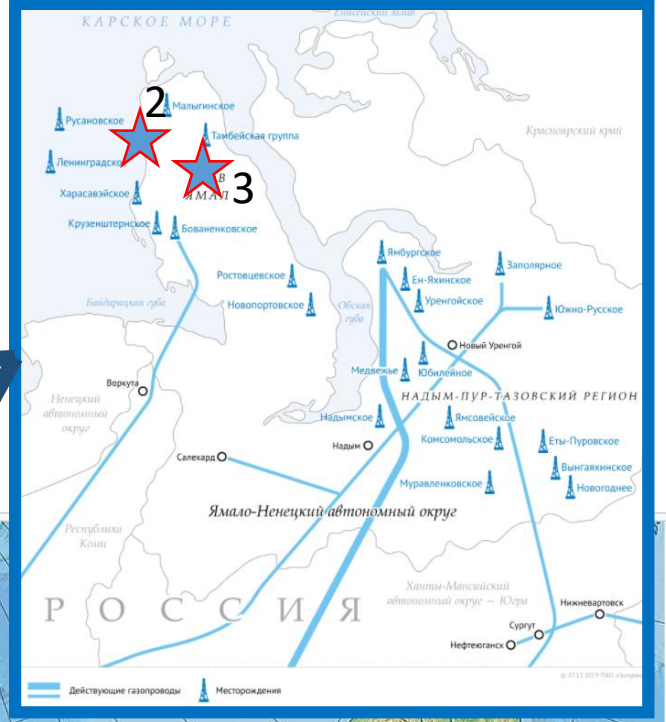
Geography of nuclear & hydro power stations and major area of gas production in Russia (Nadym-Pur-Taz & Yamal) – proposed domestic production of H2 for export would be deep inside Russia & will require long-distant large-scale transportation of H2/MHM to the EU via existing RF-EU GTS to be deeply modernized



Concept of Russian H2 Strategy (05.08.2021) => four territorial export-oriented H2 clusters:

1. **North-Western: export H2 to the EU,**
2. **Eastern: export H2 to Asia,**
3. **Arctic: zero-carbon energy supply systems for Arctic zone RF and/or export H2 & H2-based energy mixes,**
4. **Southern (based on NatGas & RES): close to export ports**



Nuclear

Hydro

Nadym-Pur-Taz & Yamal

Large-scale LNG plants, acting: (1) Sakhalin-2; (2) Yamal LNG; (3) Arctic LNG

Sources of maps:
https://www.gazprom.ru/f/posts/15/770293/map-yamal-ru-2019-12-30.png;
https://ru.wikipedia.org/wiki/Атомная_энергетика_России;
https://ru.wikipedia.org/wiki/Список_гидроэлектростанций_России;

MINISTRY OF INDUSTRY AND TRADE RUSSIA

Russian Atlas of Low-Carbon and Carbon-Free (*) Hydrogen and Ammonia Production Projects

(*) more correctly would be: with low & zero direct emissions

1. Project company
2. "Colour" of H2
3. Technology
4. Source of end-use energy
5. Time of start-up: 2021-2031
6. Region, place
7. Target markets
8. Production volumes, t/Y : 13 (Krasnodar) – 5/6 mln t (Kamchatka/Yakutia)
9. Logistics: Hydrogen transportation to customers [within Russia and] of European countries/Asia-Pacific
10. Consumption: Long-term contracts with [Russian and] European/AP customers

?

33 projects in 18 regions, incl.:
25 - Green H2 (- wind, - tidal, - hydro),
5 - Blue H2
1 - Turquoise H2
2 - Yellow (low-carbon) H2
11 - incl. Ammonia

1 Export-oriented H2 clusters (acc. to Gov't "Concept of Russian H2 Strategy", 05.08.2021): **1** – North-Western, **2** - Arctic, **3** – Eastern, **4** – Southern

A Regional Carbon Testing Sites (**): **A** -Yamal ("Seven larch-trees"); **B** – Kaliningrad obl.; **C** - Chechnya; **D** – Krasnodar kr.; **E** – Sverdlovsk obl.; **F** - – Kuzbass; **G** – Novosibirsk obl.; **H** - Sakhalin => to be expanded to 14 regions

