Hydrogen strategies EU, Germany, Russia: how to correlate different interests & the role of Russia-EU Energy Dialogue

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XIII International Scientific Conference "ENERGETIKA-XXI: Economics, Politics, Ecology" –
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Водородные стратегии ЕС, ФРГ, России: какова зона совпадения несовпадающих интересов и роль Энергодиалога РФ-ЕС

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Со-председатель с российской стороны Рабочей Группы 2 «Внутренние рынки» Консультативного совета РФ-ЕС по газу;
Член Научного Совета РАН по системным исследованиям в энергетике

XIII Международная Научная конференция «ЭНЕРГЕТИКА-XXI: Экономика, политика, экология» – *«Мировая энергетика после пандемии COVID-19»*, 25-27 ноября 2020 г., СПбГЭУ – ПАО «Газпром», Санкт-Петербург, онлайн

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My key takeaways from ENERGETIKA Hydrogen Pre-conference Workshop 25.11.2020 – prospects for Russia-EU collaboration in Hydrogen

- **EU H2 Strategy** (08.07.2020)*: green vs blue, ambitions vs achievable aims*
  - Not to confuse decarbonisation aims with RES as one of possible instruments
  - Strategy: from "MOU/LOI" to "full legally binding contract" (to conditions for investments),
  - Strategy aims perceptions: proportion achievable aims vs. ambitions,
  - Green H2 vs blue (gas-based) H2 => no green H2 without blue H2 => mixture of both needed => but: green H2 is end-game
  - H2 colouring/terminology:
    - technical instrument or purposed discrimination ("only clean/green H2 is sustainable" => blue H2 is almost taboo) => what is "clean" in substance, not in accepted terminology does matter
    - no really "clean" H2, non-dependent EU terminology => from H2 colours to CO2 track through full life-cycle/value chain incl. equipment manufacturing
  - RES-electricity not to produce renewable H2, but to substitute fossil fuels in powergen; 100% RES electrification impossible
  - CCUS: economics vs social acceptance, onshore/offshore EU => to move CCUS upstream cross-border gas value chain beyond EU (CCUS at Russian O&G fields => oil recovery) => import of green H2
  - Long-distant H2/MHM transportations: (i) MOU level, (ii) EU MS different standards MHM
- **Russian H2 Strategy** (in the making)*: export of gas for clean H2 production downstream EU vs export of H2*
  - To focus on domestic market (where local demand will come from, what investment stimuli), or on export (to rely on H2 export is not sustainable), or on both?
  - Export of gas for local in-EU production of clean H2 vs export of green/blue H2 (CCUS upstream Russia => oil recovery)?
  - 7-10 years ahead for pyrolysis (TRL=3-4) pilot plant commercial scale/moduling approach
  - Absorption capacity of Russian forests to be considered (methodology)
- **Overall conclusion***: not to rely on one single source/solution - "Let's 100 flowers blossom" (Mao Zedong)*
  - Transition step-by-step starting now instead of one big jump when/if ready
  - H2 as only one "brick in the wall" => we need to have H2 from different sources (technologies)
  - *moderator J.Ball:* "we have limited carbon budget: to use every possible path that will add to reaching the result (COP-21)"

Structure of presentation

1) **Russia's Hydrogen Strategy in the making: what's in the package**
2) Hydrogen Strategies EU, Germany, Russia: a comparison
3) There is no purely "clean" energy: "new supply-chains for net-zero carbon requires carbon" (Dan Yergin")
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1. Presidential Decree as of 04.11.2020 on diminishment of GHG emissions in Russia by 2030
2. Governmental Ordinance as of 09.06.2020 on Energy Strategy of Russia to 2035
3. Governmental Ordinance as of 12.10.2020 on hydrogen action plan in Russia up to 2024

1

УКАЗ

ПРЕЗИДЕНТА РОССИЙСКОЙ ФЕДЕРАЦИИ

О сокращении выбросов парниковых газов

В целях реализации Российской Федерацией Парижского соглашения от 12 декабря 2015 г. п о с т а н о в л я ю:

1. Правительству Российской Федерации:

а) обеспечить к 2030 году сокращение выбросов парниковых газов до 70 процентов относительно уровня 1990 года с учетом максимально возможной поглощающей способности лесов и иных экосистем и при условии устойчивого и сбалансированного социально-экономического развития Российской Федерации;

б) разработать с учетом особенностей отраслей экономики Стратегию социально-экономического развития Российской Федерации с низким уровнем выбросов парниковых газов до 2050 года и утвердить ее;

в) обеспечить создание условий для реализации мер по сокращению и предотвращению выбросов парниковых газов, а также по увеличению поглощения таких газов.

2. Настоящий Указ вступает в силу со дня его официального опубликования.

КАНЦЕЛЯРИЯ

Президент
Российской Федерации В.Путин

Москва, Кремль
4 ноября 2020 года
№ 666

2

ПРАВИТЕЛЬСТВО РОССИЙСКОЙ ФЕДЕРАЦИИ

РАСПОРЯЖЕНИЕ

от 9 июня 2020 г. № 1523-р

МОСКВА

1. Утвердить прилагаемую Энергетическую стратегию Российской Федерации на период до 2035 года (далее - Стратегия).

2. Федеральным органам исполнительной власти руководствоваться положениями Стратегии при разработке и корректировке государственных программ Российской Федерации и иных документов стратегического планирования.

3. Рекомендовать органам государственной власти субъектов Российской Федерации руководствоваться положениями Стратегии при разработке и корректировке государственных программ субъектов Российской Федерации и иных документов стратегического планирования.

4. Минэнерго России совместно с заинтересованными федеральными органами исполнительной власти:

представить в 6-месячный срок в Правительство Российской Федерации проект плана мероприятий по реализации Стратегии;

обеспечить реализацию Стратегии.

5. Признать утратившим силу распоряжение Правительства Российской Федерации от 13 ноября 2009 г. № 1715-р (Собрание законодательства Российской Федерации, 2009, № 48, ст. 5836).

Председатель Правительства
Российской Федерации М.Мишустин

3

ПРАВИТЕЛЬСТВО РОССИЙСКОЙ ФЕДЕРАЦИИ

РАСПОРЯЖЕНИЕ

от 12 октября 2020 г. № 2634-р

МОСКВА

1. Утвердить прилагаемый план мероприятий "Развитие водородной энергетики в Российской Федерации до 2024 года" (далее - план).

2. Федеральным органам исполнительной власти, ответственным за реализацию плана, обеспечить его реализацию.

3. Минэнерго России осуществлять мониторинг и контроль реализации плана и ежегодно, до 30 марта, представлять в Правительство Российской Федерации информацию о ходе его реализации.

Председатель Правительства
Российской Федерации М.Мишустин

Source: (1) http://publication.pravo.gov.ru/Document/View/0001202011040008; (2) http://static.government.ru/media/files/w4sigFOiDjGVDYT4IgsApssm6mZRb7wx.pdf; (3) http://static.government.ru/media/files/7b9bstNfV640nCkkAzCRJ9N8k7uhW8mY.pdf

2 Russian Energy strategy to 2035 – section on Hydrogen (p. 47)

- **Aim:** Russia to become ***one of world leaders*** in H2 production **and export (*)**
- **Measures:**
  - State support for development of **infrastructure for transport (*)** and consumption of H2 & MHM
  - State support for H2 production
  - Stepping up H2 from CH4 production, incl. with RES, nuclear
  - Development of domestic low-carbon technologies of H2 production by gas conversion & pyrolysis, electrolysis, etc., incl. possible localization of foreign technologies
  - Stimulate domestic demand for fuel cells in transport, H2 & MHM use to accumulate & convert energy
  - Develop regulatory base for hydrogen safety in energy
  - Intensify international cooperation in H2 energy development & entry to foreign markets
- **Criteria** for H2 energy development = **export of H2 (*)**:
  - 2024 – 0.2 mln tonnes,
  - 2035 – 2 mln tonnes

?

