Russian hydrogen development strategy: key provisions and some critical comments in comparison with the EU

(a follow-up of presentation on Russia's H2 Strategy in the making & prospects of effective RF-EU cooperation, 32d WS2 GAC, 13.11.2020)

Prof. Dr. A.A.Konoplyanik,

Adviser to Director General, Gazprom export LLC;
Co-chair of Work Stream 2 "Internal Markets", Russia-EU Gas Advisory Council;
Member of Scientific Council on System Research in Energy, Russian Academy of Sciences

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Russia-EU Gas Advisory Council, 22.10.2021, online

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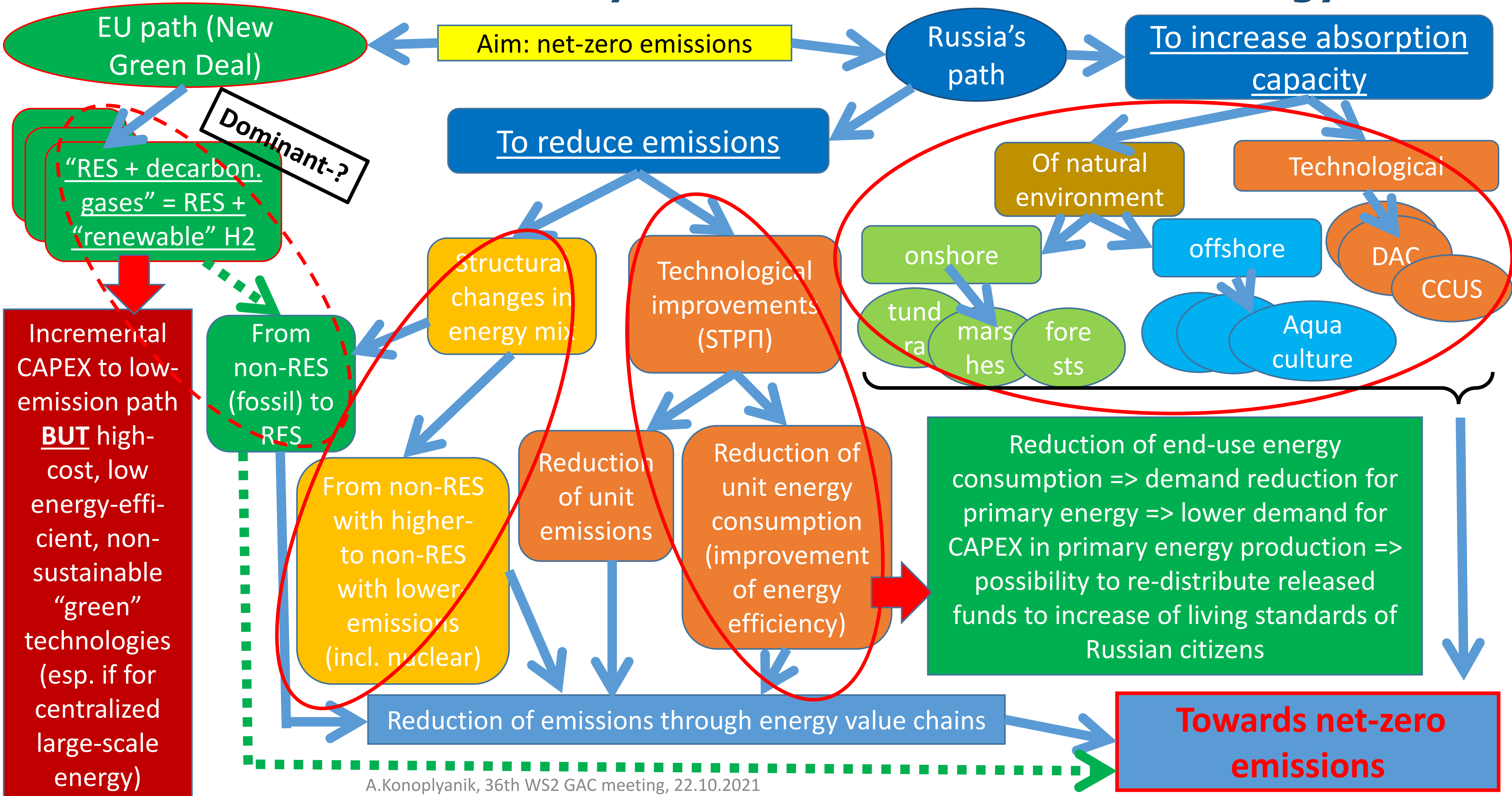
EU & Russia: two ways to net-zero emissions in energy



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

Wrong perceptions as if renewable H2 is the only clean H2 and, moreover, that it is clean at all

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**.”

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

GHG Scope 3 – **Production equipment for generation RES electricity/H2**

GHG Scope 2 – **Production RES electricity**

GHG Scope 1 – **Renewable H2 production**

GHG Scope 3 – **Utilization of equipment for RES/H2 production after project business life is over**

