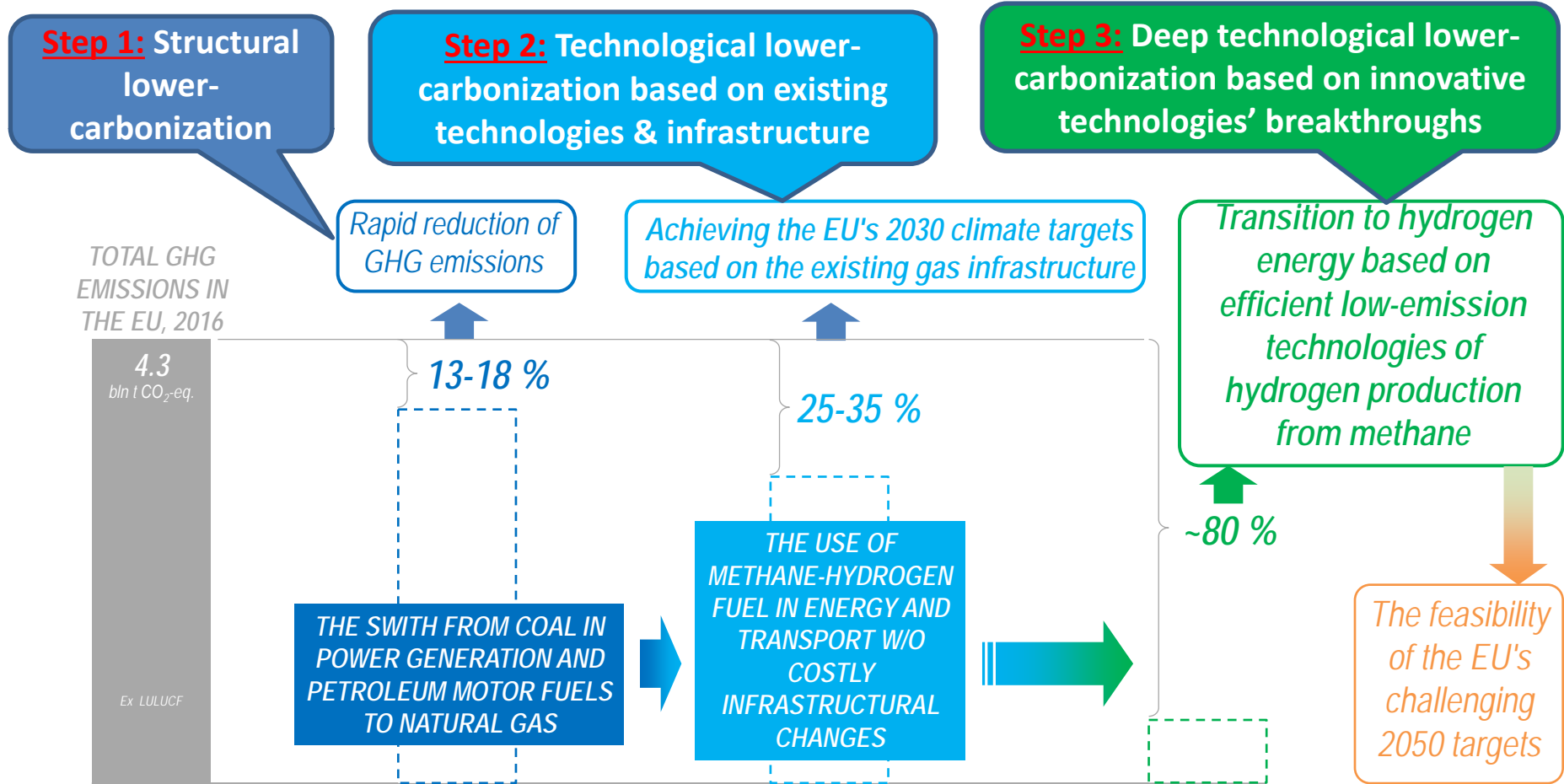


Discussion on potential joint research on key decarbonization issues of mutual interest

**Leaded by Co-chairs Work Stream 2 “Internal Markets”,
Russia-EU Gas Advisory Council**

**29th meeting of the EU-Russia Gas Advisory Council’s
Work Stream on Internal Market Issues (GAC WS2),
Berlin, Germany, 21 October 2019**

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



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

- Carbon intensity from different fuels (U.S. Energy Information Administration estimates);
- Carbon footprint of various motor fuels (European Natural gas Vehicle Association report, 2014-2015);
- EU GHG emissions (1990 – 2016 National report on the inventory of anthropogenic emissions by sources and GHG removals by sinks not controlled by the Montreal Protocol , IEA)

