A personal view on Russia-EU energy collaboration story (in gas): evolution in line with & adaptation to changing externalities within broader globalized energy environment

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Changing/evolving multi-dimension environment for energy business in "Broader Energy Europe" (geopolitical, economic, regulatory, environmental, …)

- **Geopolitics:**
  - From USSR/COMECON to dissolution of socialist system (1991) and single states => new political map of new sovereign states with their sovereign right for "rule to regulate"
  - EU integration trends: From velvet revolution in Eastern European countries (1988/1989) to their affiliation with EU (2004/2007), unification of Germany (1991)
  - EU desintegration trends: Brexit (2016-2021) plus internal UK (Scotland) & Spain (Basques) disintegration tendencies; refuges crisis (result of "colour revolutions" in MENA); internal conflict between old & new Europeans (no homogeneity yet in the EU as well as in Germany); polarization of political parties…
- **Regulation:**
  - From national champions within isolated markets to single EU common energy market still in the making through 1st (1996/1998), 2nd (2003) & 3rd (2009) EU Energy Packages and its Network Codes (2010-2017)
  - New regulatory rules influence economics (more short-term-oriented model of economic development)
- **Economics:**
  - Diminishing role of national states vs increasing role of international bureaucracy (national capitals vs Brussels)
  - From maximization of shareholders value (profit) to sustainable development incl. social responsibility, "responsible investing", ESG (environment, sustainable, governance), green financing => new development models with new balance of risks & rewards
  - Changing parameters of global competition (increasing role of China, India, BRICS etc), new global supply chains emerge
- **Environmental:**
  - Green agenda (post-COP-21/2015): climate-related concerns dominate over shareholders value; political limitation (incl. retroactive) of investment activities (i.e. ECT modernization process)
  - Increased reliance on public finance – deviation from open market rules & principles (increased direct & indirect role of public finance)
  - Climate agenda as a means of redistribution of powers and new repartition of markets and spheres of influence

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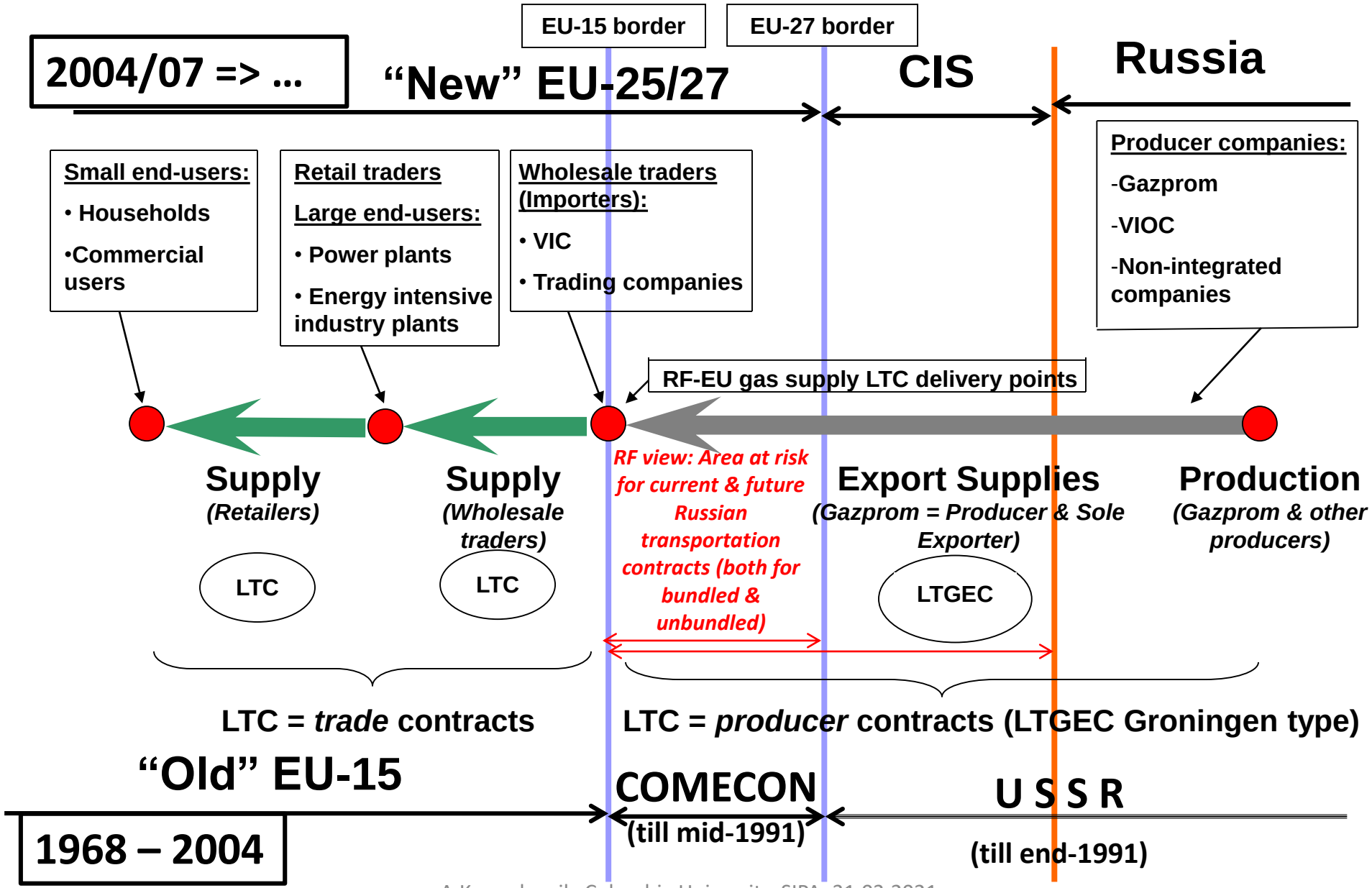
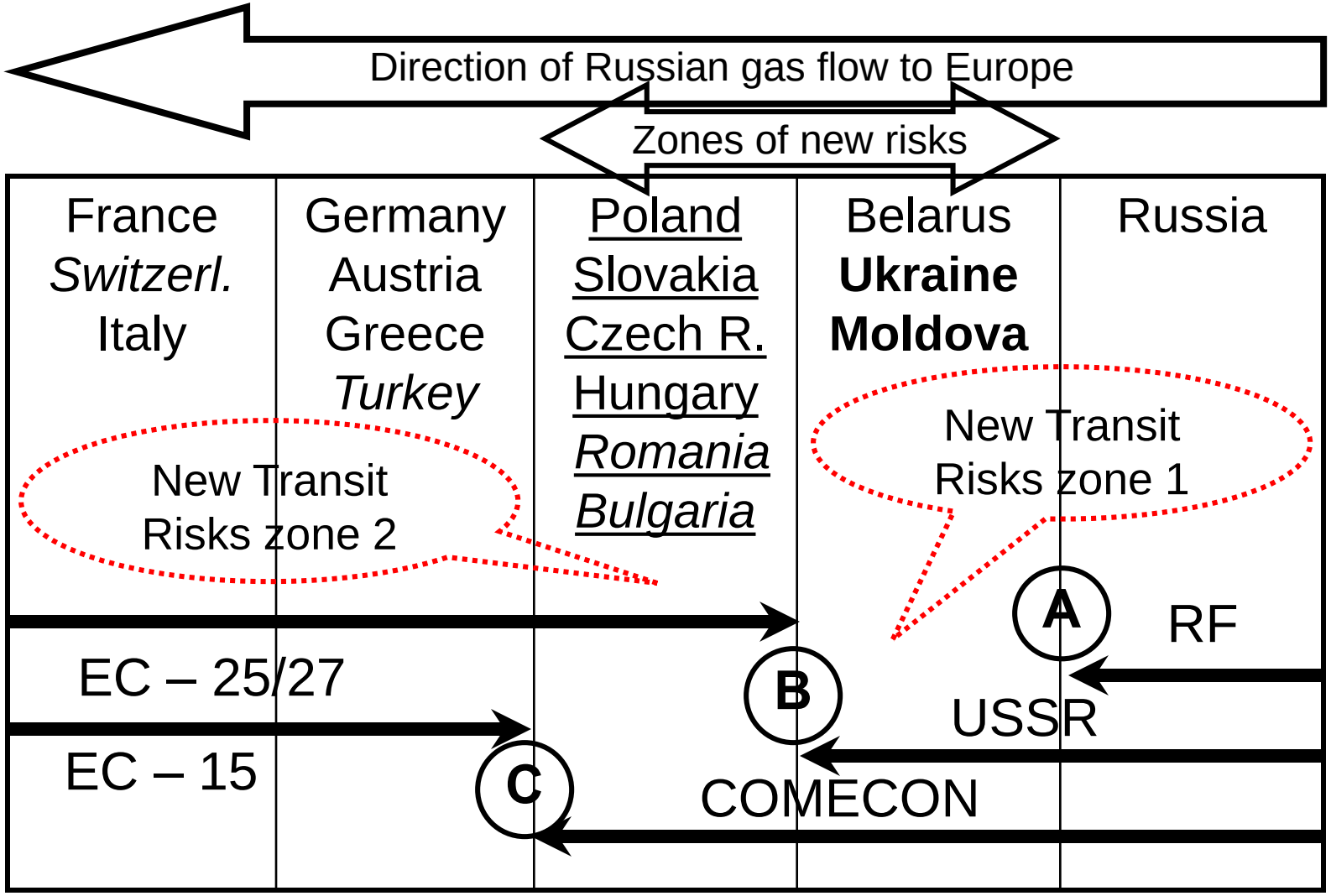
Russia-EU gas value chain: three-step LTC structure since 1968 till nowadays



Russia-EU common interest & mechanisms for minimizing transit risks

- **Prior to dissolution of COMECON/USSR**:
  - Delivery points at COMECON-EU border, de facto no transit within COMECON (de facto single area for gas export), producer/exporter had full operational control on gas value chain from wellhead to delivery point
- **After dissolution of COMECON/USSR**:
  - New sovereign independent states between producer/exporter (Russia) and the EU => producer has lost control on transit part of gas value chain (from its border to delivery points) => transit risks => acts for exporter & importer
  - To minimize transit risks for importer & exporter = to diversify:
    - For importer (transit + supply risks): multiple **routes** + sources of supply + suppliers
    - For exporter (transit + demand risks): multiple **routes** + markets + importers
  - => diversification of routes = common interest for producer/exporter & importer => to exclude transit totally or alternative pipelines (by-passes)

Russian Gas Supplies to Europe: Zones of New Risks for Existing Supplies Within Russia's Area of Responsibility



Italic – non-EU countries; New EU accession states: underlined – since 01.05.2004, *underlined + italic* – since 1.01.2007; **Bold** – FSU states members of ECOMT; A, B, C – points of change of ownership for Russian gas and/or pipeline on its way to Europe

Direction of logical chain in development of transit risks - **bottom-up approach**: *the name of the transit country is the element of last importance in the logical chain*

Change in **political** relations between transit states and its neighbors that can create interruptions of supplies through transit state

Level 3

Technical component (adequate maintenance of transit system to provide technical stability and reliability of transit)

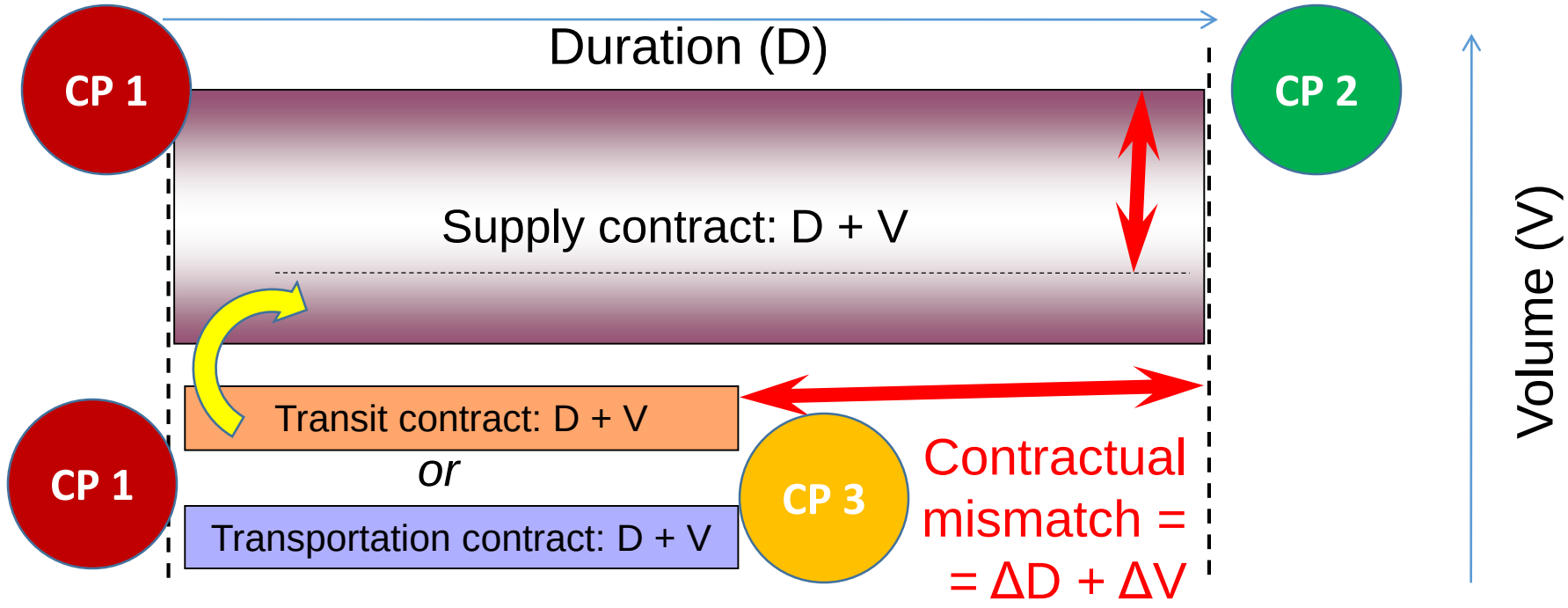
Level 2

Legal (third country sovereign law), **regulatory** (adequacy of legal transit regime to fulfillment of supply obligations between parties to LTGEC from third countries), and **contractual** component to exclude appearance of "contractual mismatch" problem

Level 1

This author's vision of the nature and three major components of transit risk in the cross-border gas value chain