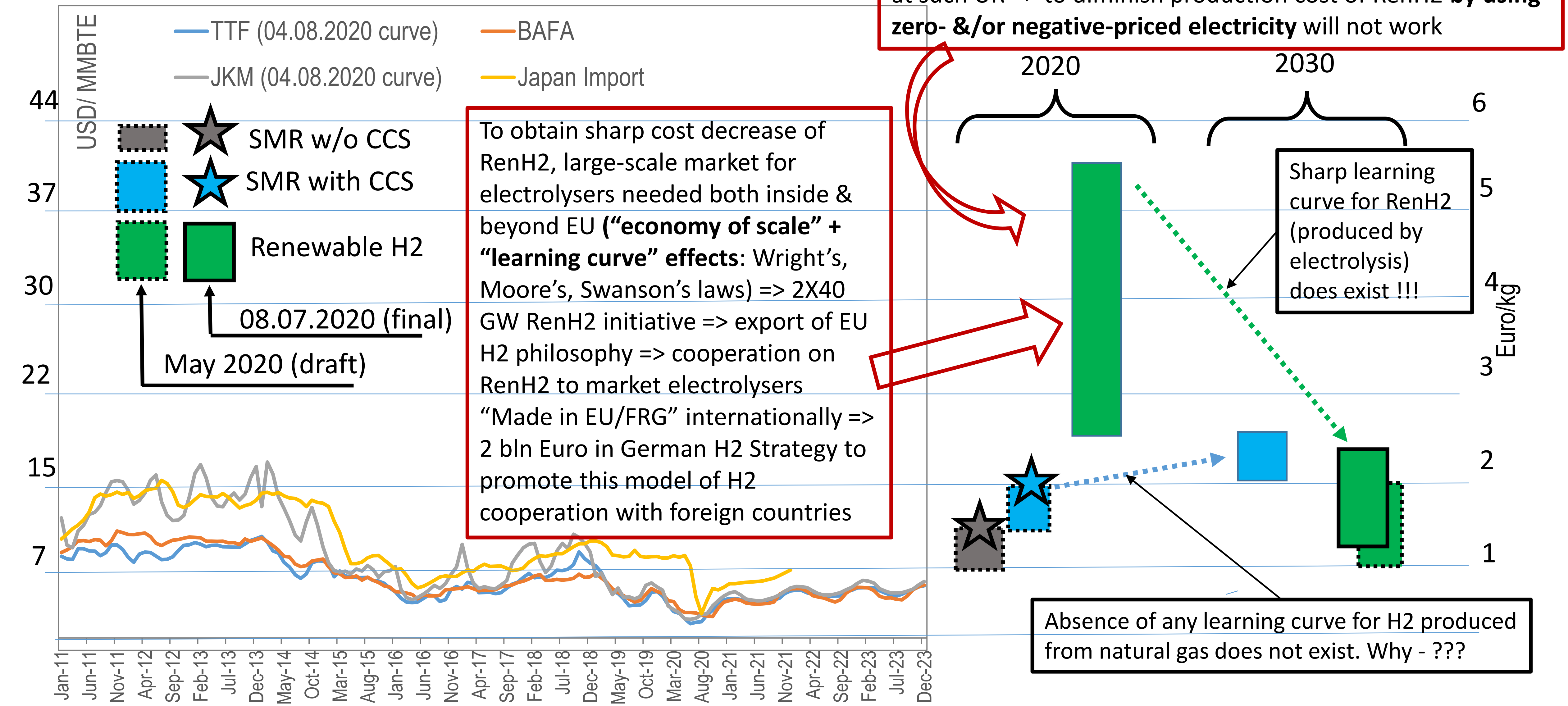
Scope 3 (production equipment)	Scopes 2 and 1 (RES electricity and H2 production)	Scope 3 (utilization after business life)
CO2 emissions: **NOT equal to Zero**	CO2 emissions: equal to Zero	CO2 emissions: **NOT equal to Zero**
EU H2 Strategy: **not included**	EU H2 Strategy: included	EU H2 Strategy: **not included**
Geographical location: **beyond EU**	Geographical location: within EU	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)

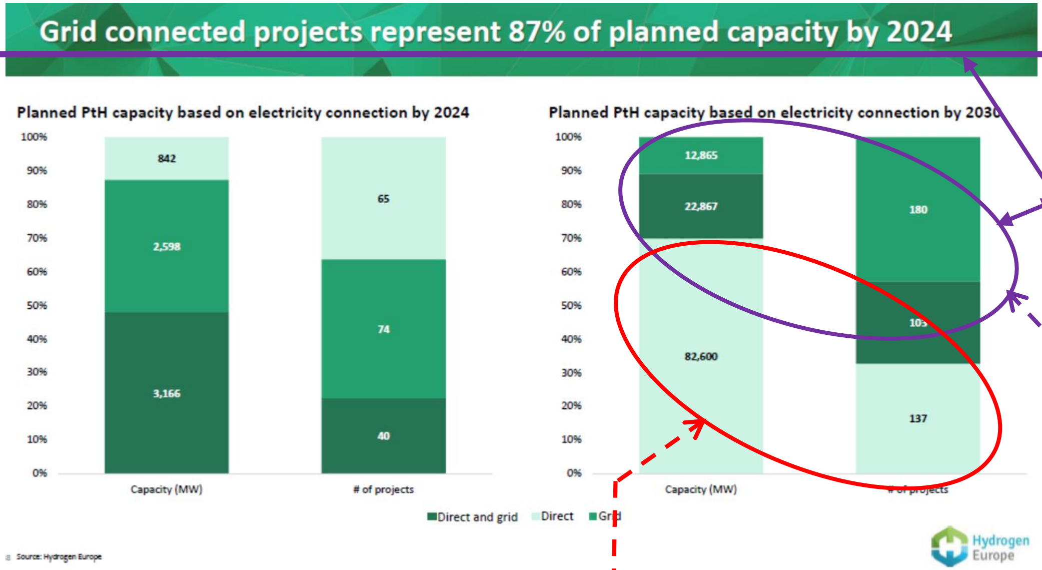
European Commission's estimated costs of H2 production by the key technologies (as presented in the EU Hydrogen Strategy as of 08.08.2020) – and natural gas prices