For comparison: today global H2 market around 75-80 MTPA;
Europe 8.3 MTPA => 2030: 20 MTPA (2X40GW)

- **(*) these terms provides different interpretations, incl. wrong perceptions**

3 Hydrogen action plan in Russia up to 2024: some key elements related to clean H2 from CH4 and to international cooperation (acc. to Governmental Ordinance as of 12.10.2020)

No	Task	Time
1.1-3	To develop Hydrogen strategy, Project office for realization of H2 strategy, Interagency Task Force	2021-Q1
2.7	To develop state support measures for priority pilot projects of H2 for energy use, incl. demonstration	2021-Q1
2.8	To develop state support measures for **export of H2** for energy use **(different interpretations/perceptions possible)**	2021-Q2
3.11	System of criteria to select priority projects	2021-Q1
3.12	To develop & annually adjust the list of priority projects	2021-Q1
3.14	Suggestions on engineering centers (to monitor & adjust annually)	2021-Q1
4.15	To provide for creation, manufacturing & implementation of **pilot projects for H2 production without CO2 emissions**	2024
4.16	To provide for creation of test-fields for **low-carbon H2 production** at O&G refining facilities & on **gas production sites**	2023
4.17	To provide for creation, manufacturing & testing of **gas turbines on methane-H2 mix (MHM)**	2024
4.19	To provide for realization of pilot project of **H2 production based on existing nuclear power stations**	2023
5.20	To develop & annually adjust the Register of existing & prospective H2 technologies	2021-Q1
5.21	To provide for development of domestic energy-efficient technologies of production, **transportation & storage of H2**; approbation of **H2 & MHM as a fuel** (with different content of H2 in MHM) **for gas turbines & boilers**	2021-2024
5.22	Research of technologies & their full production cycles GHG-tracks for different production, transportation & utilization	2021-2024
5.24	Research on **marketing of carbon black**	2021-2024
5.25	Proposals for System of certification fro decarbonized H2	2021-Q2
6.27,32	National system of standardization H2+MHM; external cooperation in standardization MHM	2021-Q1,4
8.39-43	International cooperation (*to prepare proposals*) **(=> critical stage – NOW - for domestic & international debate!!!)**	2020-2024

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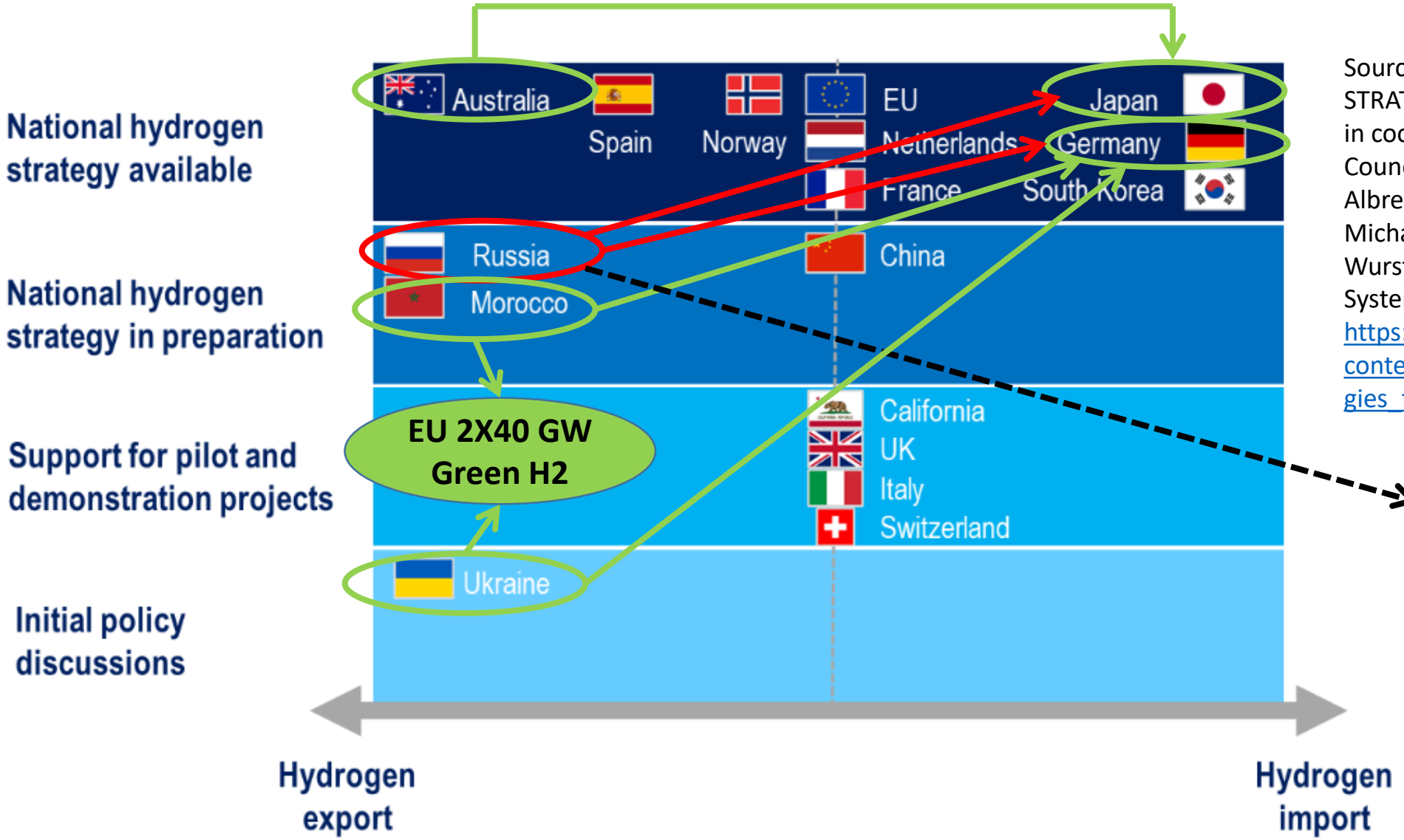

Source: INTERNATIONAL HYDROGEN STRATEGIES. A study commissioned by and in cooperation with the World Energy Council Germany, FINAL REPORT. Dr. Uwe Albrecht, Dr. Ulrich Bünger, Dr. Jan Michalski, Tetyana Raksha, Reinhold Wurster, Jan Zerhusen, Ludwig-Bölkow-Systemtechnik GmbH, September 2020, https://www.weltenergierat.de/wp-content/uploads/2020/10/WEC_H2_Strategies_finalreport.pdf, P.6

Based on perceptions (straightforward interpretations) of H2 section in Russian Energy Strategy up to 2035; internal debate in the course of its preparation; & dominant EU (i.e. German) vision of Russia's H2 strategy developments

Figure 4: Selected countries classification in respect to availability of a dedicated strategy and hydrogen imports/exports

In reality ***Pyrolysis factually ignored***: the term is mentioned 2 times within 56-pages EU H2 Strategy (as of 08/07/2020), once – incorrectly – as synonym to SMR+CCS under "blue H2", which is, in turn, only temporary unwelcome involuntary choice

"From the point of view of the German government, only hydrogen produced on the basis of renewable energy ("green" hydrogen) is sustainable in the long run

The only country with multiple choices for H2 through the whole spectrum of options through the whole time-line

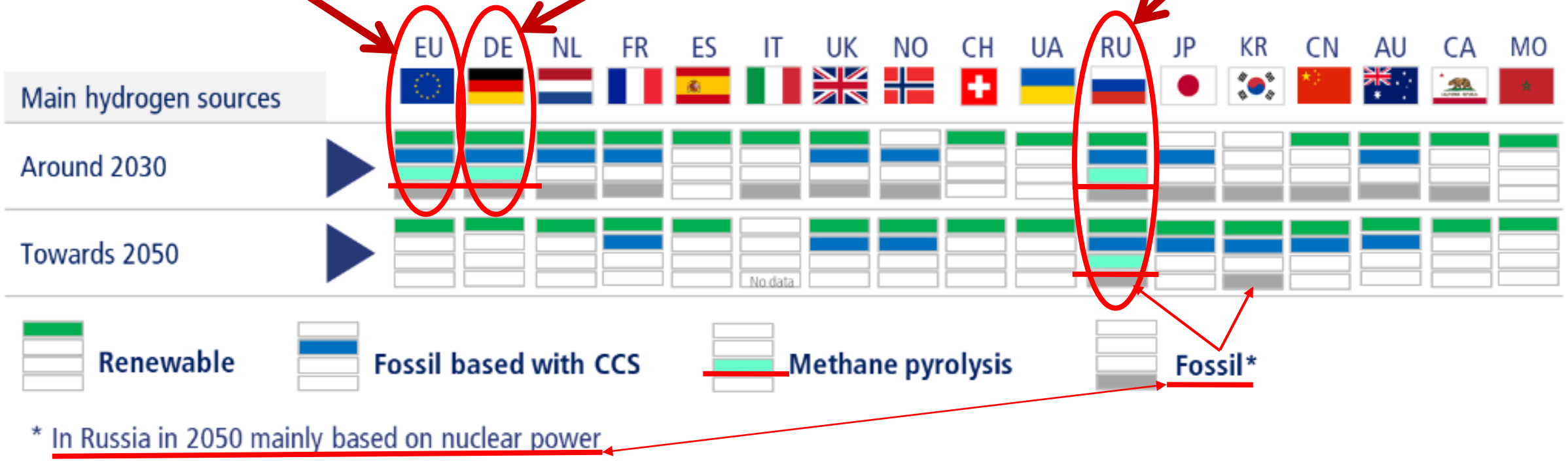

Figure 19: Considered medium- and long-term hydrogen production options by country