Level 1 issue: Contractual Mismatch Problem

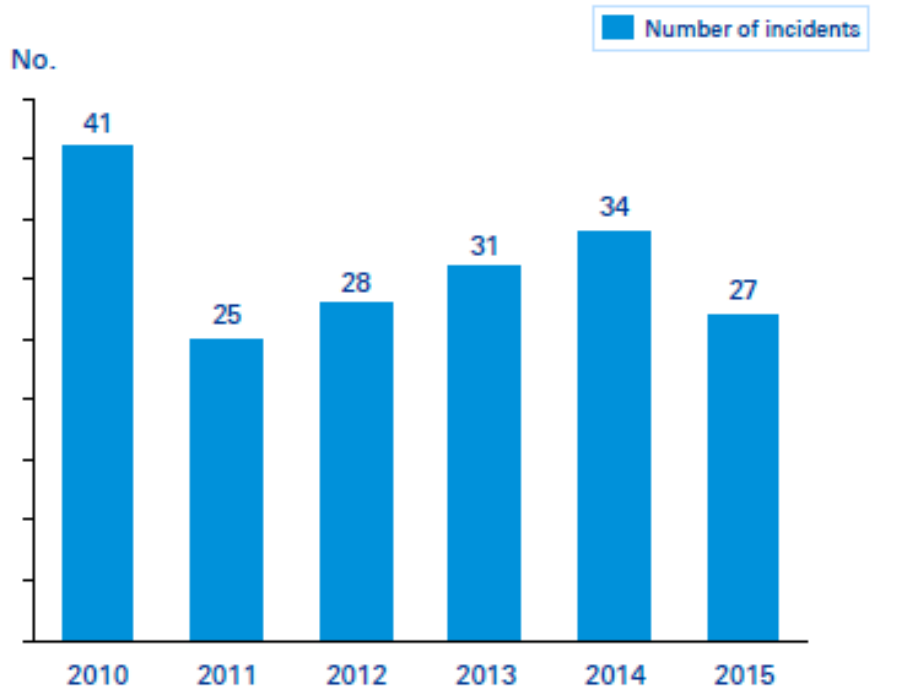


Mismatch between duration/volumes (D/V) of long term supply (delivery) contract & transit/transportation contract as integral part to fulfill delivery contract => risk of non-renewal of transit/transportation contract at **existing** capacity *or* non-creation of adequate **new** capacity => risk of non-delivery for existing/new **supply** contract (incl. arbitration consequences).

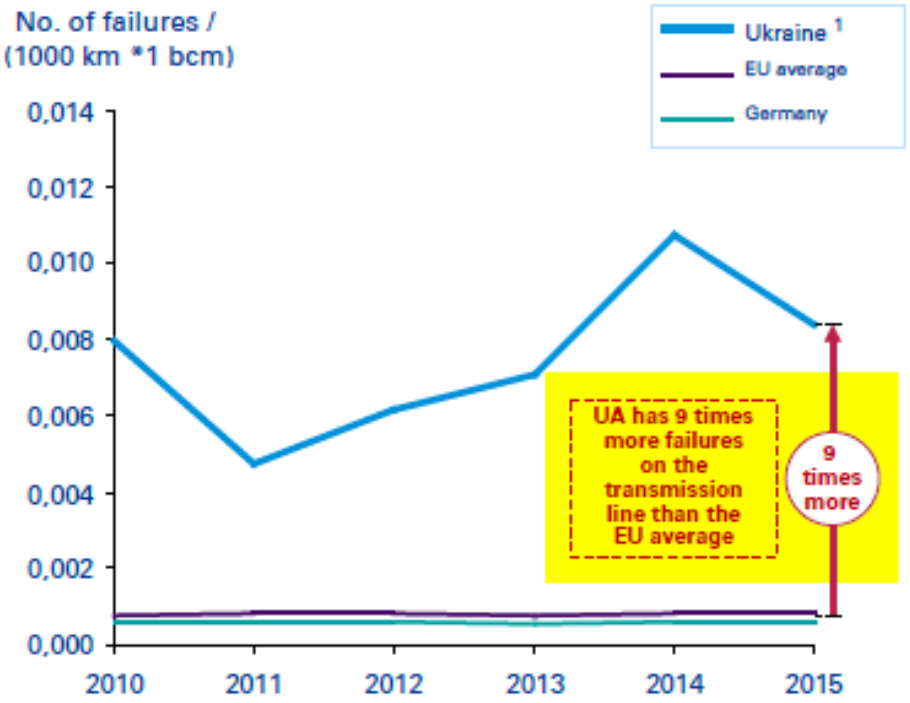
Core issue: to guarantee access to/creation of adequate transportation capacity for volume/duration of long term contracts; **shipper's contracts (booking guarantees) best financial security for debt/project financing**

Level 2 issue: Technical conditions of Ukrainian GTS (acc. to KPMG)

There was a slight improvement in 2011. but since then the number of incidents has been increasing



Compared to the international benchmark, Ukraine has the most failures per 1000 km times natural gas throughput



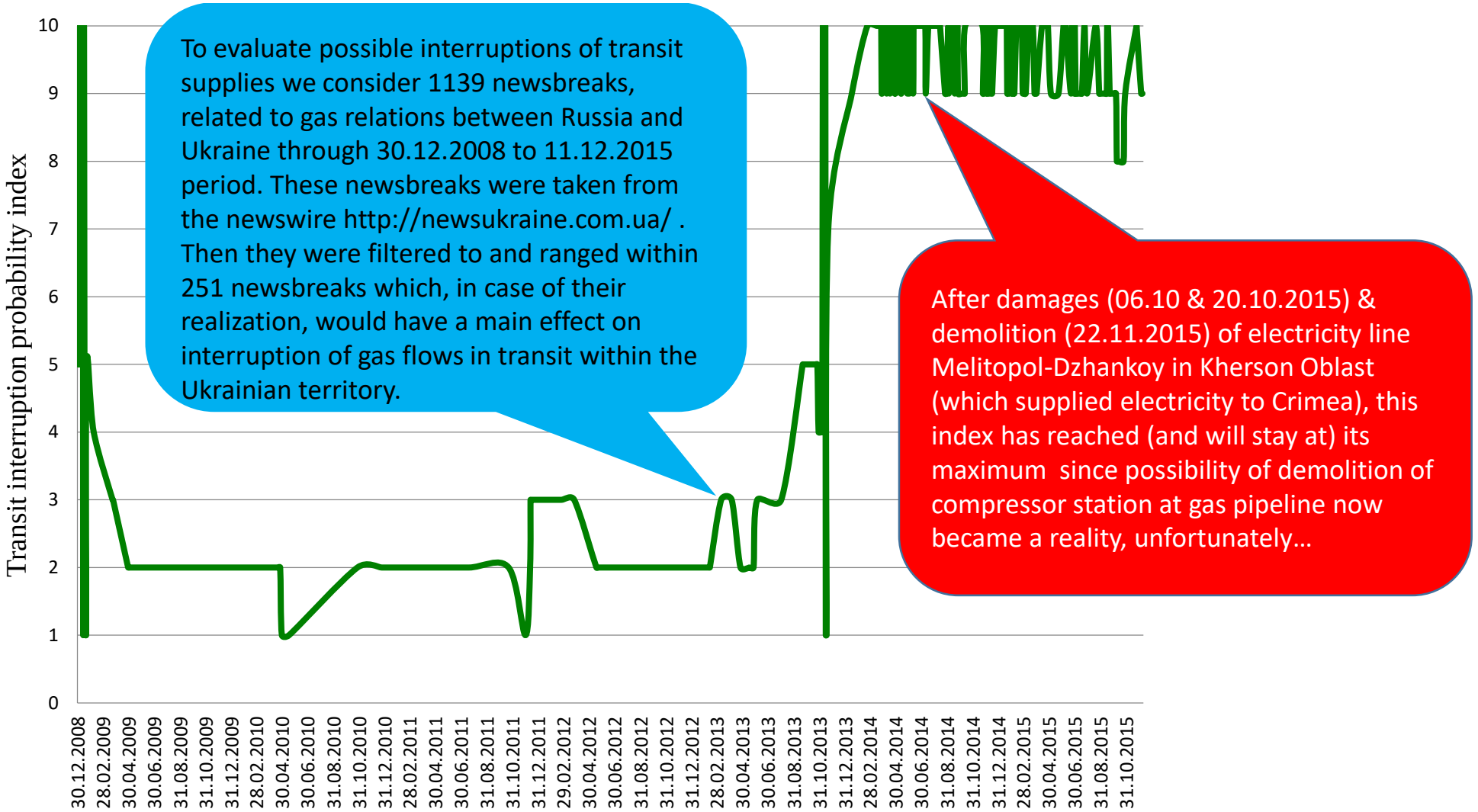
KPMG calculation methodology for failure index (No. of failures/(1000 km *1 bcm)):

(1) Ukraine: Calculated on the basis of number of failures (published by Ukrtransgaz, 2015) and 38.5 th km long transmission system and sum of transit and net imports from Russia were taken into account.
(2) EU average: Number of incidents per 1000 km from EGIG 2015 report and quantity of imports from Eurostat Statistical Dashboard.
(3) Germany: Number of incidents per 1000 km from DVGW 2011-2015 statement and quantity of imports from Eurostat Statistical Dashboard.

Source: Ukrtransgaz Publication on Incidents on the transmission system („У 2015 році кількість відмов на магістральних газогонах України зменшилась на 21%" Published on 2016.06.15), 8th Report of the European Gas Pipeline Incident Data Group on period 1970 – 2013 (2015); Sicherheit von Gasfernleitungen – das Technische Regelwerk im Licht der aktuellen Rechtsprechung (2011; 2013; 2015)

Source: Situation of the Ukrainian natural gas market and transit system. Market Study. // KPMG, 10.04.2017, p.37-38

Level 3 issue: Ukraine: “transit interruption probability” index (2009–2015)



Calculated by M.Larionova, Russian Gubkin State Oil & Gas University, Chair “International Oil & Gas Business”, Master’s programme 2013-2015, on methodology, jointly developed with A.Konoplyanik, based on principles of credit ratings evaluation by major international credit agencies

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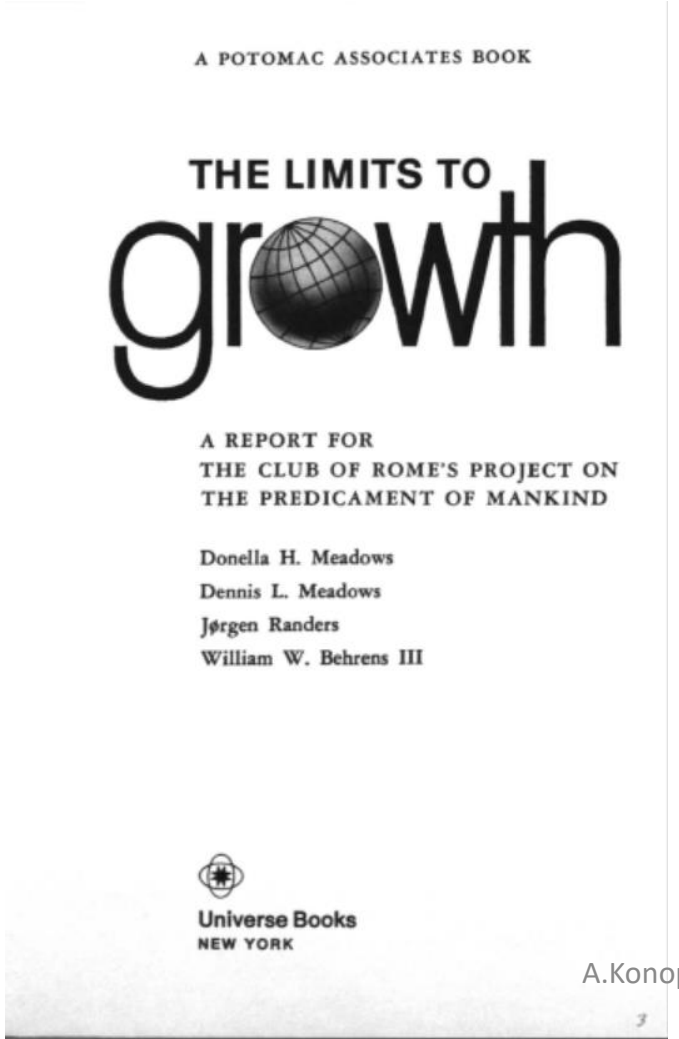
Analogy: "RF-EU informal consultations / GAC WSs" *vs* "Club of Rome" => informal organization = "invisible colleague" (informal means more trustworthy / trusted dialogue)



A POTOMAC ASSOCIATES BOOK

THE LIMITS TO growth

A REPORT FOR
THE CLUB OF ROME'S PROJECT ON
THE PREDICAMENT OF MANKIND

Donella H. Meadows
Dennis L. Meadows
Jørgen Randers
William W. Behrens III

Universe Books
NEW YORK

FOREWORD

IN APRIL 1968, a group of thirty individuals from ten countries—scientists, educators, economists, humanists, industrialists, and national and international civil servants—gathered in the Accademia dei Lincei in Rome. They met at the instigation of Dr. Aurelio Peccei, an Italian industrial manager, economist, and man of vision, to discuss a subject of staggering scope—the present and future predicament of man.

THE CLUB OF ROME

Out of this meeting grew The Club of Rome, an informal organization that has been aptly described as an "invisible college." Its purposes are to foster understanding of the varied but interdependent components—economic, political, natural, and social—that make up the global system in which we all live; to bring that new understanding to the attention of policy-makers and the public worldwide; and in this way to promote new policy initiatives and action.

The Club of Rome remains an informal international association, with a membership that has now grown to approximately seventy persons of twenty-five nationalities. None of its members holds public office, nor does the group seek to express any single ideological, political, or national point of view. All are united, however, by their overriding conviction that the major problems facing mankind are of such complexity and are so interrelated that traditional institutions and policies are

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Gas Advisory Council under Coordinators of Russia-EU Energy Dialogue, 2011 till nowadays (and the current status)

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)

Major Task of the EU-Russia Gas Advisory Council

- **"…aimed to diminish mutual risks and uncertainties to the tolerable level"** ***(Philip Lowe, Director-General, DG ENERGY, 1st/Inaugural GAC meeting, Vienna, 17.10.2011)***

Crisis!!!