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

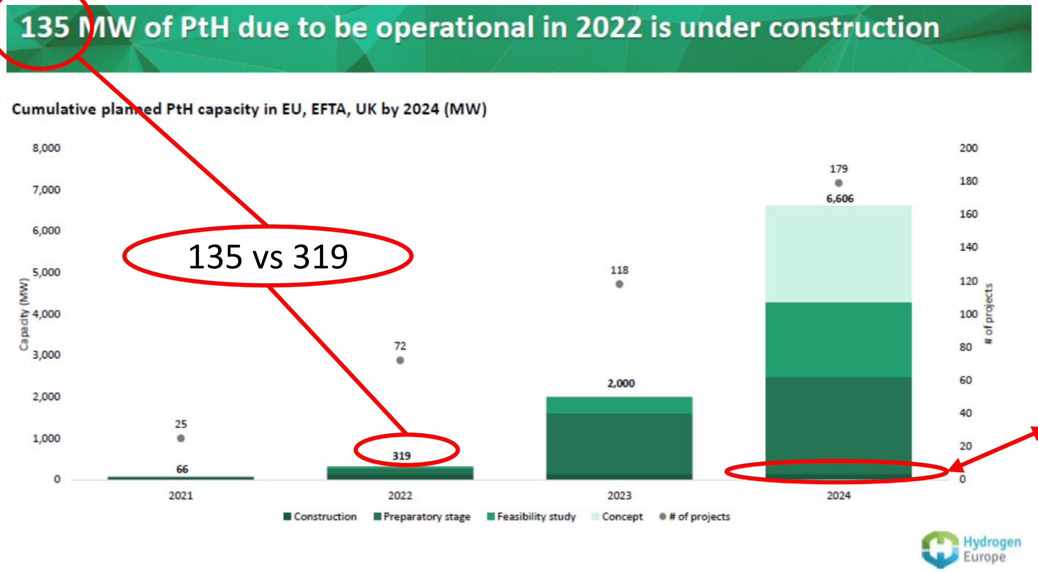


Source: natural gas prices – Gazprom export; H2 costs – European Commission (EU Hydrogen strategy: dotted lines – draft version, May 2020; solid - final document, 08.07.2020)

Some key provisions from Hydrogen Europe Clean Hydrogen Monitor 2021 Launch presentation, 15 October 2021 – still over-exaggeration of "green" H2

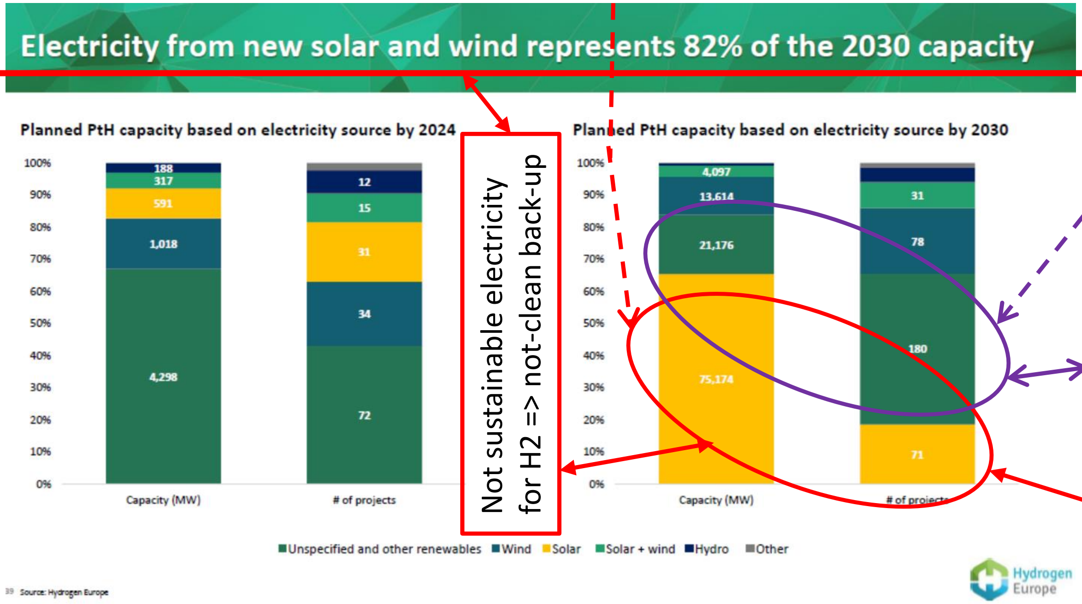


Not "clean" electricity for H2



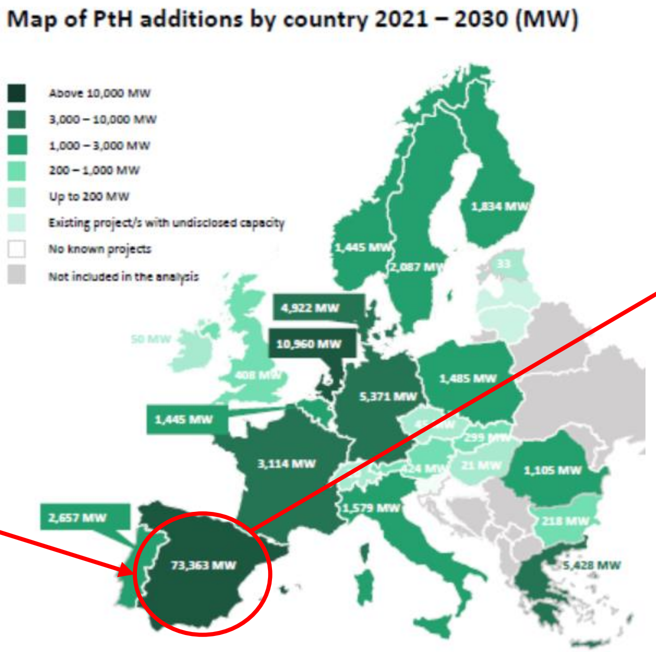
135 vs 319

Under construction



Not sustainable electricity for H2 => not-clean back-up

?