Source: INTERNATIONAL HYDROGEN STRATEGIES. A study commissioned by and in cooperation with the World Energy Council Germany, FINAL REPORT. Dr. Uwe Albrecht, Dr. Ulrich Bünger, Dr. Jan Michalski, Tetyana Raksha, Reinhold Wurster, Jan Zerhusen, Ludwig-Bölkow-Systemtechnik GmbH, September 2020, https://www.weltenergierat.de/wp-content/uploads/2020/10/WEC_H2_Strategies_finalreport.pdf, P.33

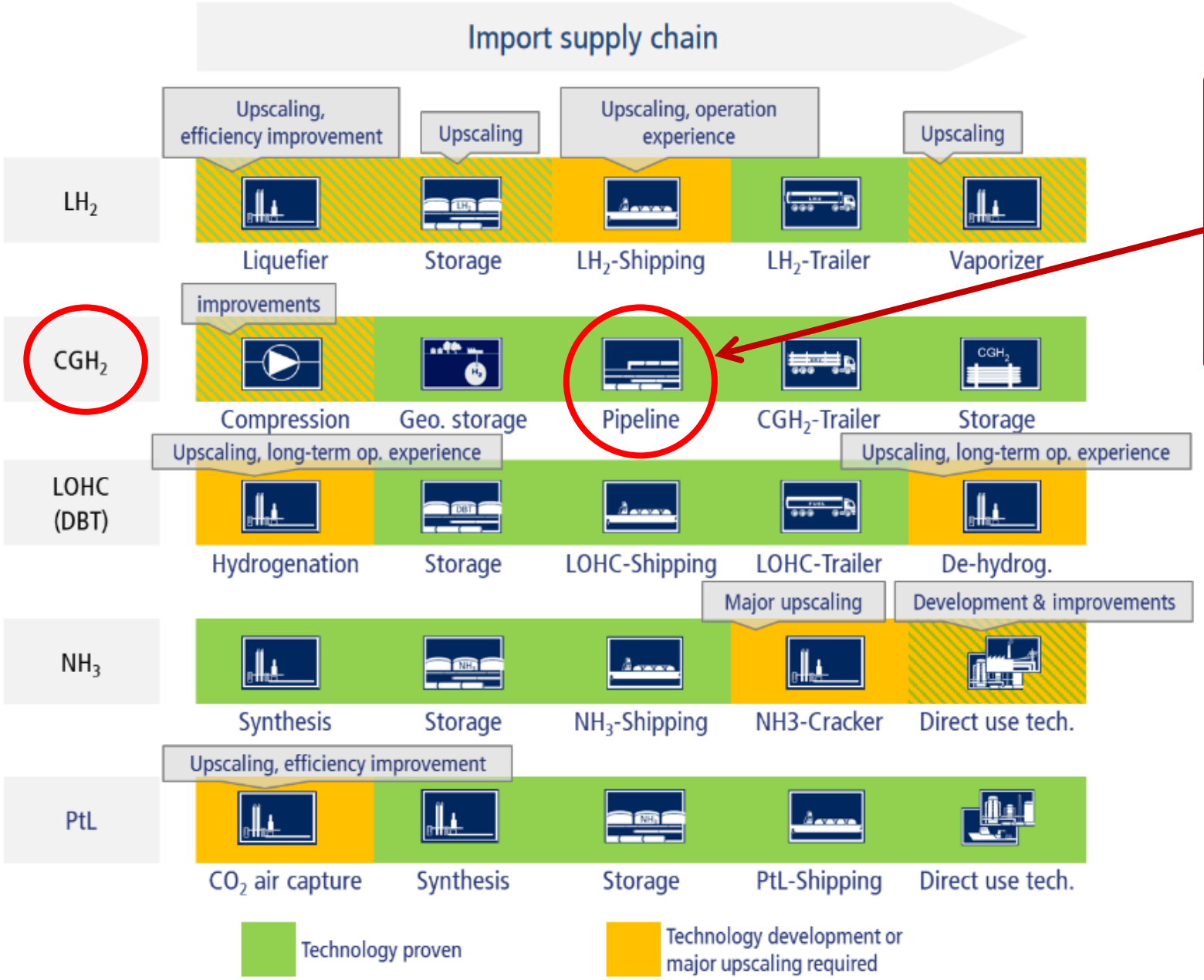

Figure 24: Principle technology availability of main export/import technologies

Wrong perception on long-distance transportation of H2: considered to be as available (technologically proven) as long-distance transportation of CH4 – WHICH IS NOT THE CASE!!!

Source: INTERNATIONAL HYDROGEN STRATEGIES. A study commissioned by and in cooperation with the World Energy Council Germany, FINAL REPORT. Dr. Uwe Albrecht, Dr. Ulrich Bünger, Dr. Jan Michalski, Tetyana Raksha, Reinhold Wurster, Jan Zerhusen, Ludwig-Bölkow-Systemtechnik GmbH, September 2020, https://www.weltenergierat.de/wp-content/uploads/2020/10/WEC_H2_Strategies_finalreport.pdf, P.64

Decarbonisation upstream: different view from East & West on long-distant high-pressure transportation & storage of H2

Litvinenko et al, SPB Mining Univ.

1) concentration of H2 in MHM increases from 10 to 90 % => **density of MHM decreases more than 4 times.**

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

3) H2 content in MHM rises from zero to 100% => **energy use** (required to compress 1 kg of MHM to raise the pressure by 1 MPa) **increased by around a factor of 8.5.**

4) it is possible to store or transport **almost 5.9 times more LNG than liquid H2**.

5) Pressurized H2 is **capable to escape** even from airtight tanks during long-term storage.

6) **Stress corrosion**: due to it Gazprom replaced over 5,000 km of large-diameter pipelines.

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.

Siemens/Gascade/Nowega

1) Pure hydrogen, as an energy source in pipelines, has an **almost comparable** transport energy **density** as natural gas. […] Contrary to popular belief, the transport energy **density** of hydrogen is **only slightly lower** than that of natural gas. Therefore, the switch from natural gas to hydrogen has little impact on the capacity of a pipeline to transport energy. […] hydrogen has a **density nine times lower** and three times the flow rate of natural gas, almost three times the volume of hydrogen can be transported in the pipeline at the same pressure, and during the same time. The energy density is only lightly reduced […] Transport via pipelines is particularly economical. Due to the high calorific value and the compressibility of the hydrogen, an **extraordinarily high energy density** can be achieved.

2) The pipeline networks are available, socially accepted, and can be gradually converted to hydrogen operation with an investment of an **estimated 10-15% of the cost** of new construction […] As measuring devices, compressors and fittings can be exchanged relatively easily, *(AK: BUT??? =>)* replacing or building new pipelines would be **very expensive.** […] To enable optimal utilization with high transport energy density in hydrogen operation, more and higher-power compressors are required than in natural gas operation. […] approximately **three times** the drive power and therefore a correspondingly **higher number of turbines and compressors** are required than in natural gas operation.

3) …it is **possible to convert** the existing steel pipelines from natural gas to hydrogen operation to the extent required for the ramp-up of a hydrogen industry. A significant **reduction in the service life** of high-pressure lines due to the influence of hydrogen **does not seem likely**

4) …hydrogen transport capacities **can initially be built up in parallel** and cumulatively with existing natural gas systems. […] **A parallel hydrogen and natural gas infrastructure at the long-distance gas level** also offers the possibility of adapting the composition of the gas

Source: Hydrogen infrastructure – the pillar of energy transition. The practical conversion of long-distance gas networks to hydrogen operation. // Whitepaper. Siemens Energy, Gascade Gas Transport GmbH, Nowega GmbH, 2020, 32 p.

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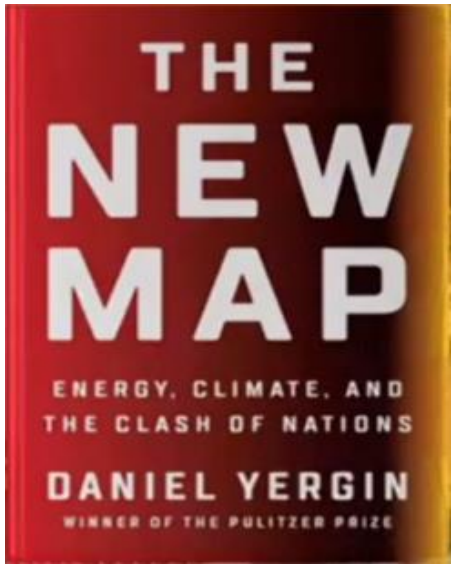
What is clean energy? Depends on how you calculate/consider it…

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

Siemens/Gascade/Nowega (Hydrogen infrastructure – the pillar of energy transition…, 2020):

"If the electricity required for electrolysis comes exclusively from renewable, CO2-free sources, the entire production process is completely CO2-free."