Source: O.Aksyutin. Future role of gas in the EU: Gazprom's vision of low-carbon energy future. // 26th meeting of GAC WS2, Saint-Petersburg, 10.07.2018 (www.fief.ru/GAC); PJSC Gazprom's feedback on Strategy for long-term EU greenhouse gas emissions reduction to 2050 // https://ec.europa.eu/info/law/better-regulation/initiatives/ares-2018-3742094/feedback/F13767_en?p_id=265612

How to 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 pipelines, both in RF & EU, based on H2 production technologies at CS on-site without CO2 emission

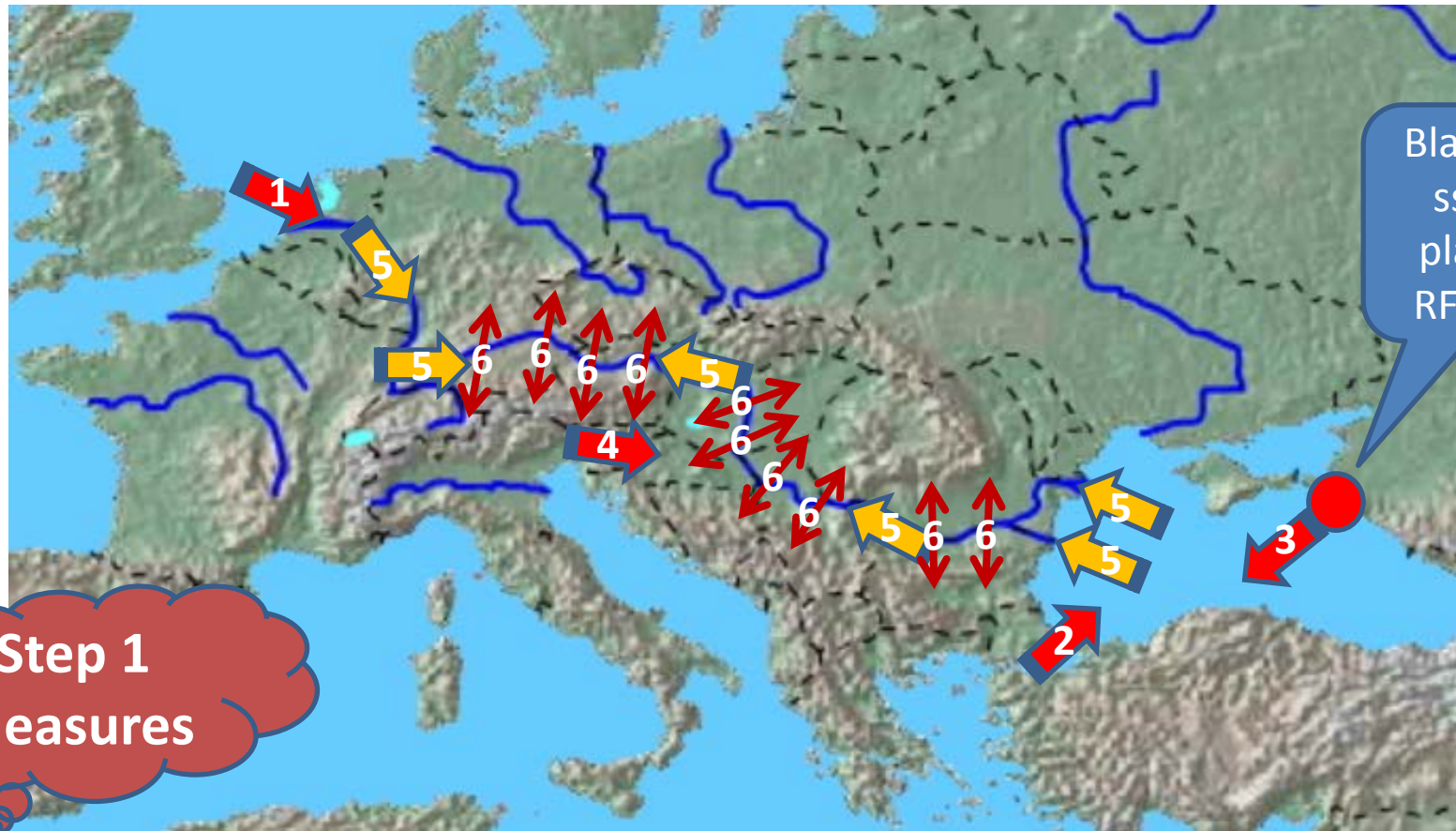
H2 production without CO2 emission (based on Russian, EU &/or on jointly developed under RF-EU cooperation technologies) as its cost-competitive advantage compared to PTG/electrolysis (too much energy intensive & thus too costly) and/or Steam Reforming with obligatory CCS (CCS as incremental immanent cost component up to 30+%)

Small-scale LNG for Black Sea & Danube region

Potential incremental export of Rus gas for H2 production & of H2 production technologies (either of Rus origin or jointly developed by RF & EU)