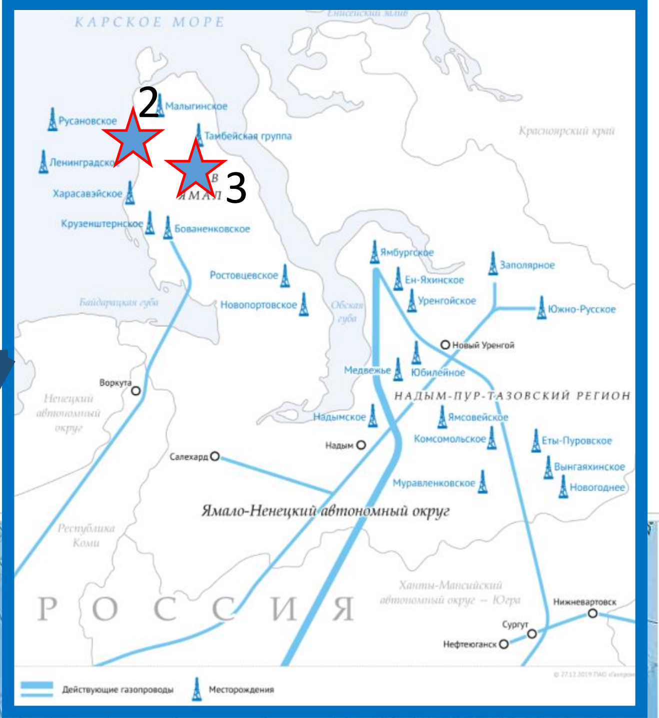
As of 03.08.2021 among 142 known DS (ECT Art.26) of investors from ECT MS against ECT MS, 88 refer to RES, incl.: Spain (49) & Italy (13). Almost all RES-related DS - unilateral early withdrawal of host-states from contractual RES agreements with fixed ROR with investors

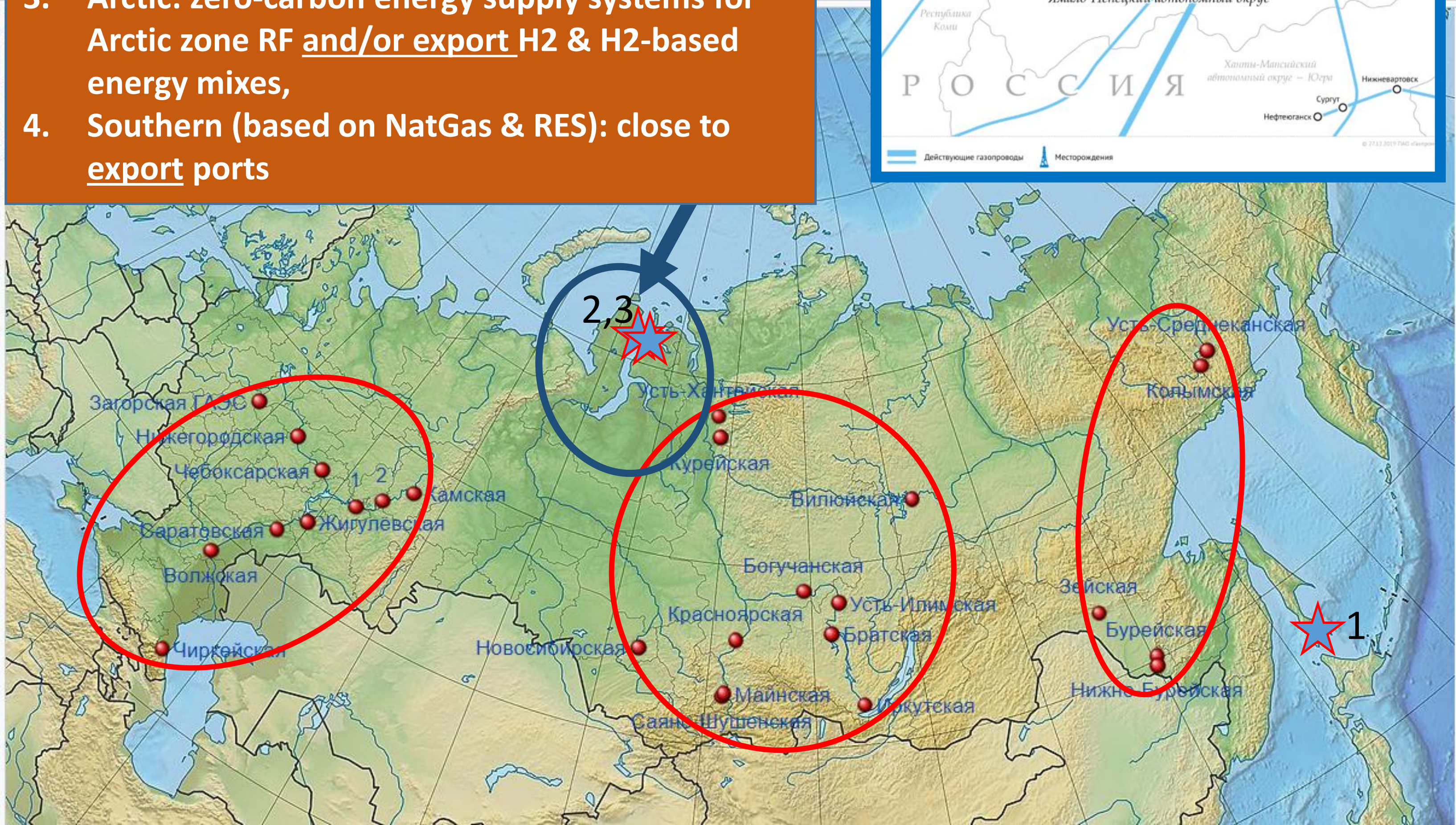
Source: Hydrogen Europe. Clean Hydrogen Monitor 2021 Launch presentation, 15.10.2021 (https://mcusercontent.com/2ff709335803c858f16cabde8/files/4bae0abf-8790-b2bf-c38f-07e43df97e22/2021.10.15_CleanH2Monitor_Launch.pdf)