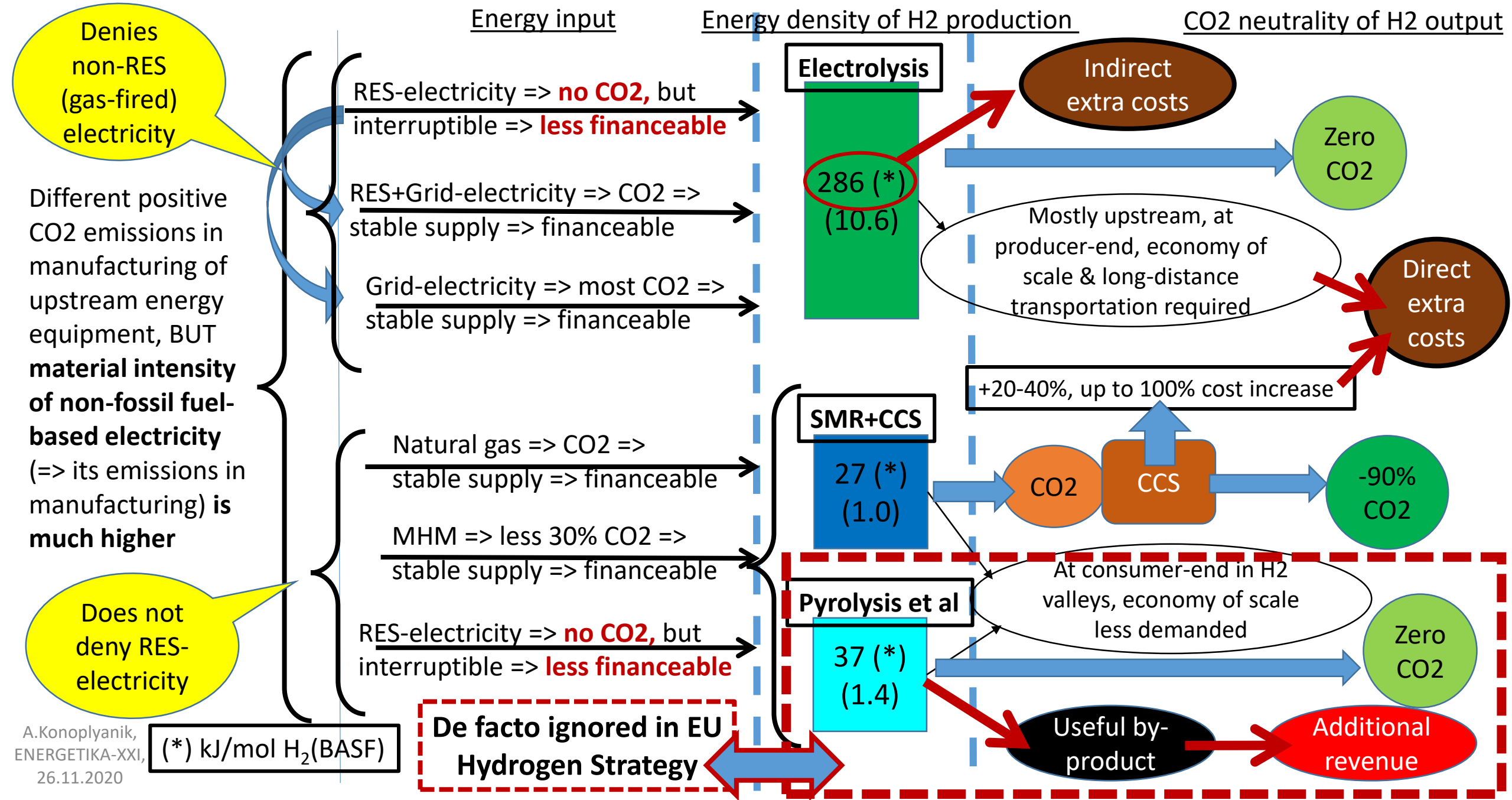


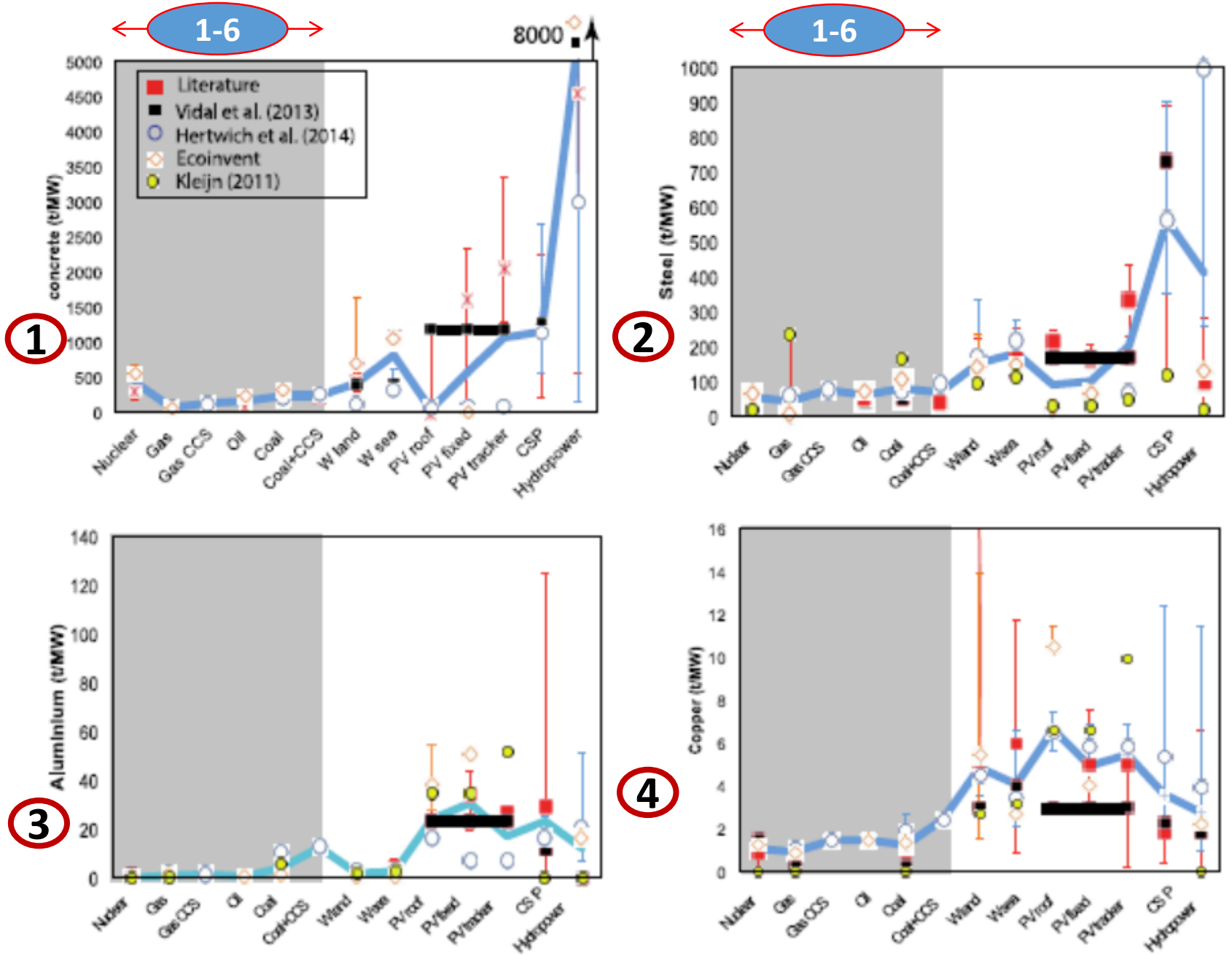
Daniel Yergin,
Pulitzer Prize winner for "The Prize" book at presentation of his new book "The New Map" (US Atlantic Council, 25.09.2020, online):

"**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)