Step 1 cooperative measures

Prospects of creation of Black Sea-Danube/CSEE ssLNG market



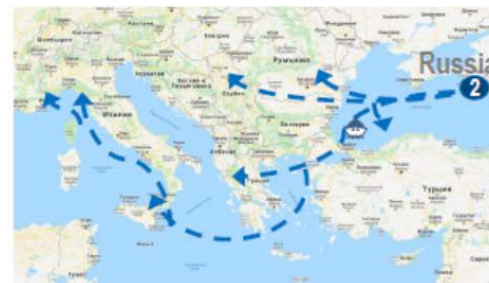
Step 1 Measures

1-4 = ssLNG supplies to SEE (1 = from NS area by barges; 2 = through Turkish Straits (limited); 3 = from Black Sea RF plant by sea-river vessels; 4 = by trucks via N.Italy); 5 = supplies within Rheine-Danube waterway by barges/see-river vessels; 6 = ssLNG fueling stations

Black sea plant

Location	Black sea coast of Russia
Capacity	0.5 – 1.5 mtpa
Status	Prefeasibility study
Delivery countries	Countries of South-Eastern Europe, countries of Danube river region, Turkey.

- potential bunkering areas



Source: K.Neuymin (Gazprom). Development of Small and Medium –Scale LNG Infrastructure in Russia. Presentation at 9th SPB International Gas Forum, 1-4.10.2019

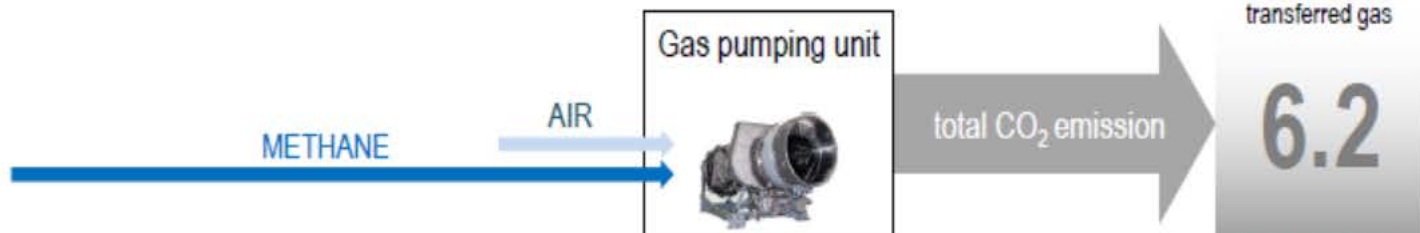
Draft proposals for joint RF-EU research (1)

- Prospective topic:
 - Assessment of aggregated demand for ssLNG within Black Sea-Danube area (bunkering (sea/river vessels), trucks (intra- & inter-city transport), off-grid households) and prospective sources of its competitive supply
- Prospective participants:
 - EU side:
 - Academic/research level: IENE (research center for SEE energy), ...
 - Intergovernmental level:
 - Energy Community Secretariat (know-how & information hub for SEE),
 - Organisation for Black Sea Economic Cooperation (regional development organisation)
 - EU institutional support
 - Business level: OMV, ...
 - RF side:
 - Gazprom & its affiliations/institutes:
 - ...

Step 2 cooperative measures

CONVENTIONAL TECHNOLOGY

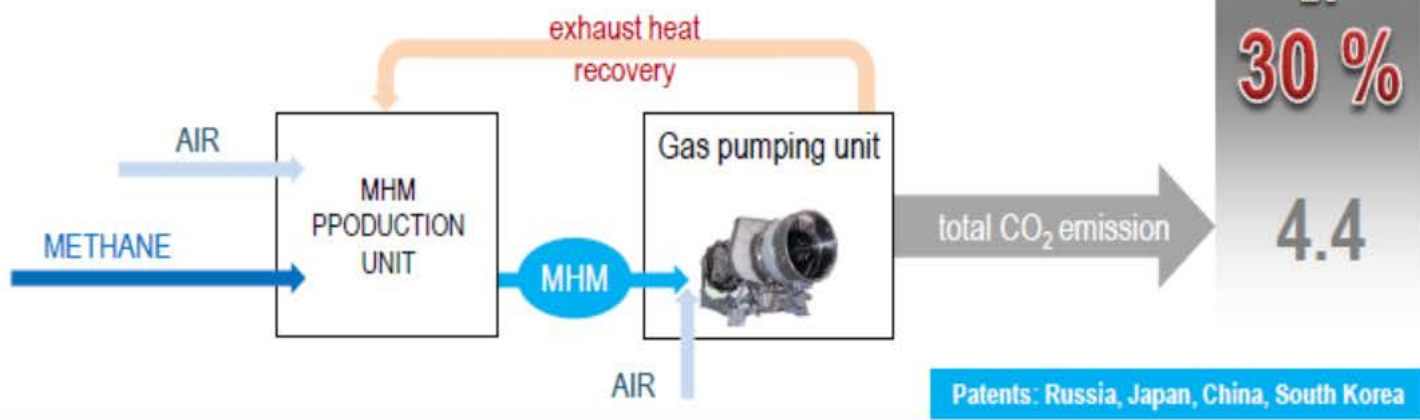
Methane as fuel gas in gas pumping units