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

Nadym-Pur-Taz & Yamal

Hydro

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;

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

MINISTRY OF INDUSTRY AND TRADE RUSSIA

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

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

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

Kalininggrad Territory

24. H2 Clean Energy: Green Hydrogen

Sakhalin Region
29. Rosatom: Blue Hydrogen / Ammonia
30. Rosatom: Green Hydrogen
31. H2 Clean Energy: Green Hydrogen
32. H2: Green Hydrogen
Penzhinskaya bay, Kamchatka Territory
33. H2 Clean Energy: Green Hydrogen

Source of basic slide: 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…

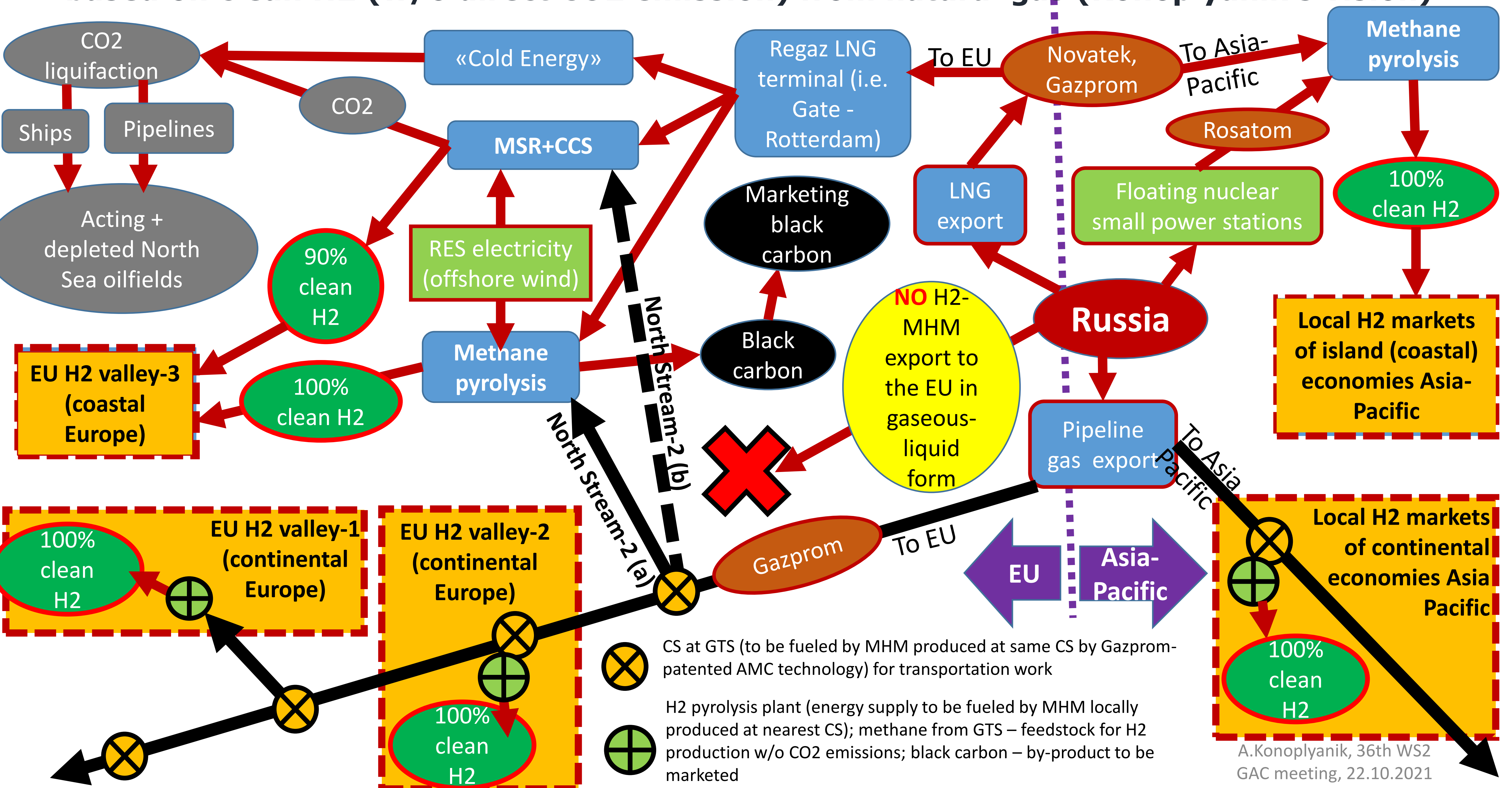
Export, mln tonnes	2024 г.	2025 г.	2030 г.	2035 г.	2050 г.
(1) Russian Energy Strategy (**June 2020**)	0.2		-	2	-
(2) Governmental Road Map (October 2020)	-			-	-
(3) Draft Concept Russian Hydrogen Energy Development (**April 2021**)	0.2-1.0		-	2-7	7.9-33.4
(4) Yu.Dobrovolsky (*) («We with Minenergo… 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 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)

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)



A.Konoplyanik, 36th WS2 GAC meeting, 22.10.2021

Thank you for your attention!