3H2: Input-output CO2 options – no totally clean alternative through value chain





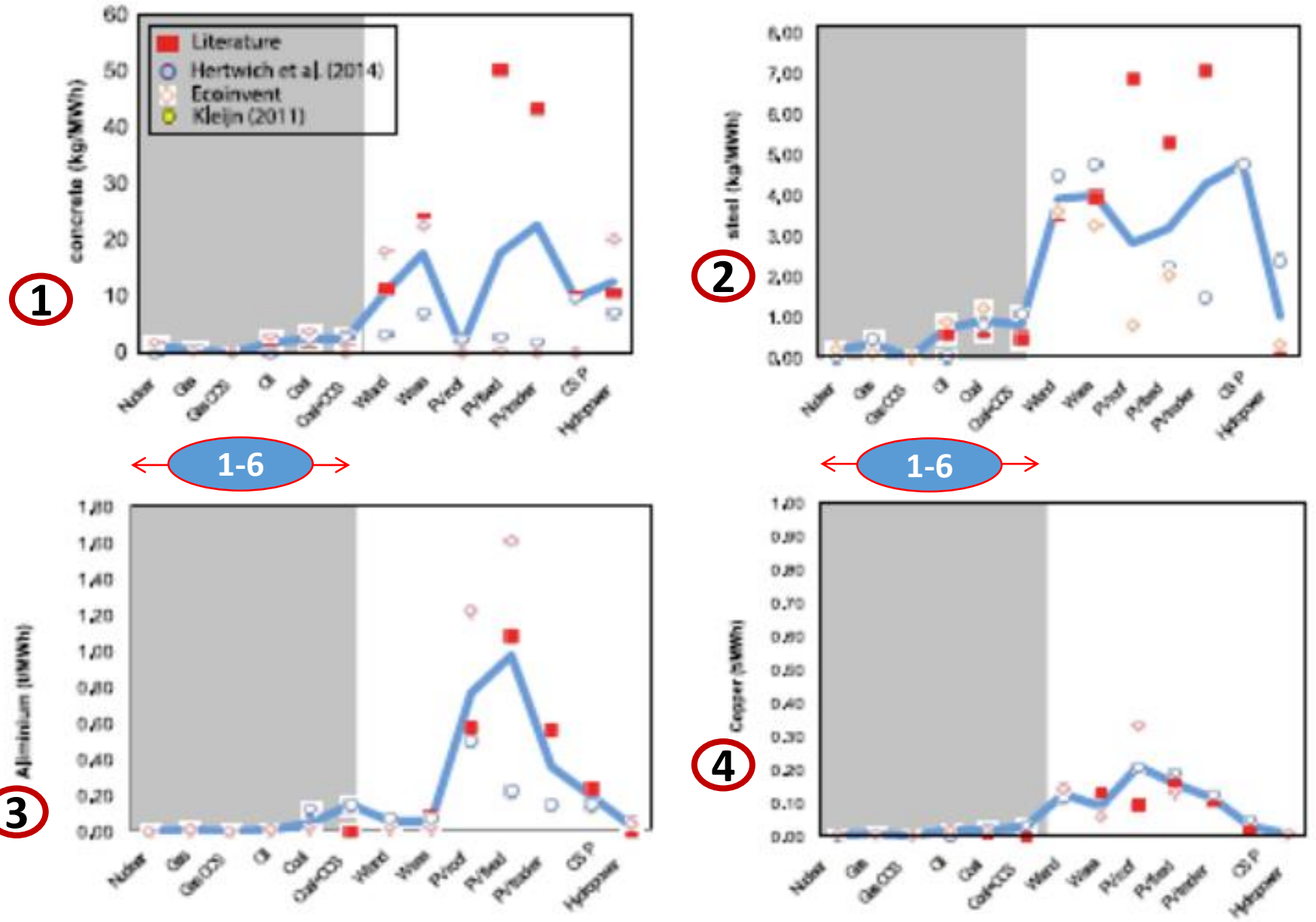
Quantities (t/MW) of four structural materials used to manufacture different power generation infrastructure (material intensity) :

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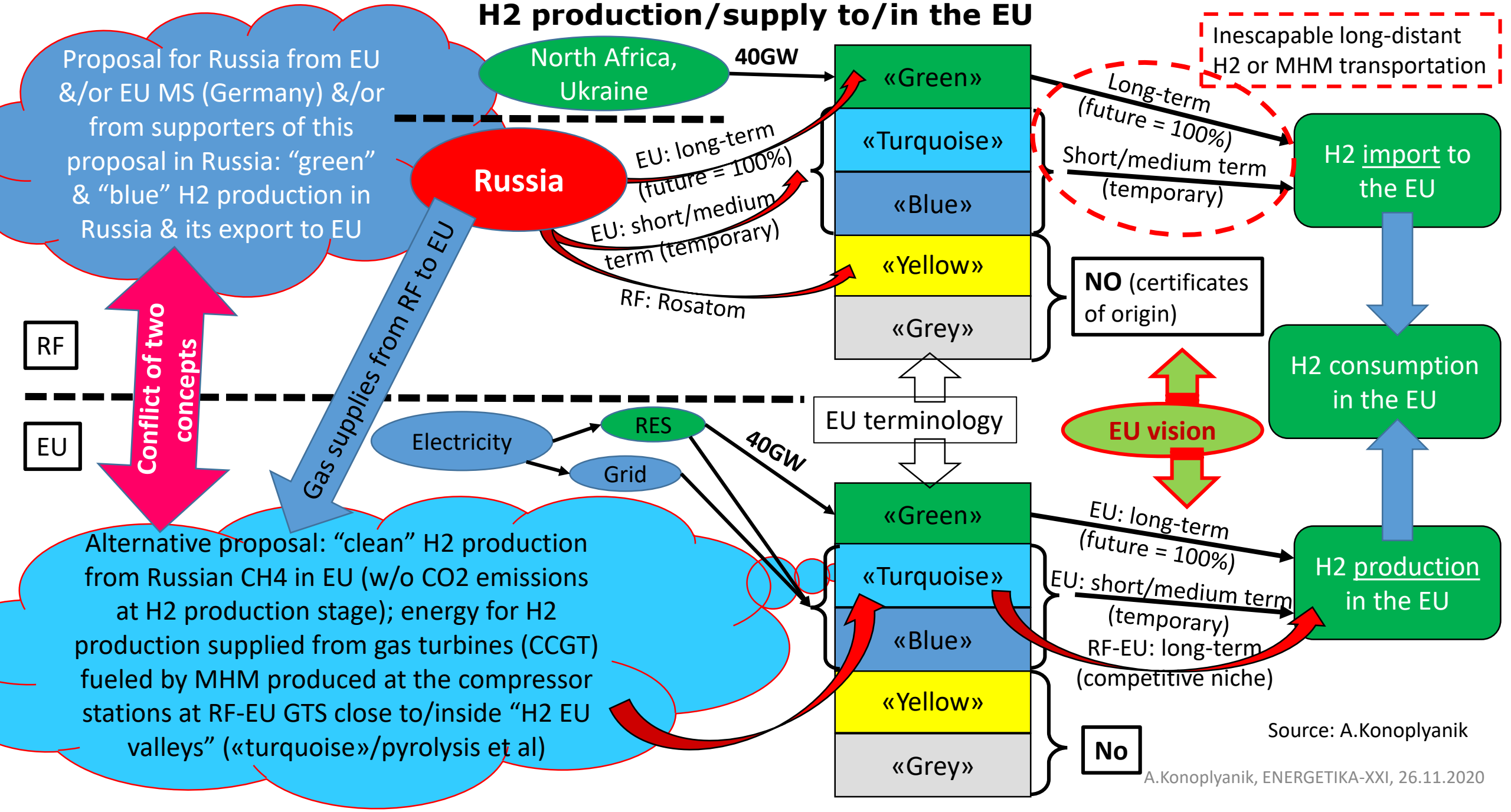
Russia-EU cooperation prospects in H2 area as it seen by different parties: alternatives for H2 production/supply to/in the EU