(**) Ministry Education & Research pilot project to create integrated system GHG gases movements

Source of basic slide: RF Ministry of Trade & Industry, 15.10.2021, https://minpromtorg.gov.ru/common/upload/docVersions/6169d30a61364/actual/Atlas_en_15102021_compressed.pdf

Ministry of Energy/Russian Government: more & more ambitious stake on H2 export, but the problem with its delivery to export market technically is not solved, while voiced draft solutions are mostly counter-productive, unprofessional & devastative…

Export, mln tonnes	2024 г.	2025 г.	2030 г.	2035 г.	2050 г.
(1) Russian Energy Strategy (June 2020)	0.2	-	-	2	-
(2) Governmental Road Map (October 2020)	-	-	-	-	-
(3) Draft Concept Russian Hydrogen Energy Development (April 2021)	0.2-1.0	-	-	2-7	7.9-33.4
(4) Yu.Dobrovolsky (*) («We with Minenergo… acc. to conservative forecast») (O&GV, June 2021)	-	2-3	20-30 & more	-	-
(5) Concept of Russian Hydrogen Energy Development (August 2021)	0.2-1.0	-	-	2-12	15-50

Risk of counterproductive decision to inject H2/MHM into acting GTS for export to EU

16 Mt in 2031 in RF MinPromTorg Atlas

(1) Энергетическая стратегия Российской Федерации на период до 2035 года. Утверждена распоряжением Правительства РФ от 9 июня 2020 г. № 1523-р (http://static.government.ru/media/files/w4sigFOiDjGVDYT4IgsApssm6mZRb7wx.pdf)

(2) План мероприятий «Развитие водородной энергетики в Российской Федерации до 2024 г.». "Утвержден распоряжением Правительства РФ от 12 октября 2020 г. № 2634-р (http://static.government.ru/media/files/7b9bstNfV640nCkkAzCRJ9N8k7uhW8mY.pdf)

(3) Итоги работы Минэнерго России и основные результаты функционирования ТЭК в 2020 году. Задачи на 2021 год и среднесрочную перспективу. Материалы заседания Коллегии Минэнерго России, 12 апреля 2021 г., слайд 7 (https://minenergo.gov.ru/system/download-pdf/20322/154219)

(4) Ю.Добровольский. Водороду нужна господдержка. // «Нефтегазовая Вертикаль», июнь 2021, №11-12, с.80-84 (84) (http://www.ngv.ru/upload/iblock/ad7/ad759fe2657454a1adbe4d7435d1fba3.pdf) *(*) this person positioned himself as one of the main drafters of Russian H2 Strategy*

(5) Концепция развития водородной энергетики в Российской Федерации. Утверждена распоряжением Правительства РФ от 5 августа 2021 г. № 2162-р (http://static.government.ru/media/files/5JFns1CDAKqYKzZ0mnRADAw2NqcVsexl.pdf)

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Approximate potential areas of preferential use of key H2 production technologies in Europe under state regulation based on "technological neutrality" principles – potential new competitive niche for Russian gas & technologies for H2 production w/o direct CO2 emissions

Source: dashed lines - A.Konoplyanik, based on conversations with Ralf Dickel; dotted lines - Ukraine & North Africa are added based on "The 2x40GW Green Hydrogen Initiative Paper" Hydrogen Europe study for illustration purposes with the observation of this author's skepticism in regard to long-distance transportation of H2 produced in these geographical areas

Map source: ENTSOG

P2G wind

P2G solar

P2G hydro

P2G nuclear

«Clean» H2 (EU: **«green»**, renewable H2)

Pre-determined EU priority

MSR/ATR plus CC(U)S

Decarbonised (low-carbon) H2 (EU: **«blue»**)