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

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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

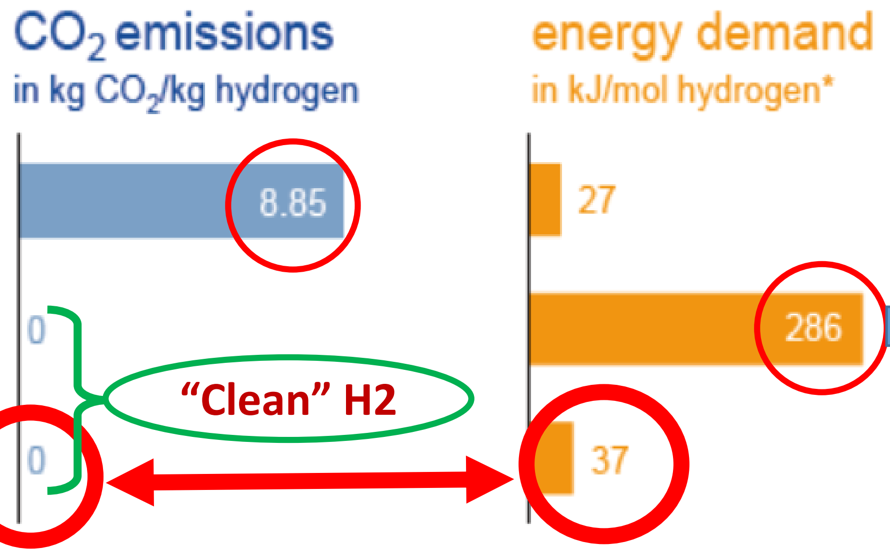
Reserve slides

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

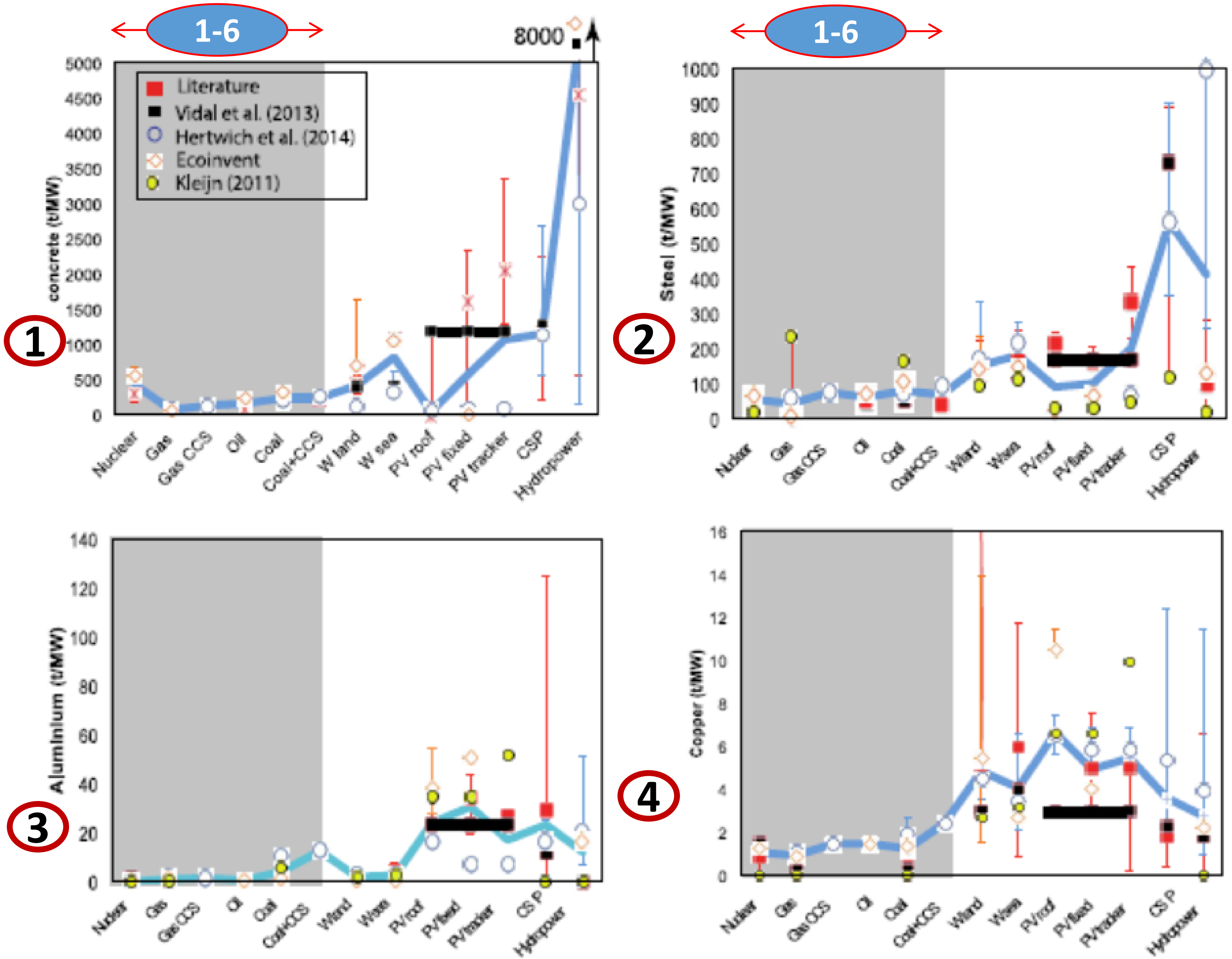
Steam reforming of natural gas	$CH_4 + 2H_2O \rightarrow 4H_2 + CO_2$
Water electrolysis	$2H_2O \rightarrow 2H_2 + O_2$
Methane pyrolysis	$CH_4 \rightarrow 2H_2 + C$



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)