Danger

Starting point: Concerns

Resulting point: Proposals

Challenge, Chance

Prepared by Zhao Yuan Jing (园静), Master-student EMM-1702 group, Russian State Gubkin Oil & Gas University

A.Konoplyanik, Columbia University, SIPA, 31.03.2021

WS2: evolution of the agenda/actors, "matryoshka" style (1)

- **Early/Past stages (2010+):**
  - **Traditional gas agenda:**
    - Contractual, pricing & related regulatory issues of Russian pipeline gas in the EU within new architecture of EU gas market post-Third EU Energy Package (2010-2017: TEP + NCs) =>
    - evolving rules for single product (CH4) = commoditization + financialisation of gas market with *single* product
  - **Actors:**
    - EU side: new regulatory rule creators & those who implement these rules (EC, NERs, TSOs)
    - Russian side: suppliers, shippers of pipe gas who are to follow these rules = GP => GPE = Russian state export monopoly (by law) of pipeline gas, i.e. state agent of the sovereign state
  - **Key issue for RF-EU debate:**
    - Natural resource rent cross-border allocation
- **BUT:** objective trend: diversification/expansion of topics => actors

WS2: evolution of the agenda/actors, "matryoshka" style (2)

- **Current stages (since 2018+ - after "Borchardt turn"):**
  - **Traditional gas plus new (decarbonized) gas agenda & related issues:**
    - *Multiple* products: natural gas (CH4) plus decarbonized & related gases (MHM, H2, CO2, bio-methane, syngas, renewable gases, etc.) =>
    - Integration of gas & electricity markets => some reverse trends to 1st, 2nd, 3rd Packages (from unbundling to re-bundling, etc.)?
  - **Actors:**
    - EU side: same plus participants of decarbonized gas value chain, incl. technology producers
      - *preference:* clean (CO2 neutral) H2 as renewable H2 (from RES electricity)
    - Russian side: gas producers/suppliers (pipe gas + LNG) plus participants of decarbonized gas value chain, incl. technology producers
      - *preference:* clean (CO2 neutral) H2 from natural gas
  - **Key issue for RF-EU debate:**
    - Resource rent cross-border allocation *plus* technological rent creation and allocation in economically cost-effective & ecologically-neutral way

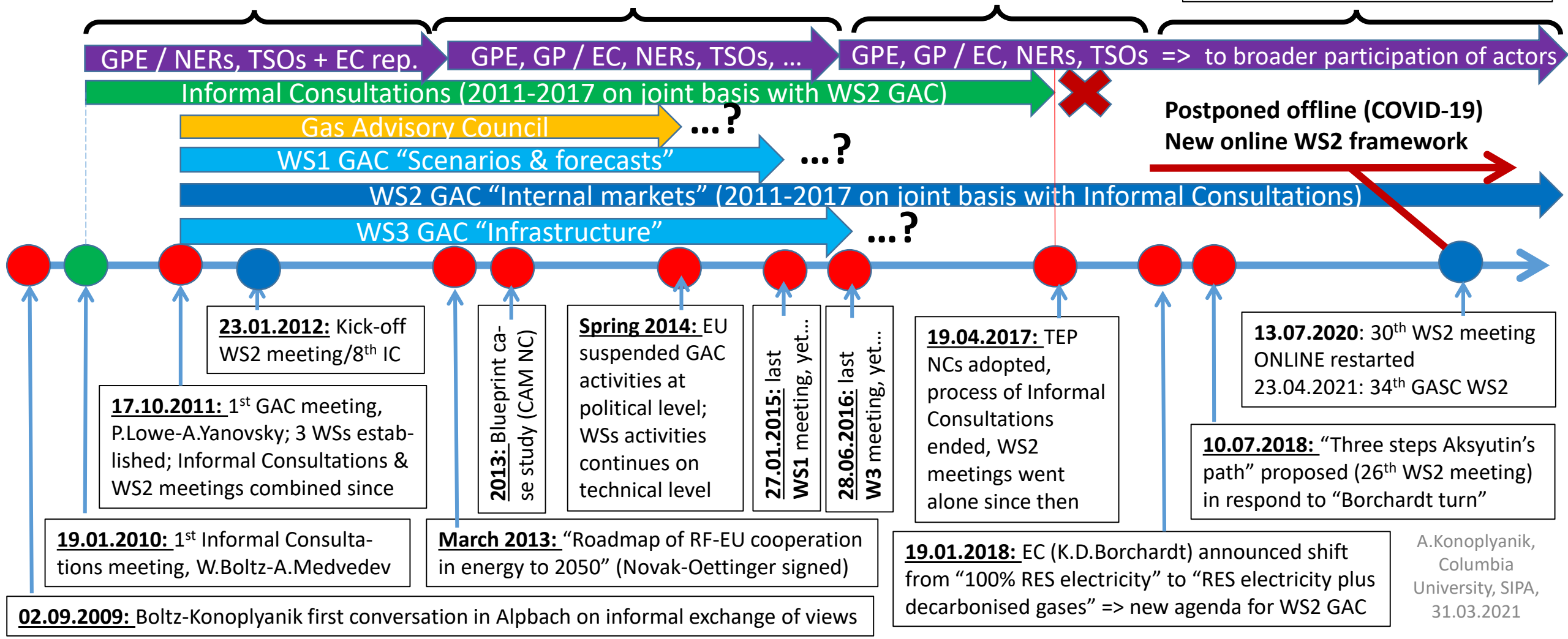
Historical evolution of WS2 GAC process

TEP EU consequences on LTC-based gas **cross-border trade**, incl. GTM, etc. (2010-13)

TEP EU consequences on **cross-border trade & investment** in new & incremental gas infrastructure (NCs: CAM NC INC, TAR NC), etc. (2013-16)

TEP EU overall **regulatory efficiency** (EC Quo Vadis consequences), etc. (2016-18)

EU Decarbonisation vision, incl. of gas value chain, & RF export-oriented **gas decarbonisation**: what are win-win opportunities, incl. in H2, etc. (1Q2018+)



A.Konoplyanik, Columbia University, SIPA, 31.03.2021

Russia-EU Informal Consultations in gas => GAC WS2 meetings: offline (2010-2029) + online (2020 till nowadays)

=>

Workshop – informal consultations, 1st round, E-Control, Vienna, 19.10.2010

29th meeting of Work Stream 2 "Internal Markets", Russia-EU Gas Advisory Council, 21 October 2019, Russian Embassy, Berlin

=> Since mid-2020 (update to COVID) – online: 34th GAC WS2 meeting on 23.04.2021

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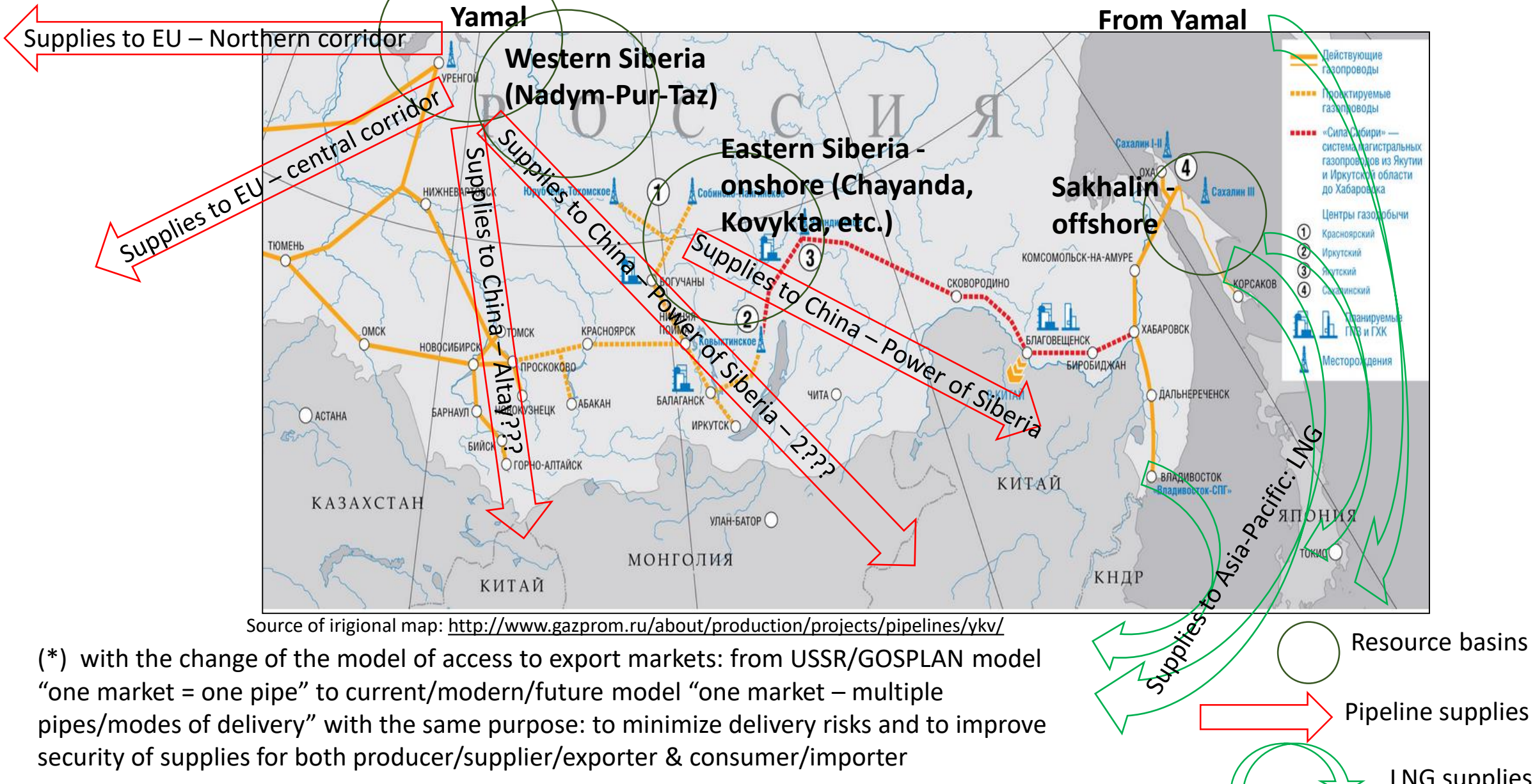
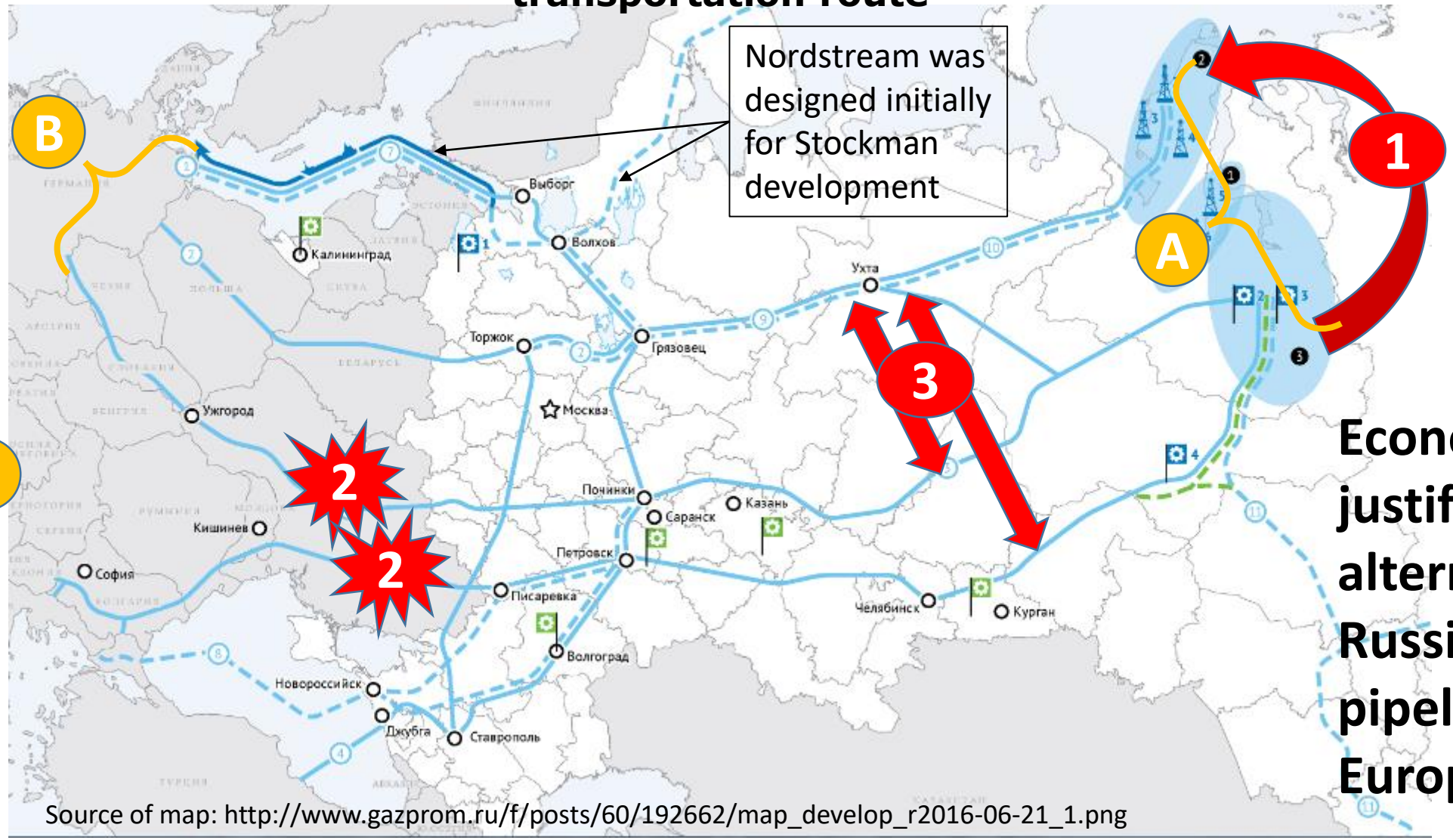
The markets for Russian gas: European(export) and Russian (domestic) = past/present; same plus Asia Pacific (export) + arbitrage operations worldwide = present/future (*)



Source of irigional map: http://www.gazprom.ru/about/production/projects/pipelines/ykv/

(*) with the change of the model of access to export markets: from USSR/GOSPLAN model "one market = one pipe" to current/modern/future model "one market – multiple pipes/modes of delivery" with the same purpose: to minimize delivery risks and to improve security of supplies for both producer/supplier/exporter & consumer/importer

Russia's existing/new supplies to Europe (to the unbundled EU gas market): (1) resource base moves from Nadym-Pur-Taz to Yamal, (2) Ukrainian transit risks & costs increases, => (3) modernization existing (since end-60's) infrastructure *vs* construction new transportation route