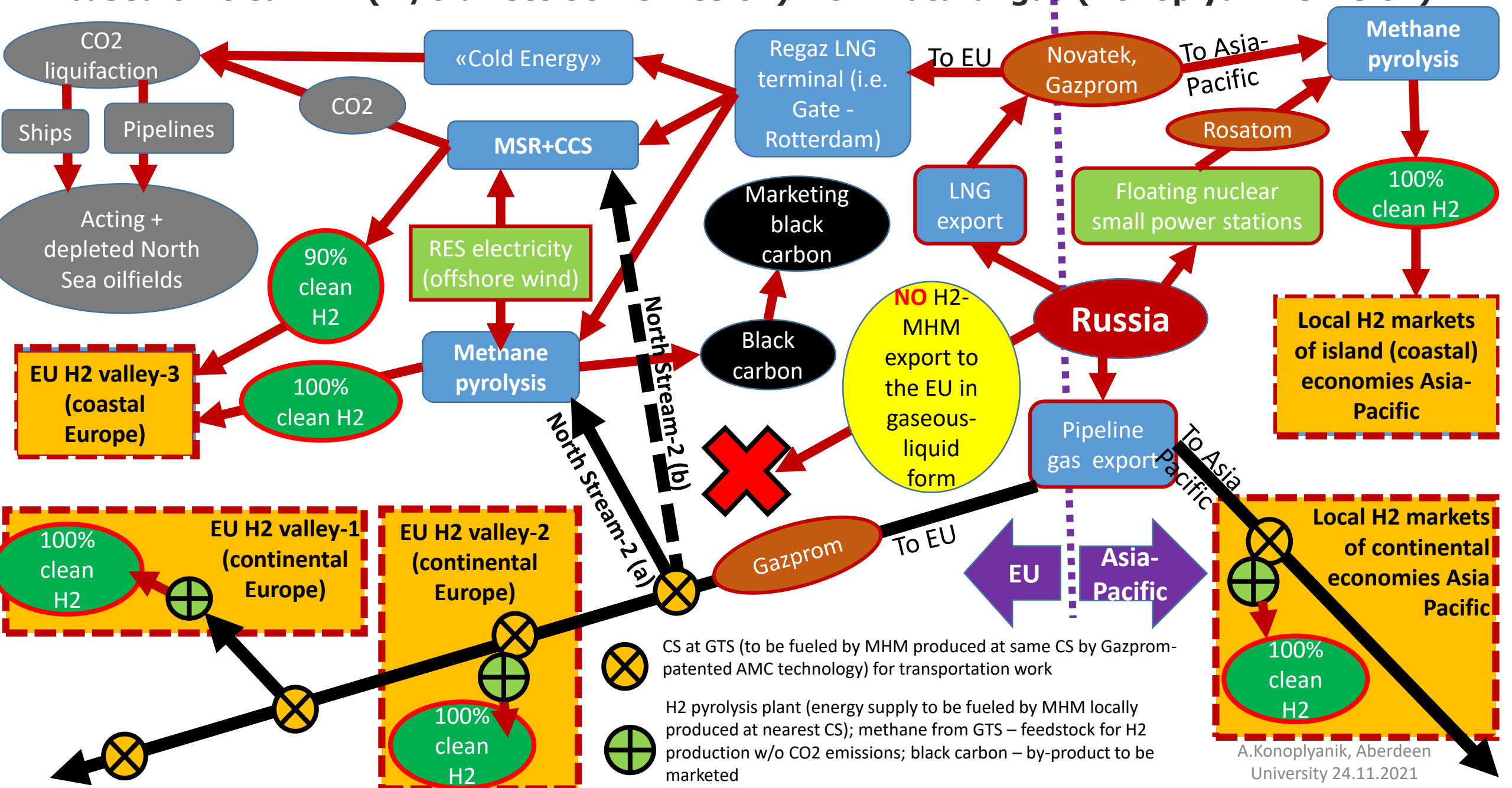
Accepted temporary solution for the EU

Methane pyrolysis, plasma-chemical method et al w/o access O2 & CO2 emissions

«Clean» H2 (EU: **«turquois»**)

Mutually acceptable (beneficial) long-term solution RF & EU

Alternative concept for export-oriented segment of Russian hydrogen energy economy – based on clean H2 (w/o direct CO2 emission) from natural gas (Konoplyanik's vision)



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Thank you for your attention!

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Note: Research is undertaken with financial support of Russian Foundation for Fundamental Research (RFFR) within the project "Influence of new technologies on global competition at the raw materials markets", project № 19-010-00782