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

1 – concrete,

2 – steel,

3 – aluminium,

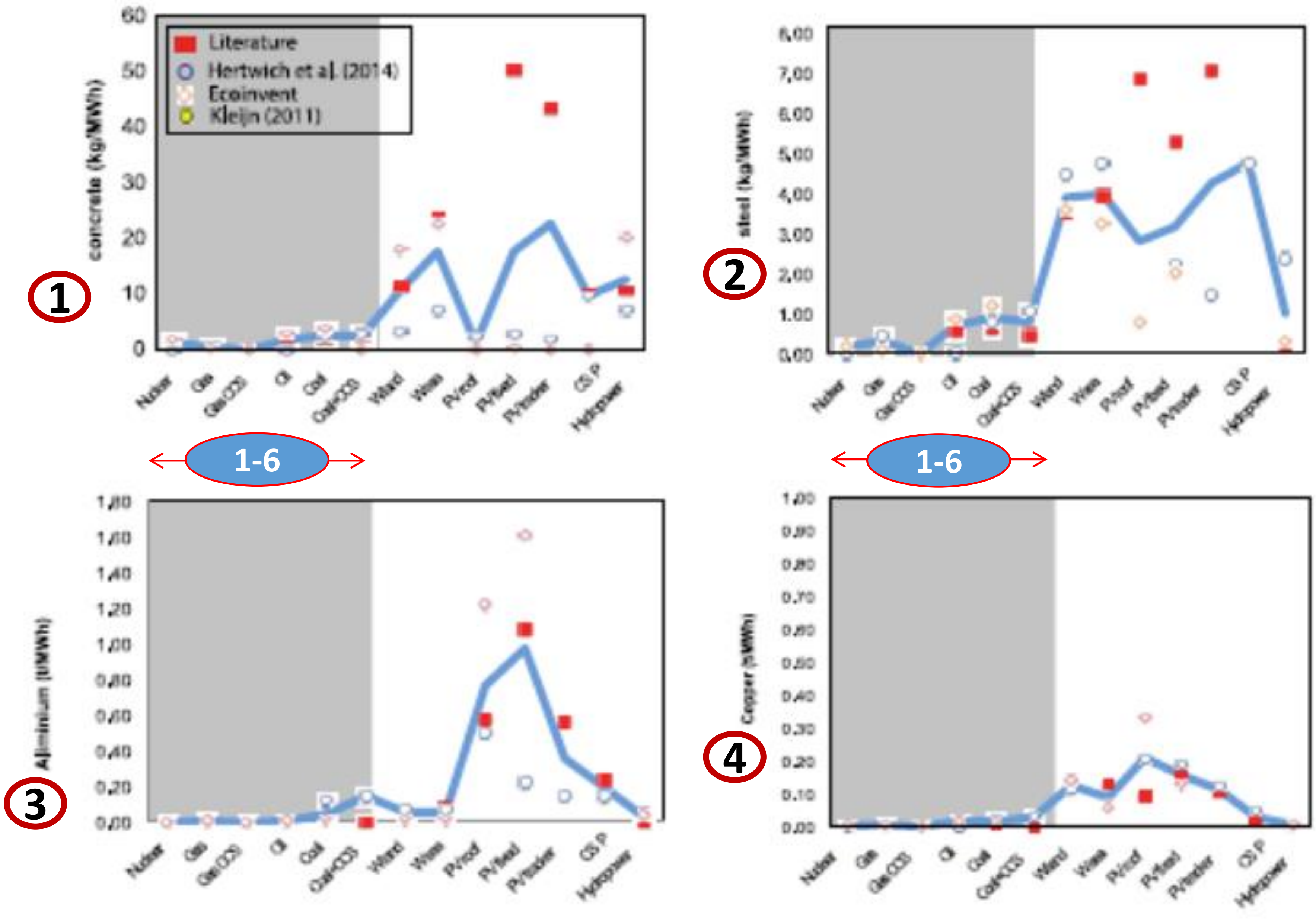
4 – copper

(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)

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



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)

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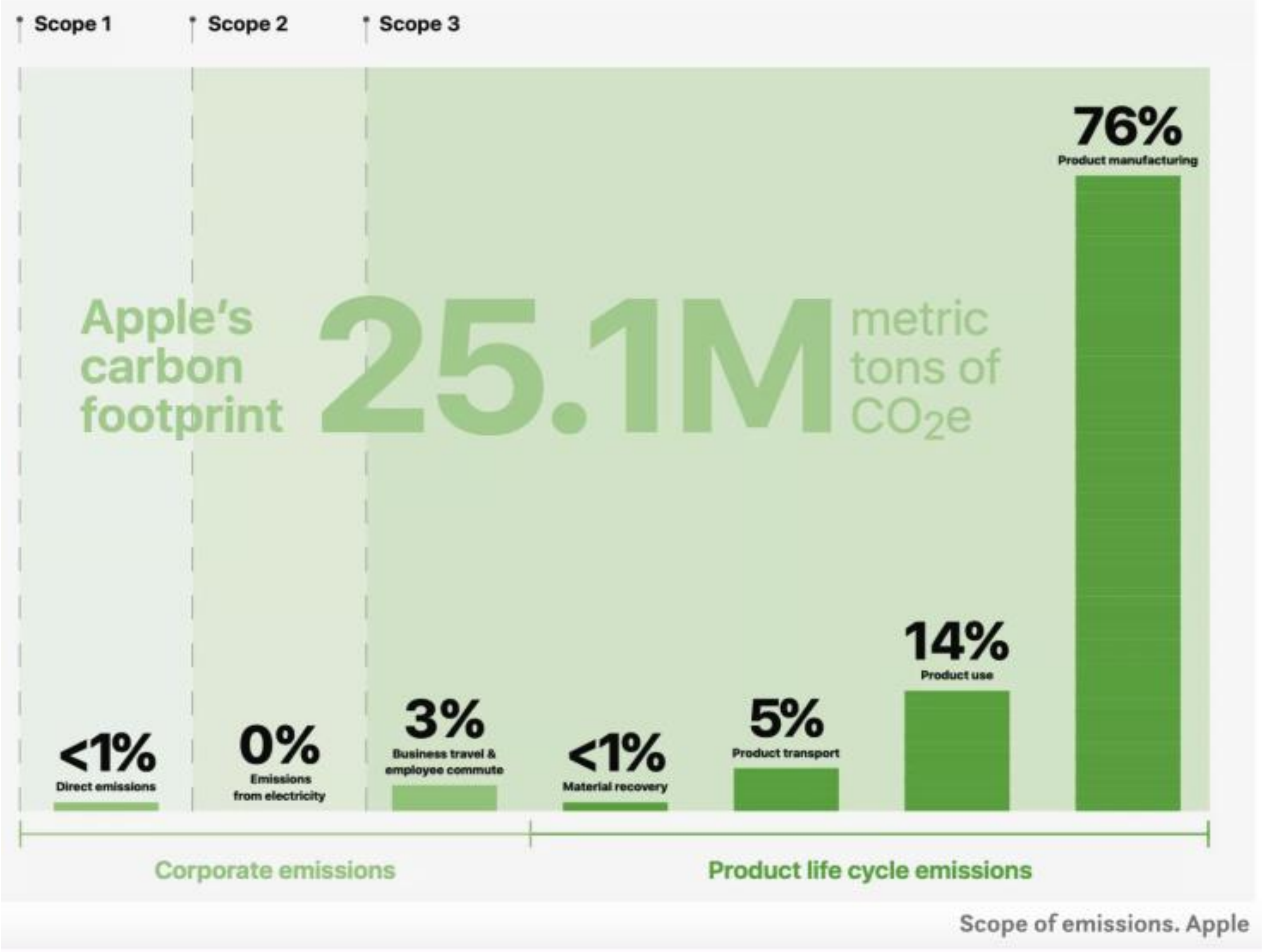