A = 2 X B

Source of map: http://www.gazprom.ru/f/posts/60/192662/map_develop_r2016-06-21_1.png

Economic justification of alternative Russian gas pipelines to Europe

Comparison of length & some other parameters for different gas routes from Yamal to Germany/EU

	Yamal-Greifswald	NPTR-UA-Waidhaus
Pressure, bars	120/90	75/55
Distance between CS, km	240	120
Inner coating	Yes	No
Efficiency GCU	Twice high	18-25%
Gas-compressor units capacity, MWt	32, 25	12, 16 (new/UA)

Compiled from public sources, incl.: С.Правосудов. Почему Газпром не доверяет украинской трубопроводной системе. // «НГ-Энергия», 16.01.2018

	Yamal – Germany routes	km
1	**Yamal – Greifswald:**	**4166**
	Yamal – Ust-Luga (within RF)	2977
	Ust-Luga – Greifswald	1189
2	**Yamal – NPTR – UA - Waidhaus:**	**6051**
	Yamal – Sudja (within RF)	3987
	Sudja – Waidhaus	2064

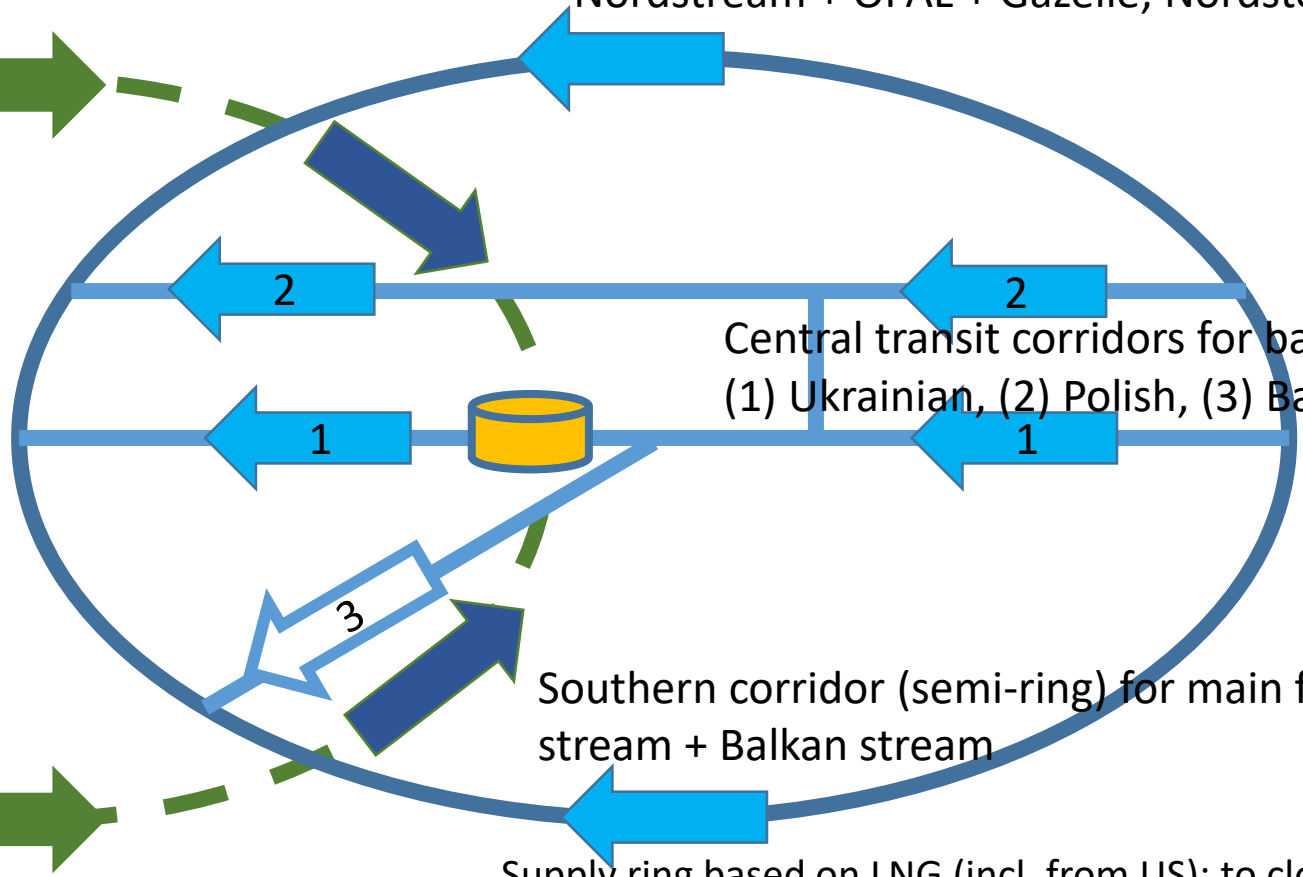
Source: PJSC "Gazprom"

Length of the route via Nord Stream is 1885 km shorter than through UA GTS, incl. that within Russian territory the distance is shorter by 1010 km. Route via Ukraine is 45% longer than via Nord Stream.

Two rings for future European gas supplies in formation: "disruptive" ring of global LNG supplies & "integral" with internal backup ring of Russian pipeline gas supplies within radial-circle gas infrastructure system

-> Europe for Russian pipeline gas supplies = target market

-> Europe for LNG supplies (incl. US LNG) = closing (bridge) market within arbitrage deals (but target market for US LNG in Eastern Europe => "to kill the competitor")



Source: A.Konoplyanik

Pipeline gas

LNG

Ukraine UGS

Regaz LNG

Supply ring based on LNG (incl. from US): to close loop in the East – to displace Russian gas from Eastern Europe

Supply ring based on Russian pipeline gas: to close loop in the West – to increase security of supplies

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Global macroeconomic competition & changing role of key players

- Three historic world economic centers (US/NA, WE/EU, Asia-Pacific/SEA)
- But: Growing role of emerging economies (BRICS et al) as additional world economic centers => tightening global economic competition both between “old” and “new”, & within “old” economic centers => threat for US dominance
  - Two ways (policies) to protect one’s competitive niche (to become more competitive yourself, to make another one less competitive)
  - USA (under “America First” & “US Global Energy Dominance” doctrines) is to improve its global competitive niche for the account of the “partners” => of the EU (!)
- EU as a “weakest player” among “old” economic centers:
  - Non-homogenous EU post-2014: expectations (pre-2014) & realities (post-2014) for new EU MSs - a deathblow to hopes on equality & same economic prosperity
  - Two EUs – “old” and “new” EU MSs: “old” EU MSs are EU-oriented, “new” EU MSs are US-oriented;
    - demand for “external threat” for “new” EU MSs in respond to their non-equal (secondary) role in the EU => thus closer ties with US over the head of Brussels
  - On top of this: refugees, BREXIT, US & EU anti-Russia (means: anti-EU) sanctions, etc., which weakens EU global competitiveness
- Increasing energy costs for EU (proposed US LNG instead of Russian pipeline gas) will further decrease EU global competitiveness & welfare (*Nothing personal. America First. Only business*.) => Russian gas to improve EU global competitive positions

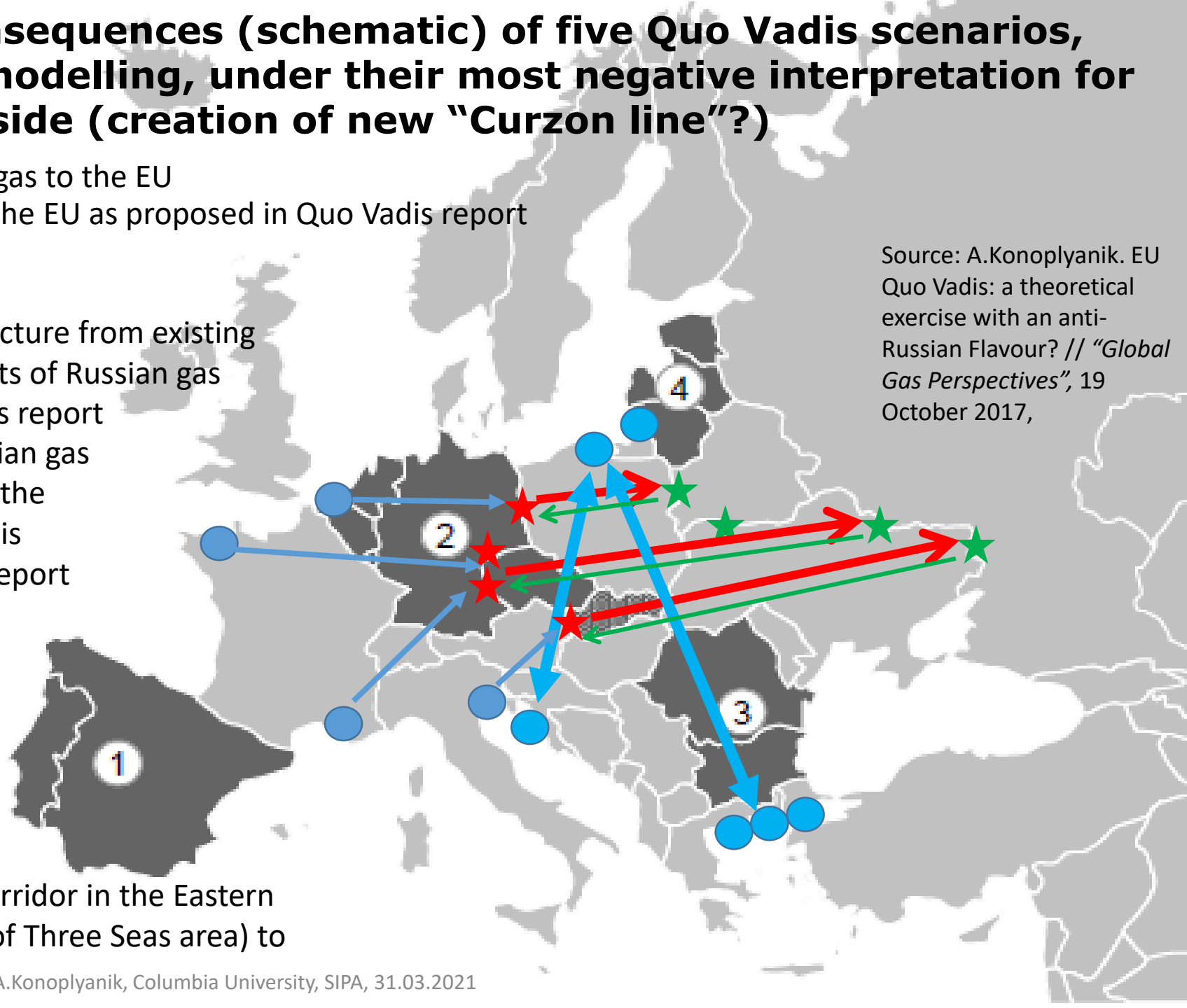
Динамика цен на газ и себестоимости* поставок СПГ из США в Европу

(*) Based on forward curves Henry Hub;
P = HH + 15% + X,
X – costs of liquefaction, shipping, regasification

Source: Gazprom export

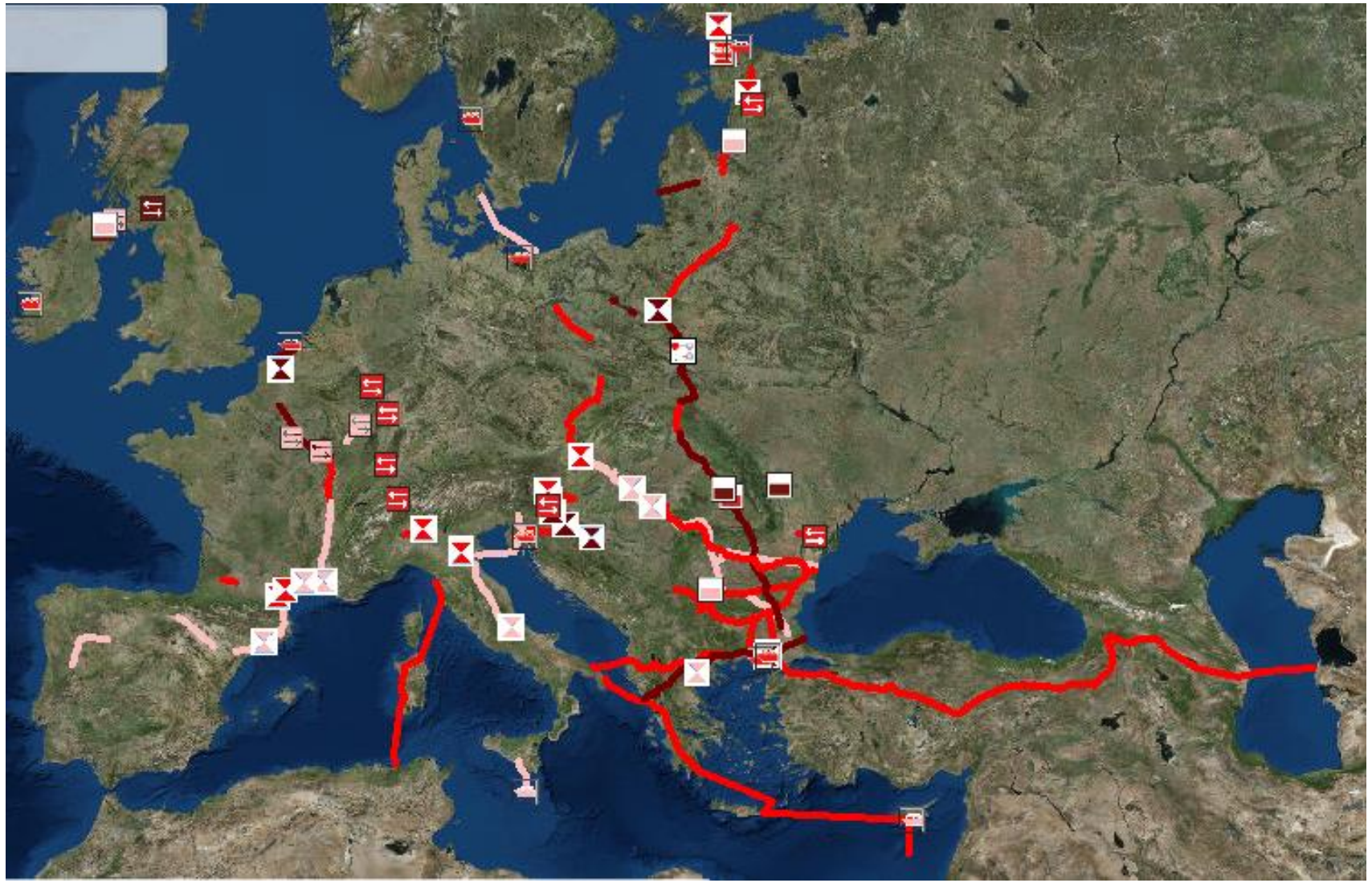
Possible application consequences (schematic) of five Quo Vadis scenarios, selected for quantitative modelling, under their most negative interpretation for Russian side (creation of new "Curzon line"?)