Source: A.Konoplyanik

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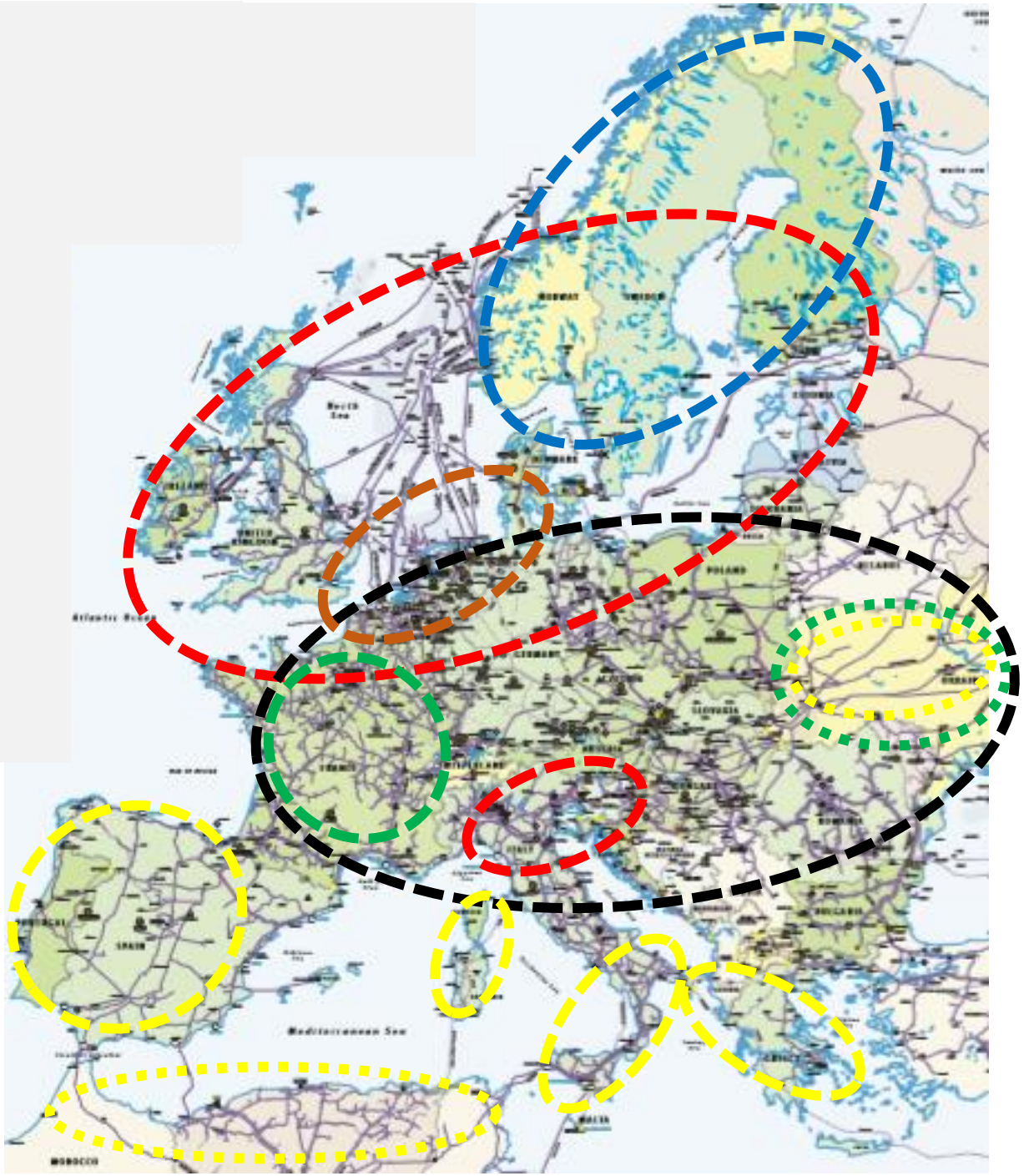


Approximate potential areas of preferential use of key H2 production technologies in Europe under state regulation based on "technological neutrality" principles

P2G wind

P2G hydro

P2G solar

P2G nuclear

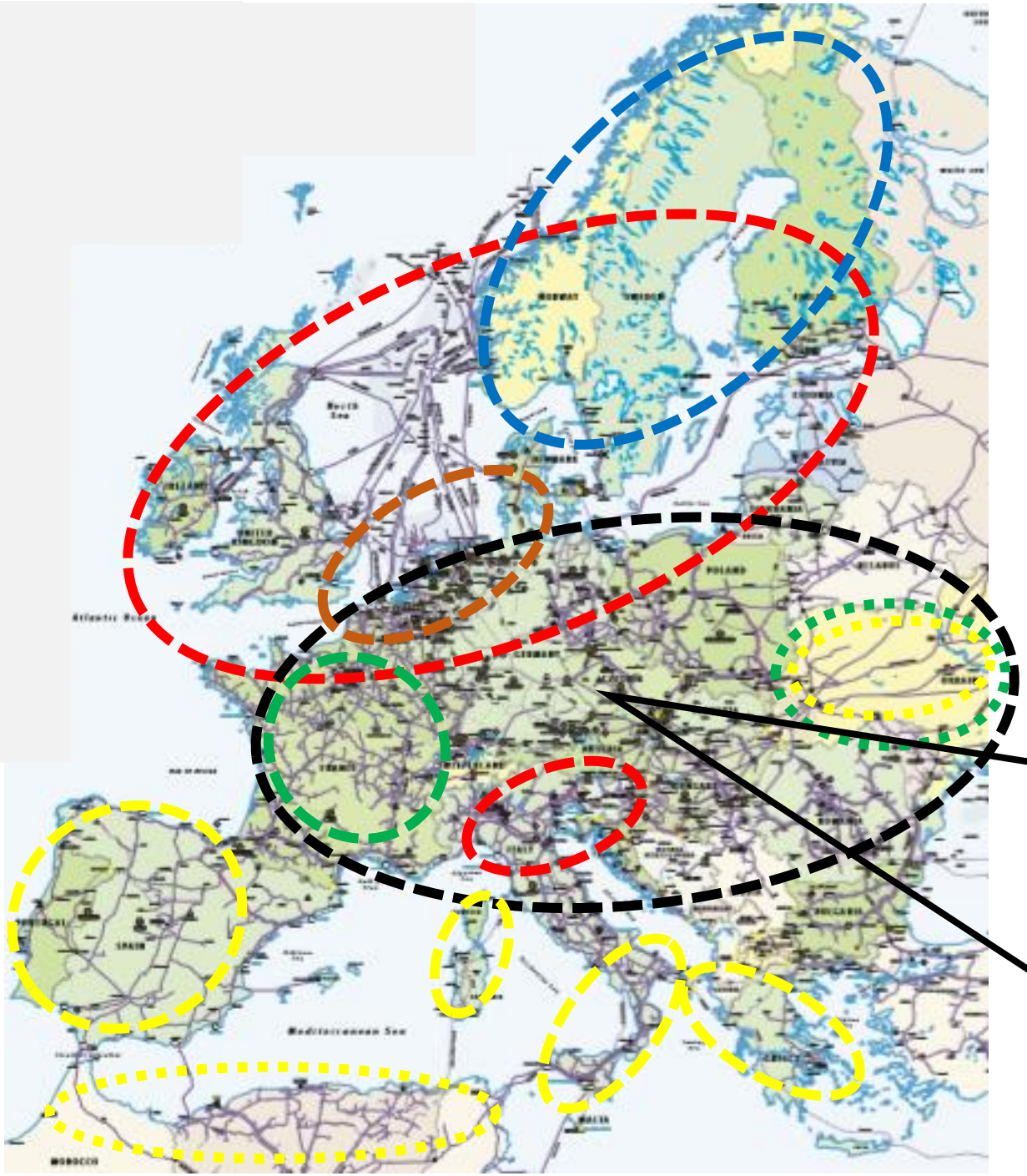
Electrolysis based on different primary electricity sources