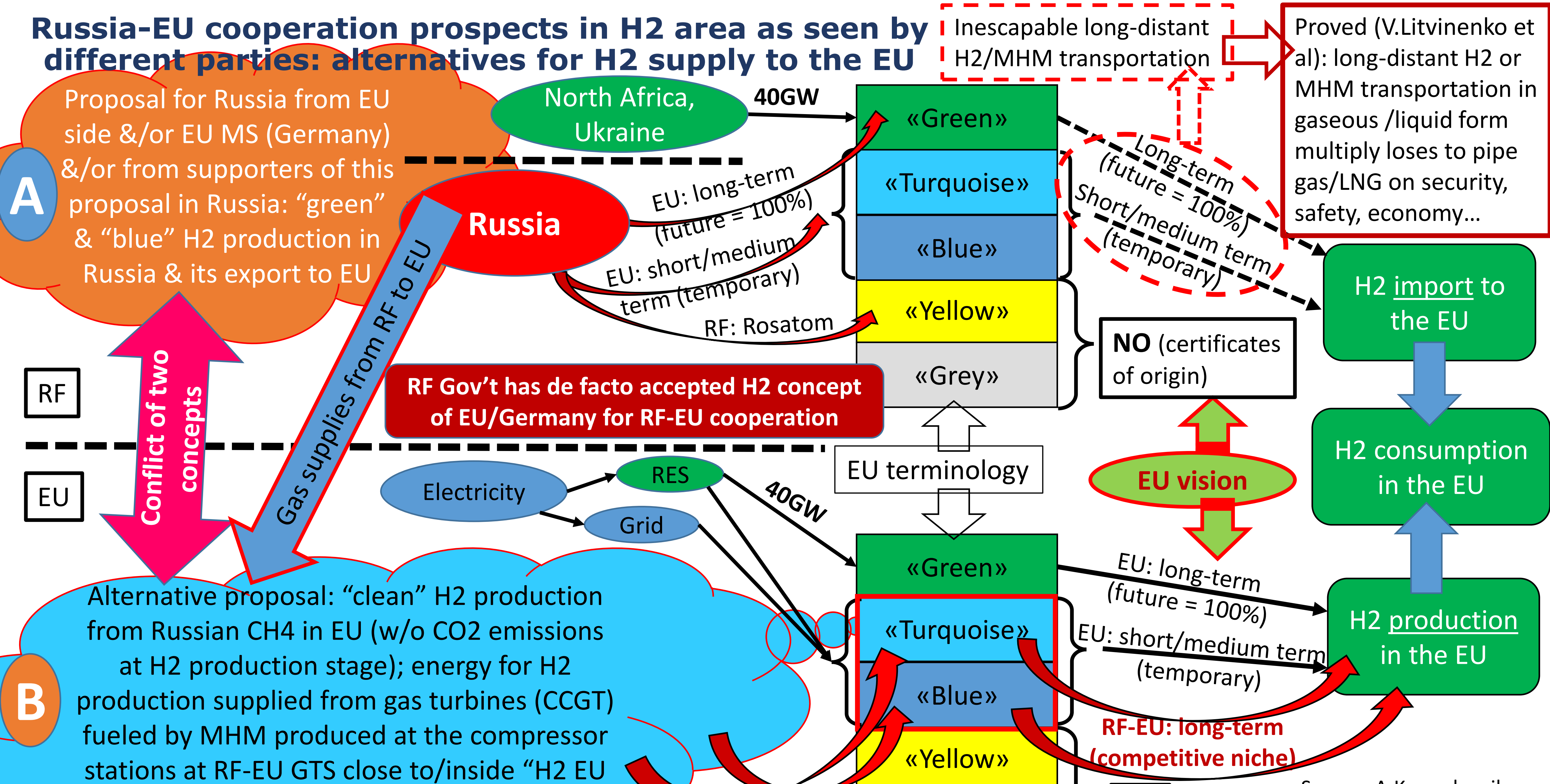
The importance of scope 3 emissions – Apple carbon footprint
Credit: Apple

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/)

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



Source: A.Konoplyanik

A.Konoplyanik, 36th WS2 GAC meeting, 22.10.2021

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

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

Competitive niches for Russian gas at the EU market prior to (existing) and in the process of EU movement (possible additional) through decarbonisation path