- Existing key delivery points of Russian gas to the EU
- New delivery points of Russian gas to the EU as proposed in Quo Vadis report
- Existing LNG terminals
- New LNG terminals
- Development of new pipeline infrastructure from existing LNG terminals to existing delivery points of Russian gas within the EU as proposed in Quo Vadis report
- Shift of existing delivery points of Russian gas inside the EU to their new locations at the external border of the zone of EU acquis application as proposed in Quo Vadis report
- Transfer of existing transit business of Russian gas to existing delivery point within the EU to the mid-stream companies of the EU as proposed in Quo Vadis report
- (1) New merged regional gas market zones as proposed in Quo Vadis report
- New North-South EU gas pipeline corridor in the Eastern part of the EU (Intermarium / zone of Three Seas area) to connect new LNG regaz terminals



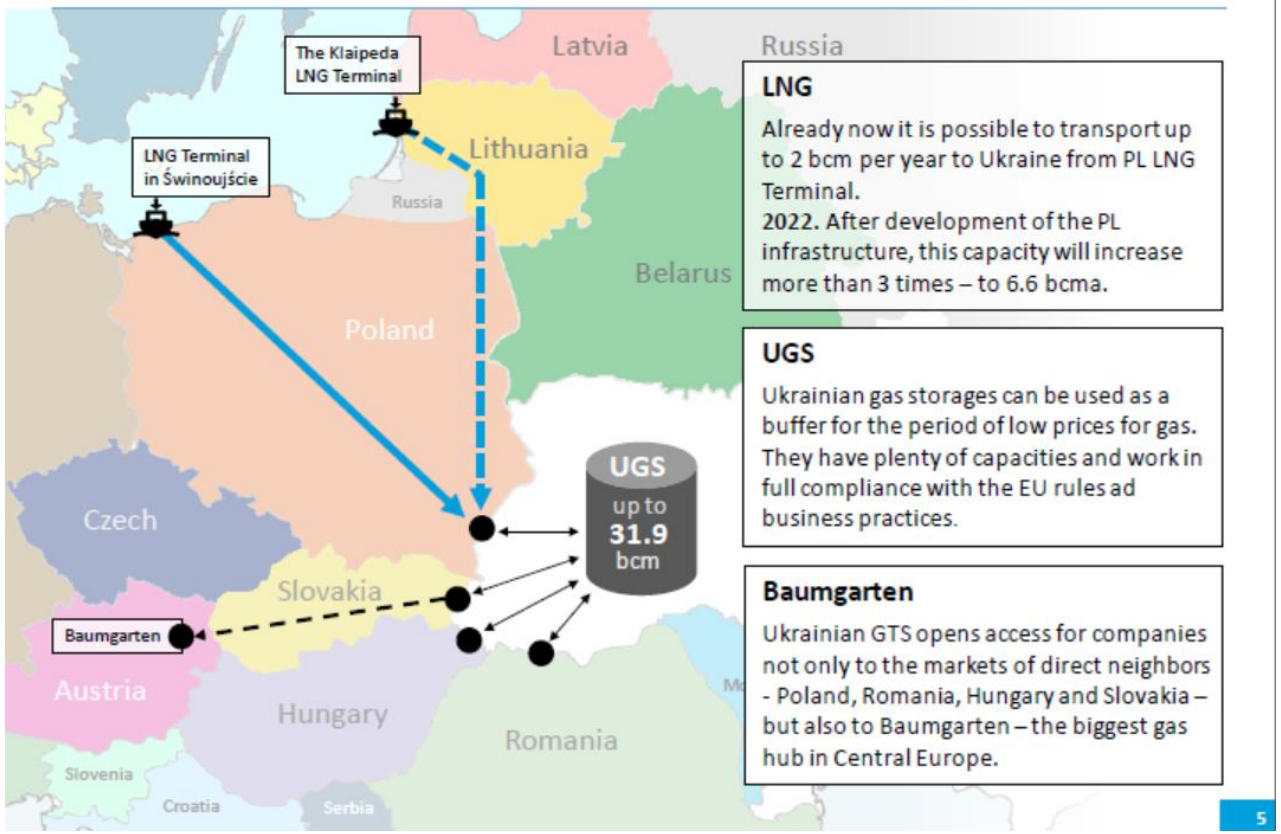
Source: A.Konoplyanik. EU Quo Vadis: a theoretical exercise with an anti-Russian Flavour? // *"Global Gas Perspectives"*, 19 October 2017,

New (incremental) gas infrastructure in the East of the EU (projects of common interest/PCI): technical & economic logic and EU regulatory requirements (3+ sources of supplies for individual EU member-state) is added by political interests



Источник:
http://ec.europa.eu/energy/infrastructure/transparency_platform/map-viewer/main.html

LNG and Ukraine – "Northern direction"



LNG

Already now it is possible to transport up to 2 bcm per year to Ukraine from PL LNG Terminal.
2022. After development of the PL infrastructure, this capacity will increase more than 3 times – to 6.6 bcma.

UGS

Ukrainian gas storages can be used as a buffer for the period of low prices for gas. They have plenty of capacities and work in full compliance with the EU rules ad business practices.

Baumgarten

Ukrainian GTS opens access for companies not only to the markets of direct neighbors - Poland, Romania, Hungary and Slovakia – but also to Baumgarten – the biggest gas hub in Central Europe.

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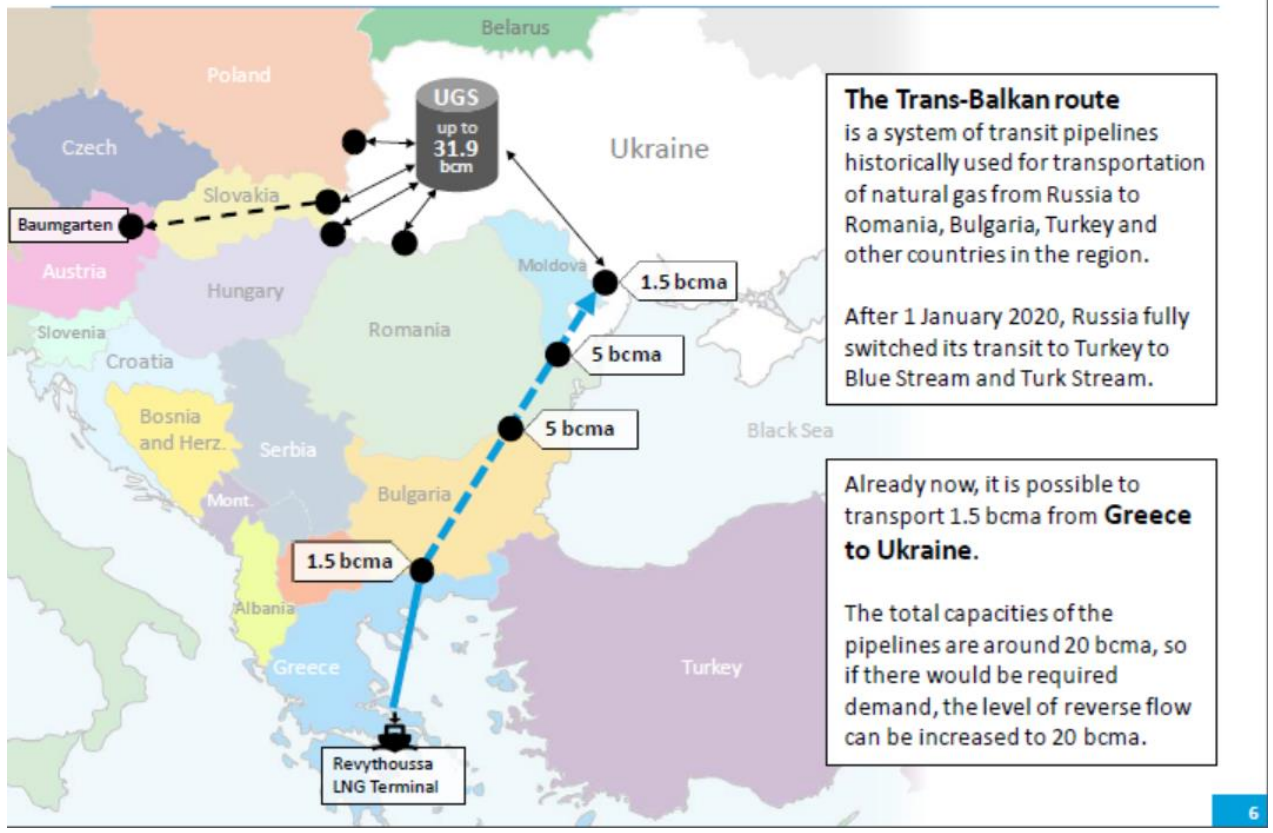
LNG and Ukraine – "Southern direction"



The Trans-Balkan route
is a system of transit pipelines historically used for transportation of natural gas from Russia to Romania, Bulgaria, Turkey and other countries in the region.

After 1 January 2020, Russia fully switched its transit to Turkey to Blue Stream and Turk Stream.

Already now, it is possible to transport 1.5 bcma from **Greece to Ukraine.**

The total capacities of the pipelines are around 20 bcma, so if there would be required demand, the level of reverse flow can be increased to 20 bcma.

6

Source: Sergii MAKOGON (CEO of Gas TSO of Ukraine, LLC). GTSOU presentation. Overview. // Presentation at webinar "Ukrainian Gas Storage Opens for Business", LNG-Worldwide Ltd, DMG-events/World LNG & Gas Series, 10 June 2020

Fight against NS2: multilayer task for US & EU

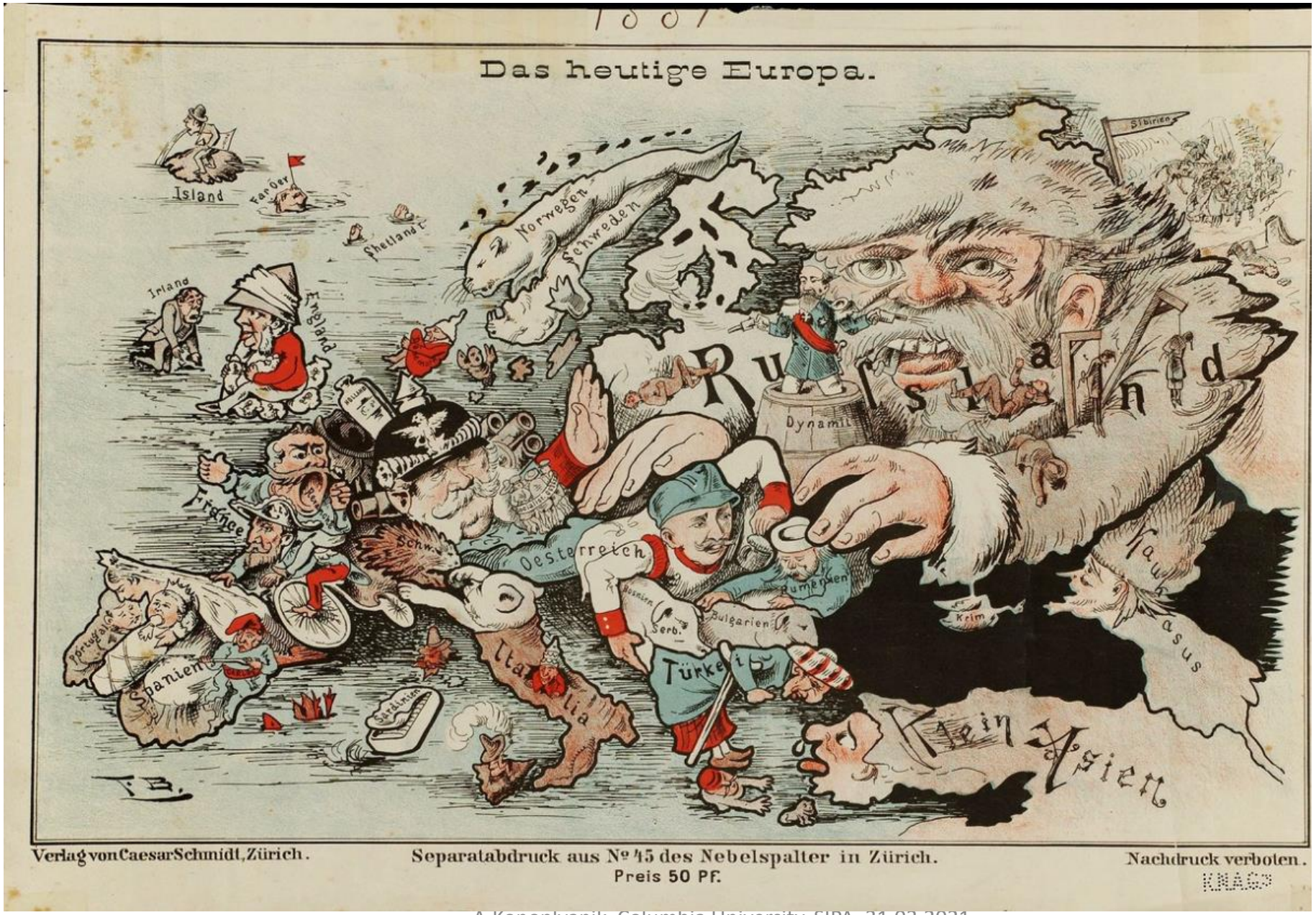
- To force Russia continue gas transit to EU via UA post-2019 & to pay transit fees (instead of supporting UA from EU/US public finance)
- Special Third Gas Directive amendments for NS2: to slow down (if not to prevent) construction/start-up + export EU acquis (MTPA/ competition between Russian companies)
  - Export EU acquis upstream cross-border gas value chains = regular long-standing EU task in favour of EU business
- Additional (hidden?) aim (?): to provoke further conflict between Gazprom & Rosneft (on Russian gas market "liberalization" issue):
  - Gazprom: state agent (sole pipeline exporter by law) on monetizing Russian pipeline gas (maximize marketable rent) => to escape Rusgas-to-Rusgas competition
  - Rosneft: would like to monetize its large gas resources (preferably internationally), agent agreements on gas marketing at external markets: with GPE vs with BP
  - Political consequences: open conflict between two Russian state companies = a blow on prestige of "Putin's regime"?
- Series of US sanctions against NS2: "to kill the competitor" (to US LNG in EU)
  - Sanctions being earlier as o nerve-point instrument of UN international community against individual states in individual cases, now became a standard instrument of US competition policy in international sphere, incl. energy