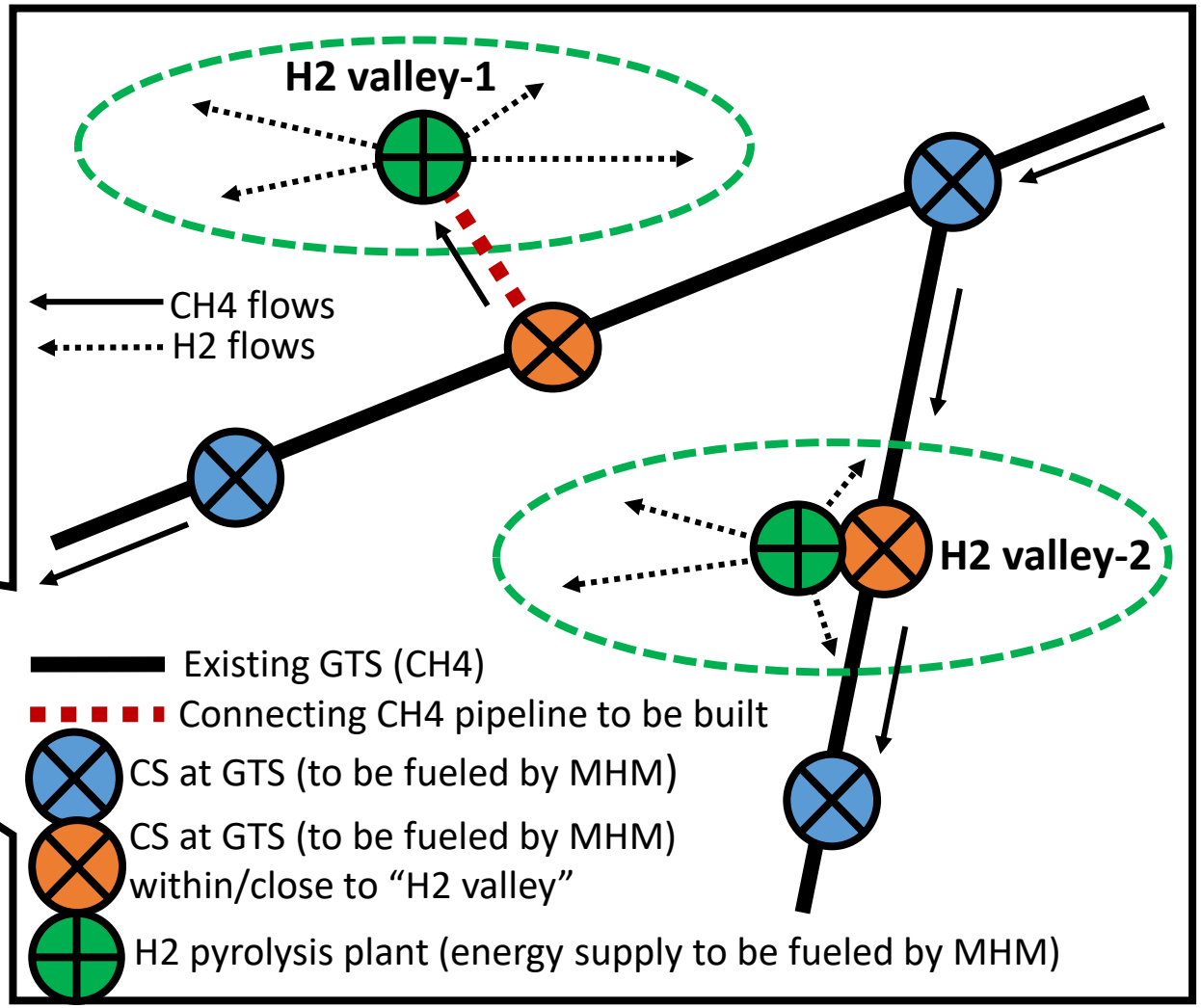
MSR/ATR plus CC(U)S

Methane pyrolysis, plasma-chemical method et al w/o CO2 emissions *(to incorporate both Step 2 & Step 3 of Cooperative RF-EU gas decarbonisation measures from "Three Step Aksyutin's Path") =>* ***based on existing cross-border gas grid***

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 (or any other remote/beyond the EU) geographical areas; source of map – ENTSOG

Approximate scheme of clean H2 production from natural gas placement within existing cross-border RF-EU gas value chain (gas grid) inside the EU close to prospective "hydrogen valleys"





Clean H2 production (w/o CO2 emissions) from natural gas downstream EU based on existing Russia-EU GTS & MHM produced at CS on-site

- Clean H2 production close to EU demand centers (H2 valleys) located close to existing compressor stations (CS) at cross-border RF-EU GTS. To use gas from the grid:
- As energy source for:
  - (1) transportations work:
    - to produce MHM on-site at CS on transportation routes of Russian gas to the EU;
    - to use this MHM at these CS as a fuel gas instead of methane for further gas transportation.
    - Such substitution of CH4 by MHM as fuel gas at CS diminishes CO2 emissions by 30% (acc.to Gazprom);
  - (2) clean H2 production:
    - at the H2 production plants which are to be built close to these CS in “H2 valleys”;
    - scale of production adequate to H2 demand of particular “H2 valley”;
    - energy supply of CCGT of adequate capacity - acc.to above-mentioned scheme in (1).
    - Though substitution of CH4 by MHM as fuel gas is not for transportation work, but for energy supply (electricity &/or heat) to H2 production plant;
- (3) As a feedstock for:
  - new clean H2 production plants from CH4;
  - plants to be located close to CS and aimed to cover H2 demand of local “H2 valley” (this will exclude demand for long-distance transportation of H2 or MHM).

Gas Advisory Council under Coordinators of Russia-EU Energy Dialogue, 2011 till nowadays

Coordinators of Russia-EU Energy Dialogue

Russia - Minister of Energy

EU – Commissioner on Energy

Russia-EU Gas Advisory Council

Co-Chairs:

Russia – Anatoly Yanovsky

EU – Philip Lowe (2011-2013), Klaus-Dieter Borchardt (2014-2020)

Co-speakers:

Russia – Vladimir Feygin

EU – Jonathan Stern

Work Stream 1

«Long-term gas scenarios and forecasts»

Co-chairs:

Russia – Vladimir Feygin

EU – Jonathan Stern

Work Stream 2

«Internal markets»

Co-chairs:

Russia – Andrey Konoplyanik

EU – Walter Boltz (2011-2019), Wim Groenendijk (since 2020)

Work Sytream 3

«Gas infrastructure»

Co-chairs:

Russia – Theodore Shtilkind

EU – Stephan Kampues

Russian Ministry of Energy:

«…in Spring 2014 Russia-EU Energy Dialogue was frozen at EU initiative. Expert Work Stream 2 on Internal markets, among three existing WSs of GAC, is practically the only one working body of the Energy Dialogue» (https://minenergo.gov.ru/node/14646)

DG ENERGY, European Commission:

«The EU-Russia energy dialogue… has been on hold since 2014… Only the technical work-stream on internal market issues under the previous EU-Russia Gas Advisory Council (GAC WS2) remains operational» (https://ec.europa.eu/energy/topics/international-cooperation/key-partner-countries-and-regions/russia_en)

Literature of this author on the topic of presentation (www.konoplyanik.ru)

- (650) Чистый водород из природного газа — новое перспективное направление сотрудничества России и ЕС. // «*Газпром*», сентябрь 2020, №9, с. 2-11
- (647) Декарбонизация газовой отрасли в Европе и перспективы для России. Чистый водород из природного газа как новая основа для взаимовыгодного сотрудничества РФ и ЕС в газовой сфере. // «*Нефтегазовая Вертикаль*», 2020, №16, с. 30-41 (часть 1); №17, с. 29-38 (часть 2); №18, с. 50-56 (часть 3); № 19, с. 66-74 (часть 4); № 20, с. 39-45 (часть 5)
- (643) Decarbonising European Gas: A New EU-Russia Partnership? // "*Global Gas Perspectives*", 07 July 2020
- (639) Декарбонизация ЕС: угроза или возможность? // *«Эксперт»,* 18-24.05.2020, №21, с.23
- (622-624) Перспективы взаимодействия РФ и ЕС в сфере декарбонизации. Есть ли возможности для расширения рынка для российского газа в Европе? // *«Нефтегазовая вертикаль»,* август 2019, №13, с.101-105 (часть 1); сентябрь 2019, №14, с.43-49 (часть 2); сентябрь 2019, №15, с.26-32 (часть 3)
- (2020/7) Russia's Hydrogen Strategy in the making & prospects for effective Russia-EU cooperation in this field: different aspects for WS2 GAC discussions. // Presentation at the 32-th meeting of WS2 GAC, online, 13.11.2020
- (2020/5) A "Clean Hydrogen from Natural Gas Alliance" Proposal – why it is in mutual benefit for the EU and Russia; proposal for creation of the platform. // Presentation at the 31-th meeting of WS2 GAC, online, 18.09.2020
- (2020/4) GAC WS2 - reflection on GAC WS2 evolution to its 30th meeting. // Presentation at the 30-th meeting of WS2 GAC, online 13.07.2020
- (2020/3) Decarbonization of gas industry: The Challenge or The Crisis? // Presentation for IGU Strategy Committee meeting, Tel-Aviv, Israel, 26-27.02.2020
- (2020/1) Pyrolysis: Can it be a Pathway to a "win-win" Russia-EU collaboration in regard to decarbonisation? // Presentation at the 12th Annual European Gas Conference, Vienna, 27-29.01.2020

Thank you for your attention!

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Благодарю за внимание!