Dividing line from Baltic to Black sea (Project "Intermarium") – major aim of USA in Europe (acc. to G.Friedman, "Stratfor")

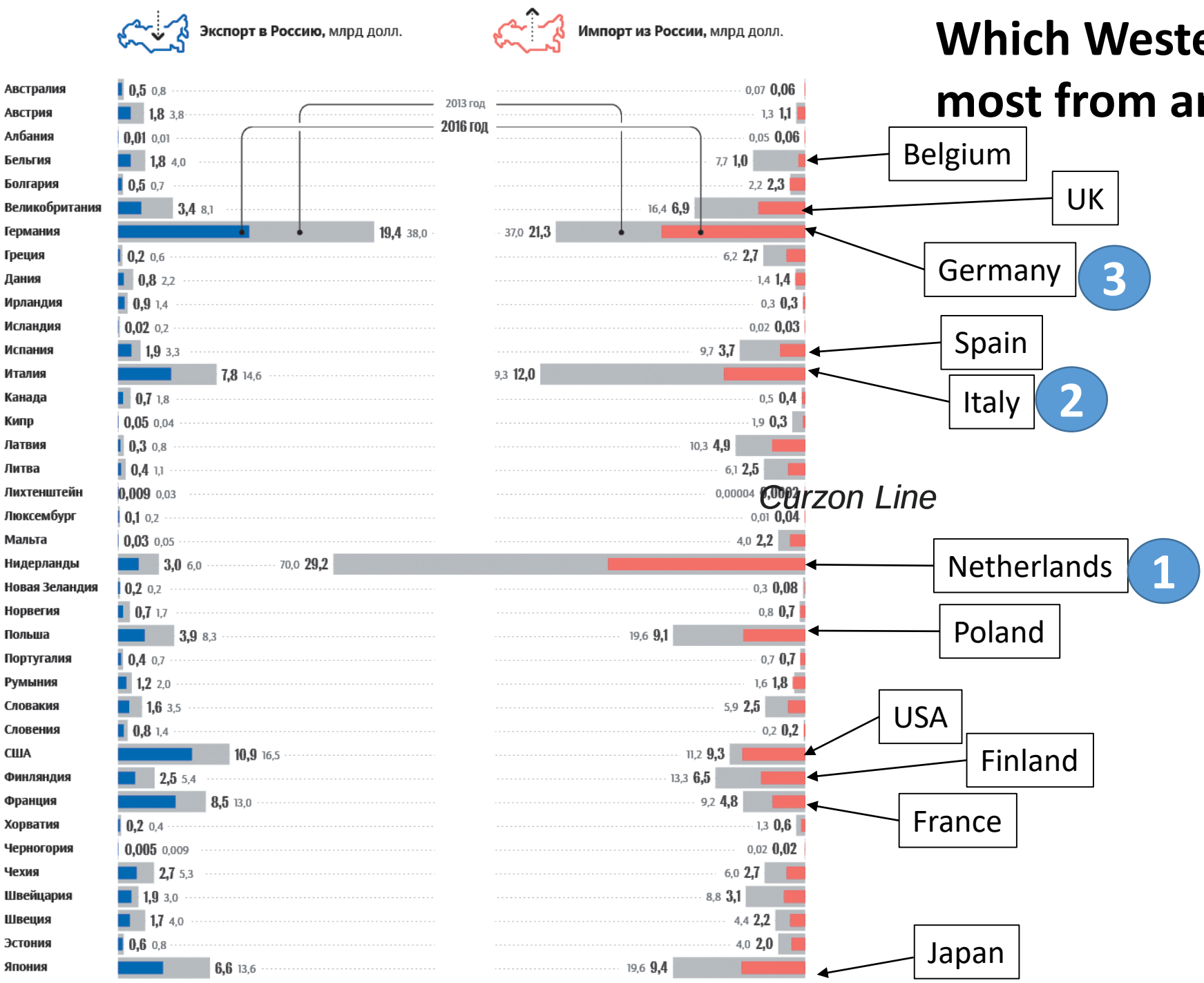
"…final aim of the US consists in creation of "*Intermarium*" – territory between Baltic and Black Seas, which concept was developed as far back as by Pilsudski. First aim for US is not to allow that German capital and German technologies were united with Russian natural resources and labour resources in the invincible combination. … Trump card of US which defeat such combination - dividing line between Baltic states and Black Sea."

Source: Presentation of George Friedman, Founder and President of private intelligence agency "Stratfor" at the conference of "The Chicago Council on Global Affairs", 4 февраля 2015 г., https://www.thechicagocouncil.org/event/europe-destined-conflict; https://www.youtube.com/watch?v=iOY1dDqa7F0; https://www.youtube.com/watch?v=xewzbMYmC_I

Demonizing Russia is nothing new… Déjà vu…



Which Western countries suffered most from anti-Russian sanctions



Belgium

UK

Germany 3

Spain

Italy 2

Curzon Line

Netherlands 1

Poland

USA

Finland

France

Japan

Source: https://ria.ru/infografika/20171123/1509243542.html?inj=1

A.Konoplyanik, Columbia University, SIPA, 31.03.2021

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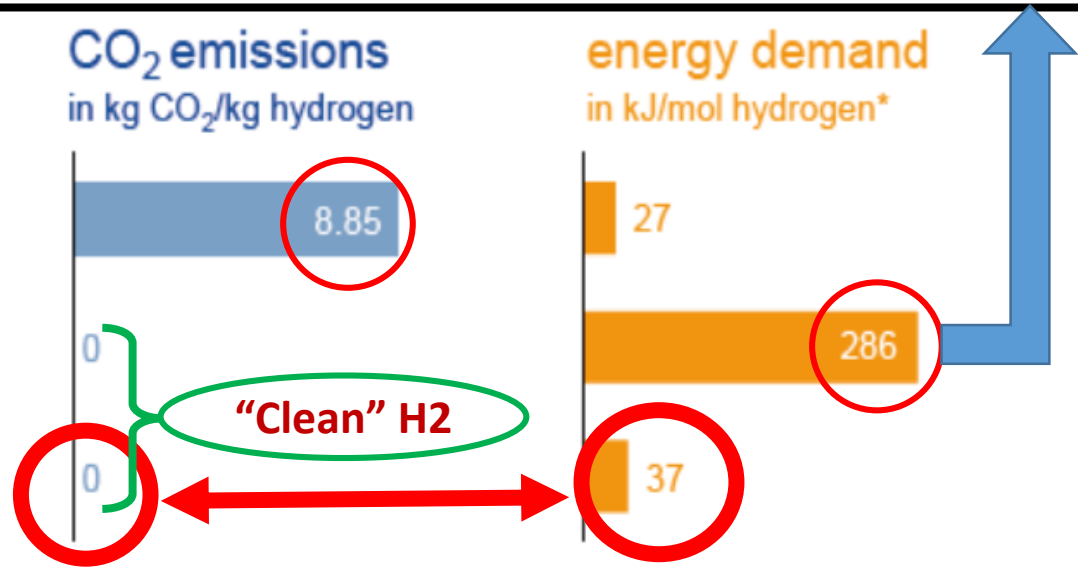
All other conditions being equal, methane pyrolysis (& similar technologies) have clear competitive advantages against two other key technologies in hydrogen production (MSR+CCS & electrolysis) under technologically neutral regulation

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	$CH_4 \rightarrow 2H_2 + C$

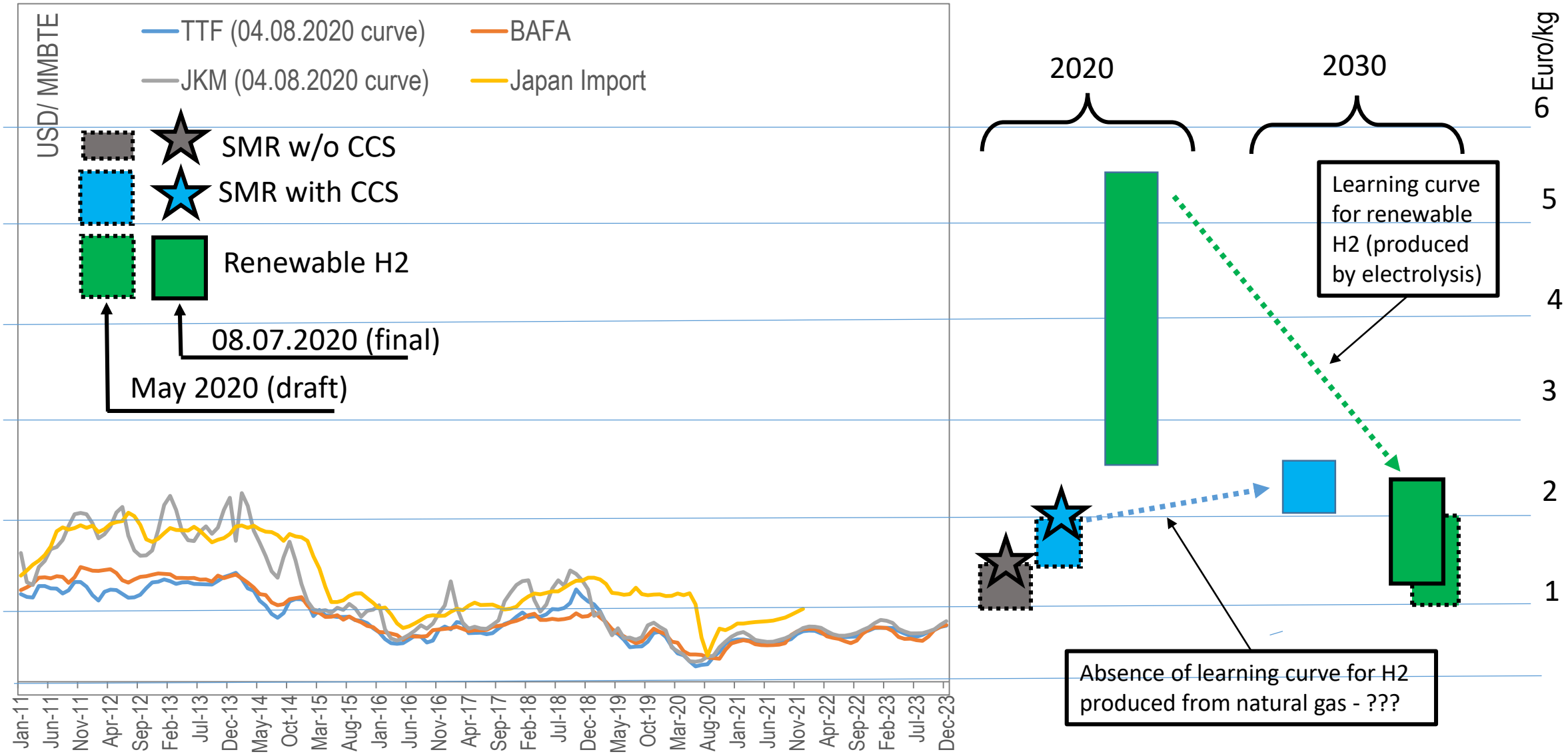


Source: A.Konoplyanik based on: Dr. Andreas Bode (Program leader Carbon Management R&D). New process for clean hydrogen. // BASF Research Press Conference on January 10, 2019 / (https://www.basf.com/global/en/media/events/2019/basf-research-press-conference.html)

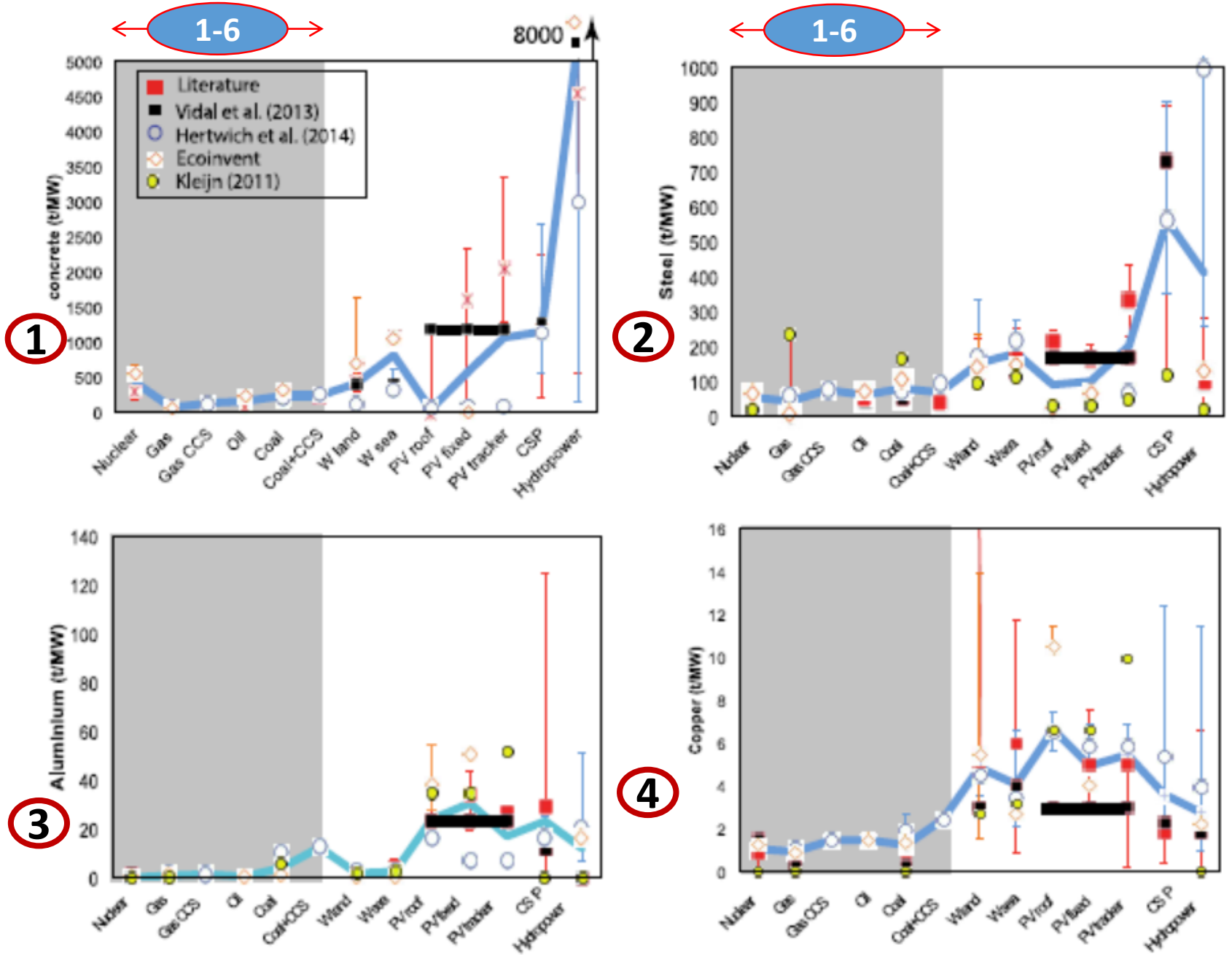
(1) No need in CC(U)S => CAPEX/OPES saving
(2) Marketing of carbon black = additional element of revenue budget => start of new investment cycle(s) based on carbon black
(3) In case of storage, carbon black does not provide same negative effects as CO2 => IMPROVES financeability

(*) 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)

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



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)



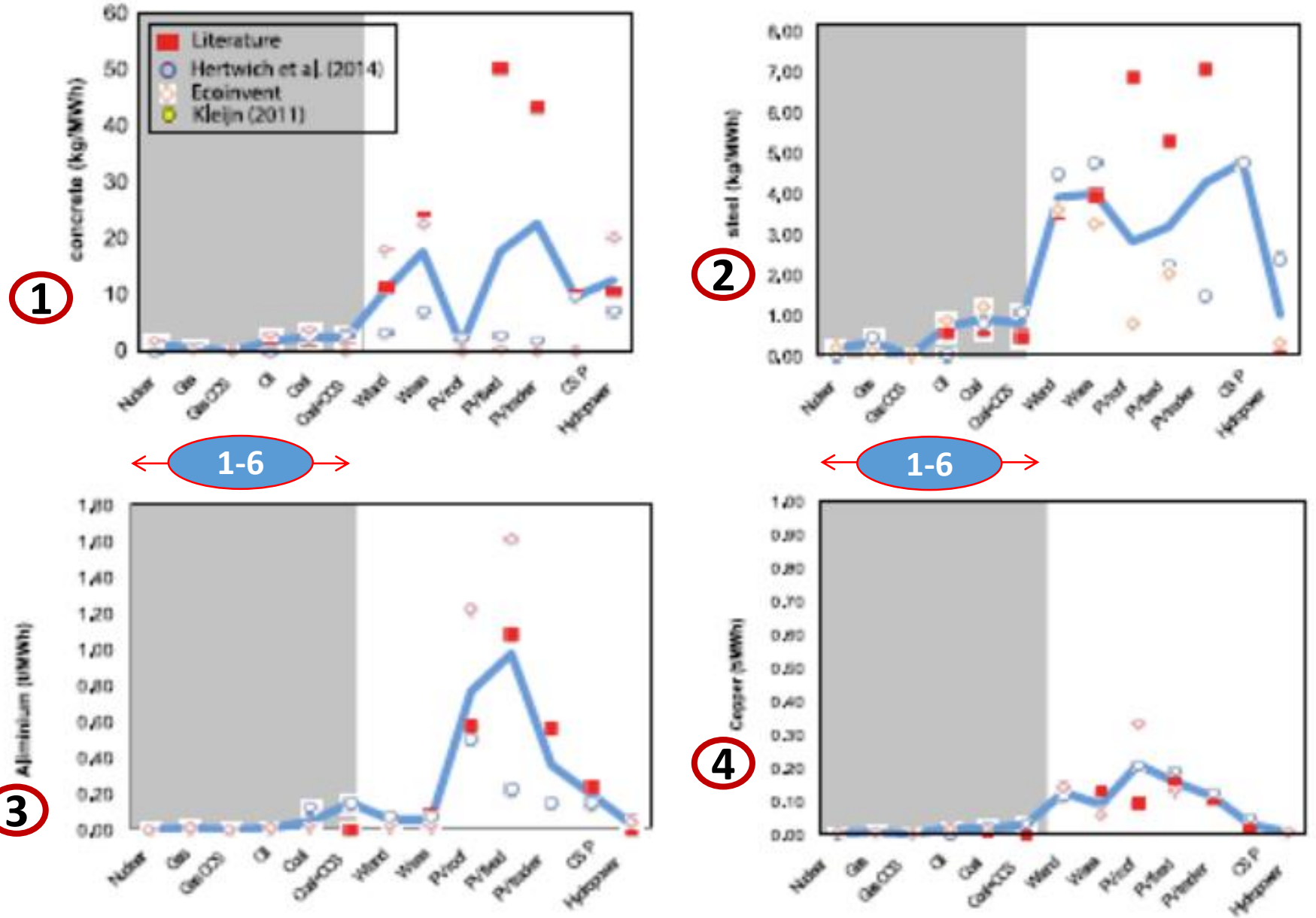
Quantities (t/MW) of four structural materials used to manufacture different power generation infrastructure (material intensity) :

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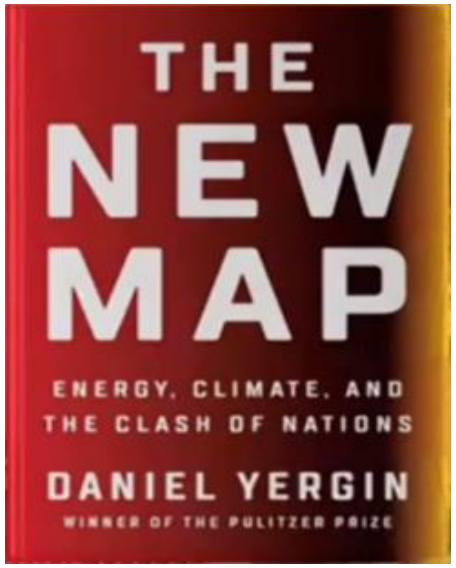
What is clean energy? Depends on how you calculate/consider it…

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)

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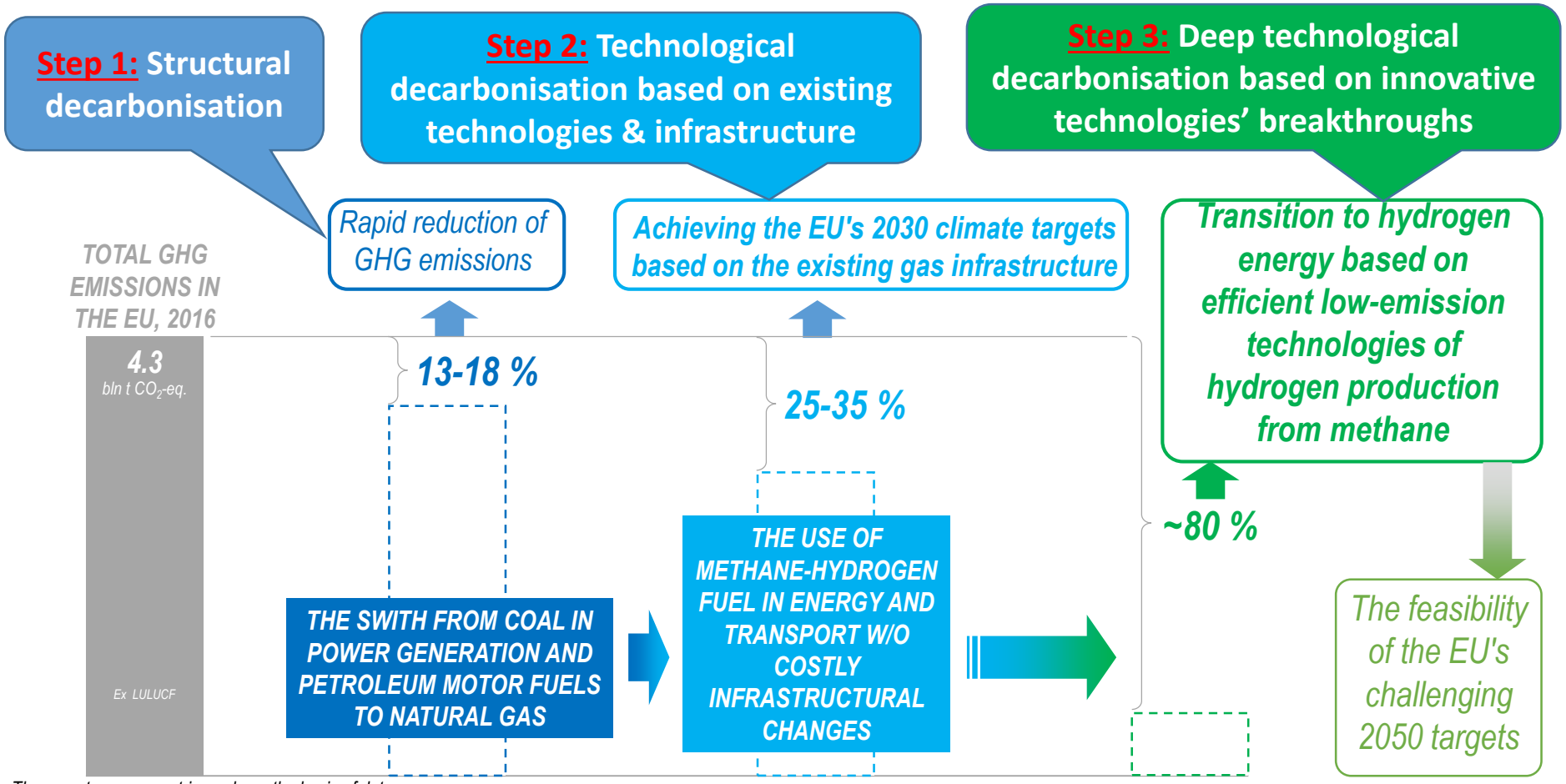
How to decarbonize: Gazprom's three-steps cooperative vision ("Aksyutin's pathway")



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 (https://minenergo.gov.ru/node/14646; 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 cooperate & implement three-steps "Aksyutin's pathway"?

Cumulative effect of step' 1 measures

Cumulative effect of step's 1+2 measures

Cumulative effect of step's 1+2+3 measures

Step 1 cooperative measures

Step 2 cooperative measures

Step 3 cooperative measures

Substitution:
(1) Coal by gas in heat & electricity production,
(2) Petroleum products by gas in transport by:
- Compressed gas,
- LNG

Methane-hydrogen mix (MHM) as fuel gas for compressor stations (CS) at the pipelines, both in Russia & the EU, based on H2 (MHM) production at CS on-site with technologies with reduced (i.e. adiabatic conversion of methane) or without (pyrolysis et al) CO2 emission

H2 production without CO2 emission (pyrolysis, plasma-chemical methods et al based on Russian, EU &/or on jointly developed & commercialized technologies under Russia-EU cooperation) as its has clear cost-competitive advantage compared to PTG/electrolysis (2.5-10 times less energy intensive & thus 3-4 times less costly) and/or SMR/ATR with obligatory CCS (CCS as incremental immanent cost component up to 20-40+%); marketing of black carbon (not a pollutant contrary to CO2) as additional area of Russia-EU prospective cooperation

Small-scale LNG for Black Sea & Danube region

Potential incremental export of Russian gas for clean H2 production downstream EU & of clean H2 production technologies (either of Russian origin and/or jointly developed by Russia & the EU)

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

Inescapable long-distant H2 or MHM transportation

Proved (Litvinenko et al): long-distant H2-MHM transportation in gaseous -liquid form multiply lose to pipe gas/LNG om security, safety, economy…

Proposal for Russia from EU &/or EU MS (Germany) &/or from supporters of this proposal in Russia: "green" & "blue" H2 production in Russia & its export to EU

North Africa, Ukraine

40GW

Russia

EU: long-term (future = 100%)

EU: short/medium term (temporary)

RF: Rosatom

«Green»

«Turquoise»

«Blue»

«Yellow»

«Grey»

Long-term (future = 100%)

Short/medium term (temporary)

H2 import to the EU

NO (certificates of origin)

RF

EU

Conflict of two concepts

Gas supplies from RF to EU

EU terminology

EU vision

H2 consumption in the EU

Electricity

RES

Grid

40GW

«Green»

«Turquoise»

«Blue»

«Yellow»

«Grey»

EU: long-term (future = 100%)

EU: short/medium term (temporary)