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Reserve slides

Decarbonisation downstream: contractual issues of long-distance gas deliveries for clean H2 production downstream the EU (bankability of decarbonization)

- How to consider carbon neutrality:
  - at the **entry point to EU** (CH4 contains C => means “dirty” => might be taxable by proposed “carbon import duty”), or
  - at the **exit of technological process of H2 production deep inside EU** (clean H2 from CH4 by pyrolysis *et al* does NOT contain CO2), =>
    - Validity of the current trend within banking community to phase-out from fossil-fuel-based projects (f.i. EIB decision as of Nov’2019) => this de facto ban findnacing H2 production from CH4 => clarification & further debate needed
- LTC issue in clean H2 production:
  - Necessity to **“contractually protect” (ring-fence) CH4 flow for clean H2 production** => requirement for cross-border LTC => what adaptation of LTC might be needed, if any?
  - LTC destined for gas supplies to (or: being part of) ring-fenced (to be better financeable) investment project of clean H2 production at the end of cross-border pipe **SHALL not be an object for on-border entry import “carbon” duties**
    - Clean intended end-use is more important for climate change purpose than carbon content in transit /input feedstock/energy product, entering the EU (methane leakages to be considered)
    - If full value chain carbon-track taxation, then:
      - NOT at the entry border
      - To consider WHOLE life-cycle through direct & adjoining industries (upstream to mining), RES/non-RES

Proposed road map/action plan for collaborative efforts on clean H2 from CH4 for RF-EU actors (non-exclusive starting list)

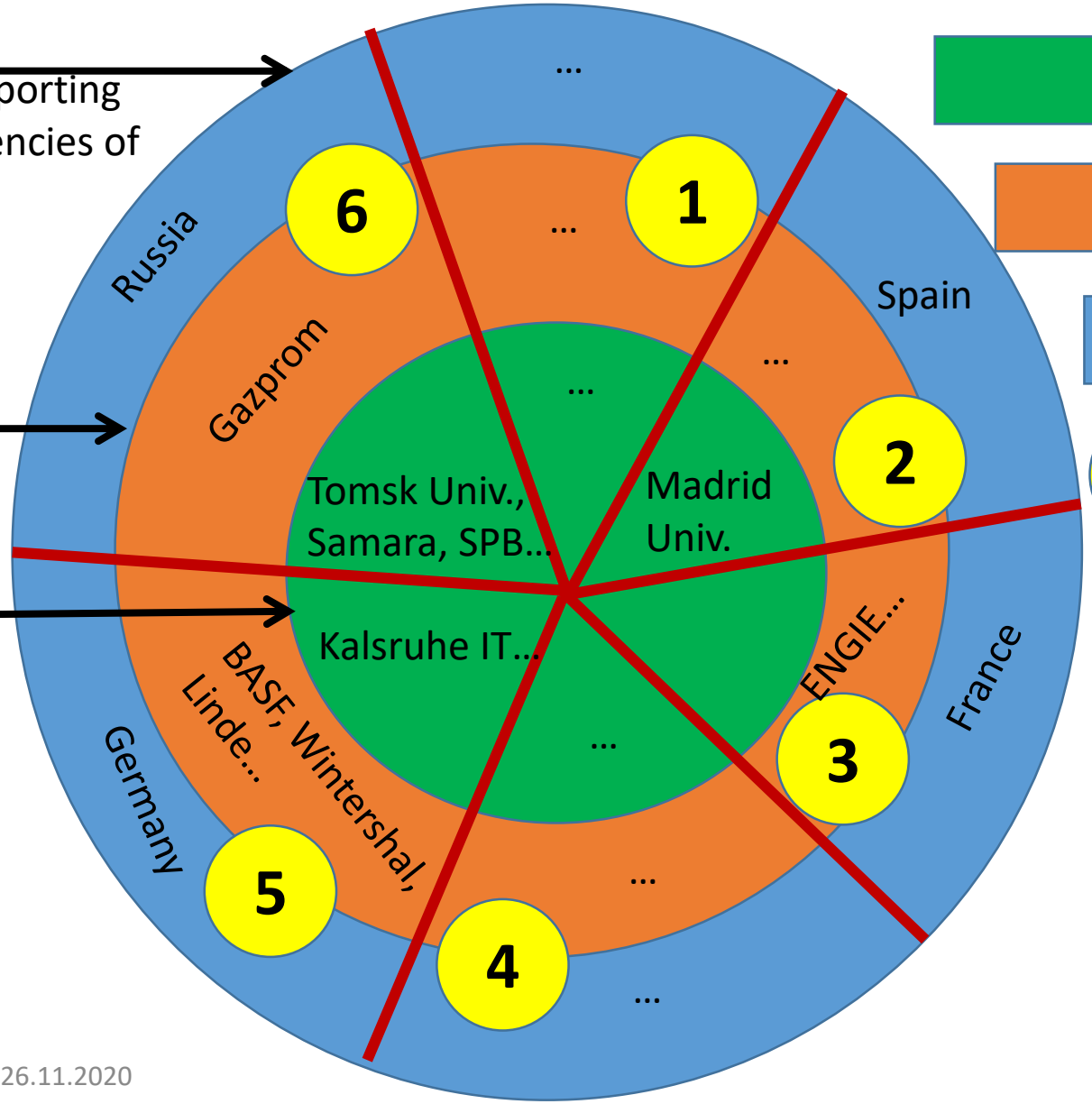
1) Programme of phased transition of compressor stations (CS) on cross-border RF-EU GTS from methane to MHM as fuel gas:
   - On existing CS for gas transportation
   - On future facilities nearby/at existing CS for energy supply for clean H2 production
2) Investigation of marketing issues for solid carbon as a by-product of pyrolysis & similar technologies
3) Forming of “Clean Hydrogen from Natural Gas Alliance”:
   - Identification of participants - those who are interested to join efforts,
   - Their readiness to joint efforts and acceptable forms of collaboration for each one,
   - Their potential input into collaboration,
   - Requested/desired support measures (types, level, etc.)
4) Identification of key potential barriers => Issues related to methane leakages:
   - methodology, terminology, correctness of comparative calculations on pipeline gas & LNG, etc.
   - Since it is that issues that are step-by-step being raised in the EU as more important in their negative climate effect compared to CO2 emissions => might act as a growing (potential-?) barrier for natural gas as one of the key sources for EU decarbonisation (for clean hydrogen production)

Possible structure of [Russia-EU] cooperative consortia on RD&D for "clean" H2 production from methane (w/o CO2 emissions)

Level & step 3 of cooperation
(Research institutions *plus* supporting business entities *plus* State agencies of the countries involved)

Level & step 2 of cooperation
(Research institutions *plus* supporting business entities of the countries involved)

Level & step 1 of cooperation
(Research institutions of the countries involved)



Research institutions of the countries involved

Business entities (companies) of the countries involved

State agencies of the countries involved

1 .. 6 Countries involved

"Clean" H2 technologies (*):
(1) Thermal (non-catalytic)
(2) - Plasma
- Microwave-plasma
(3) - Catalytic
- Liquid metal/molten salts
- Salt intermediaries

(*) Methane pyrolysis –Key findings of study. Report. // AFRY, JULY 2020, slide 10

Comparison of two Clean H2 Alliances proposals (with no CO2 emissions in H2 production)

Items	EU Clean H2 Alliance (08.07.2020)	Proposed RF-EU Clean H2 from CH4 Alliance
Targeted H2	Renewable H2 (current EU mainstream)	Clean H2 from natural gas (totally ignored in EU)
Feedstock & its inland limitation in EU	Water => natural limits	Natural gas => no limitations with diversified multiple import supplies by pipelines & LNG
Energy supply for H2 production	Renewable electricity (wind, solar): - Interruptible (difficult to finance), - Non-interruptible only with electricity storage (yet non-available) - RES-electricity clean, but its upstream equipment production chain not clean	MHM-fueled CCGT at/close to CS on existing GTS: - non-interruptible (easy financeable) - MHM not as clean as RES-electricity, but 30% less CO2 than in gas-fired turbines, its up-stream equipment production chain not clean - open issue of methane leakages
Location of H2 production units	Where intensive sun & wind => far beyond the EU => far away from EU H2 consumption centers	Close to/in EU H2 consumption centers (H2 valleys)
Triggering effect for H2 cost-reduction	Economy of scale (obligatory) + learning curve (at the production site) => maximum increase of unit production capacity required =>	Adequacy of production capacity to demand levels + learning curve => no need in obligatory economy of scale
H2 unit production capacity	=> Increase to technically achievable maximum (GW-level)! …from today's kW/100'skW/MW(?)	Selection of optimal sizes close to demand(s) in "H2 valleys" (100'kW to MW-level) ?
Long distance H2 transportation	Badly needed	No need
H2 distribution lines	Needed (in sum-total longer)	Needed (in sum-total shorter)
Existing cross-border GTS (CH4)	Risk to become a stranded asset	Continued to be used, no risk of stranded asset; prolongation of economic life
Scope	Internal EU	Internal 'Broader Energy Europe' (incl.RF-EU)