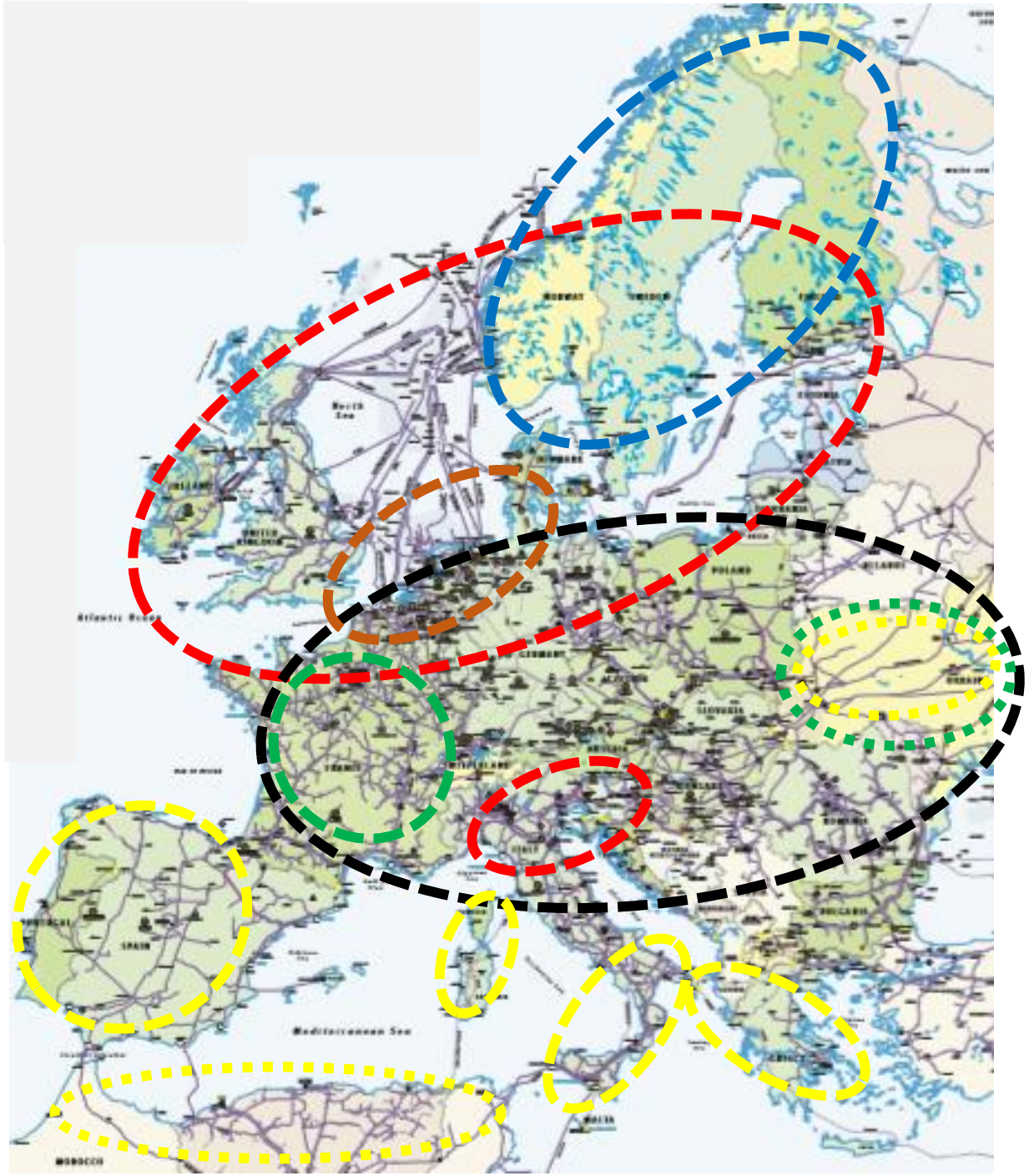
RF-EU: long-term (competitive niche)

H2 production in the EU

No

Alternative proposal: "clean" H2 production from Russian CH4 in EU (w/o CO2 emissions at H2 production stage); energy for H2 production supplied from gas turbines (CCGT) fueled by MHM produced at the compressor stations at RF-EU GTS close to/inside "H2 EU valleys" («turquoise»/pyrolysis et al)

Source: A.Konoplyanik



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

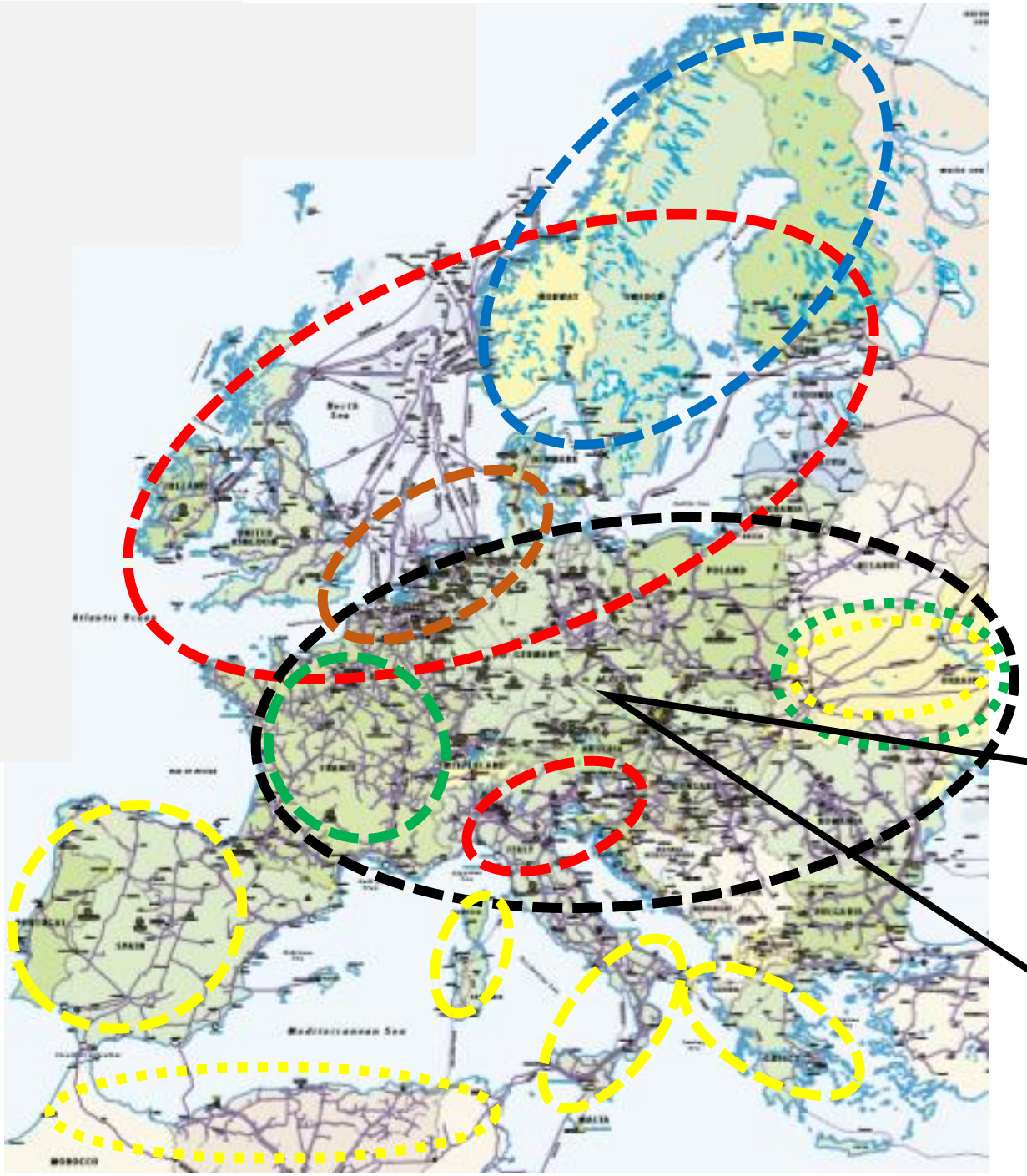
Electrolysis based on different primary electricity sources

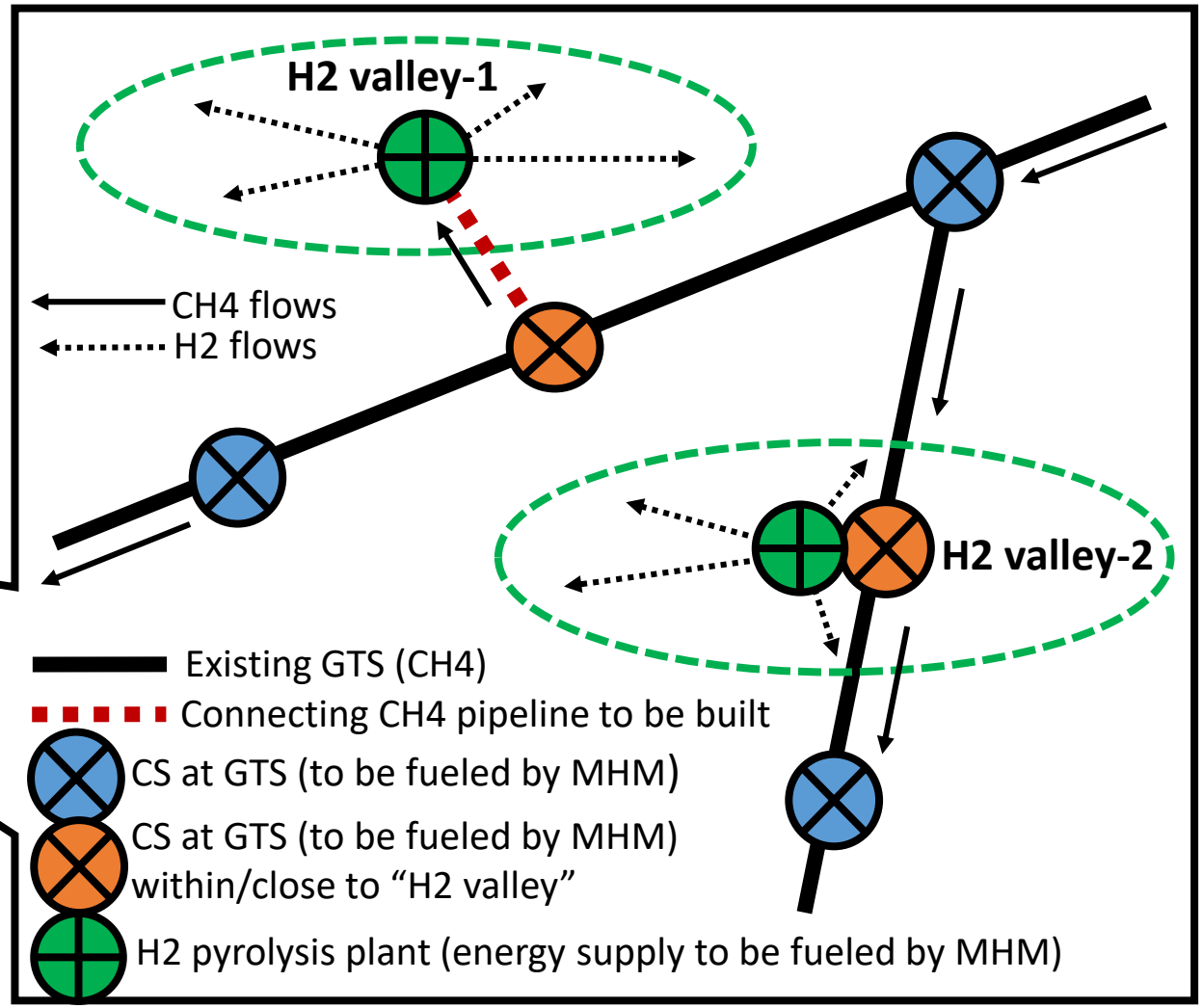
MSR/ATR plus CC(U)S

Methane pyrolysis, plasma-chemical method et al w/o CO2 emissions *(to incorporate both Step 2 & Step 3 Cooperative measures from "Three Step Aksyutin's Path")*

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; source of map – ENTSOG

Complementarity of different H2 production technologies within the EU (Konoplyanik's vision)

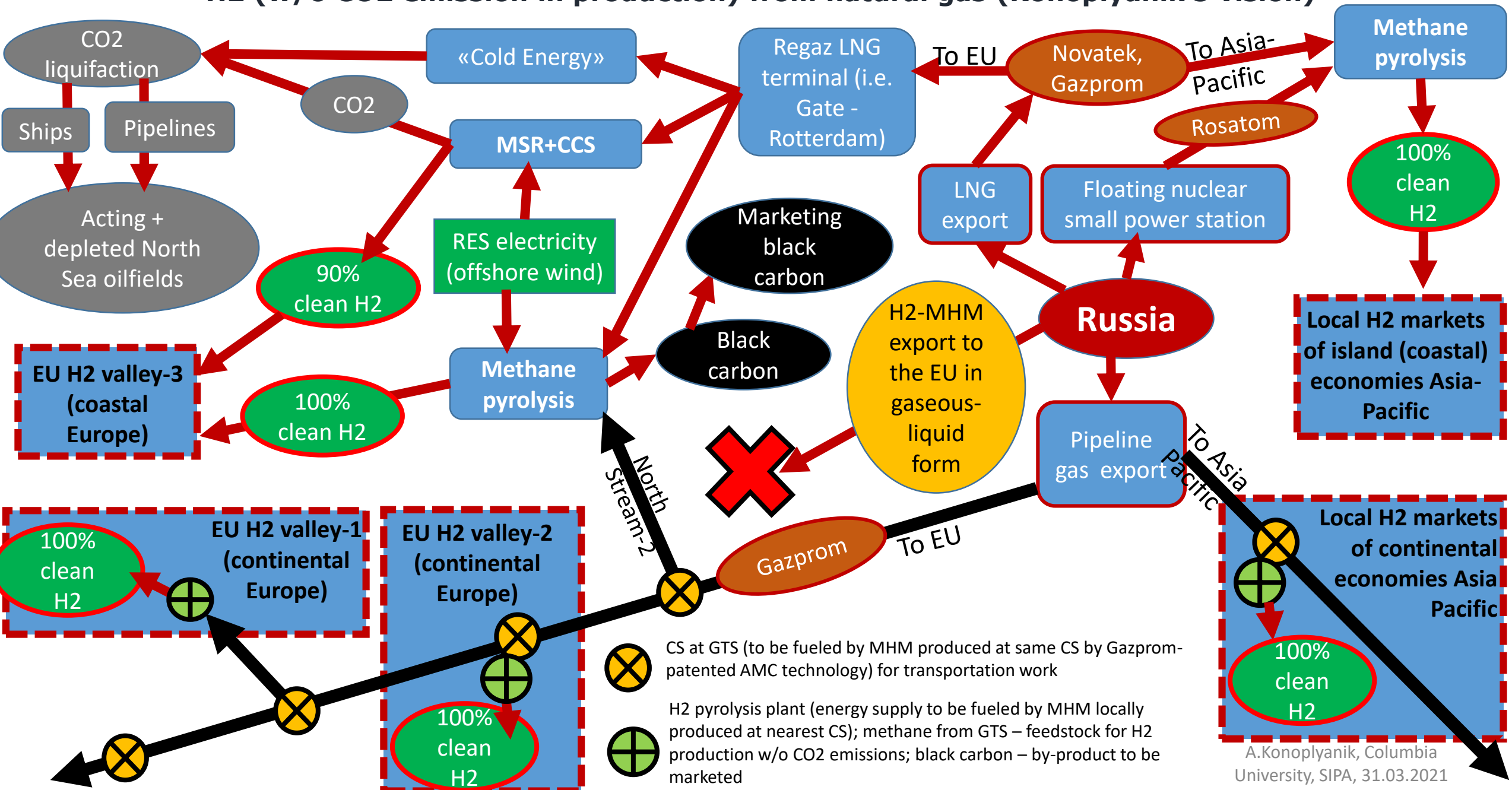




Clean H2 production (w/o CO2 emissions) from natural gas downstream EU based on existing Russia-EU GTS & MHM produced at CS on-site

- 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).

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



A.Konoplyanik, Columbia University, SIPA, 31.03.2021

Thank you for your attention!

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