NEW TECHNOLOGY

ADIABATIC METHANE CONVERSION (AMC)

Methane-hydrogen mix (MHM) as fuel gas in gas pumping units



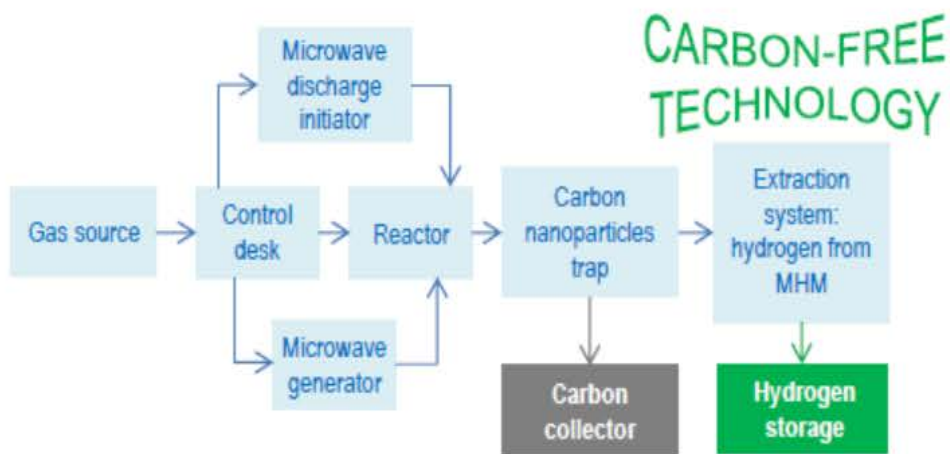
Draft proposals for joint RF-EU research (2)

- Prospective topic:
 - Assessment of prospects & potential effects of implementation of adiabatic methane conversion (AMC) technology at the compressor stations within Russia & EU gas grids (200+ CS in Russia & ... CS in the EU) – and beyond
 - Pioneering exercise (in favour of recent Baumgarten's 60th Anniversary – the key gas delivery point within USSR/Russia-EU cross-border gas supply chain): Prospective effect of implementing AMC technology within cross-border gas supply chain from Nadym-Pur-Taz through Baumgarten to Waidhaus
- Prospective participants:
 - EU side: Gas TSOs, ENTSOG, ...
 - RF side: Gazprom, ...

Step 3 cooperative measures

**Step 3
Measures**

The impact of low-temperature non-equilibrium microwave-induced plasma on hydrocarbon gas molecules



The hydrocarbon gas conversion takes place in a closed plasma-chemical flow reactor in the absence of oxygen and at ambient pressure

PROTOTYPE PLANT CARBON MATERIAL



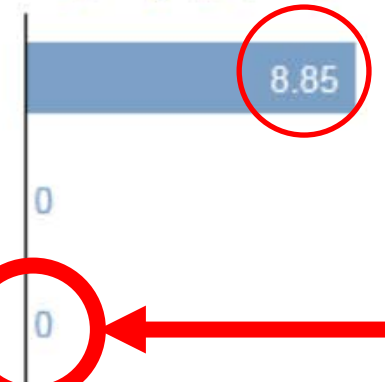
CAPACITY OF:
 - hydrogen – up to 1 m³/h;
 - carbon material – up to 80 g/h

All other conditions being equal, & under technologically neutral regulation, methane pyrolysis might win competition in hydrogen production with two other key technologies

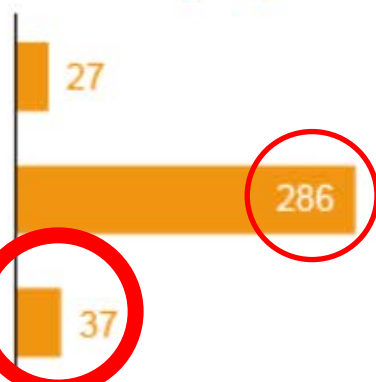
CC(U)S is needed!!! => additional imputed costs (CAPEX + OPEX) => add. 20/30+%

Steam reforming of natural gas	$\text{CH}_4 + 2\text{H}_2\text{O} \rightarrow 4\text{H}_2 + \text{CO}_2$
Water electrolysis	$2\text{H}_2\text{O} \rightarrow 2\text{H}_2 + \text{O}_2$
Methane pyrolysis	$\text{CH}_4 \rightarrow 2\text{H}_2 + \text{C}$

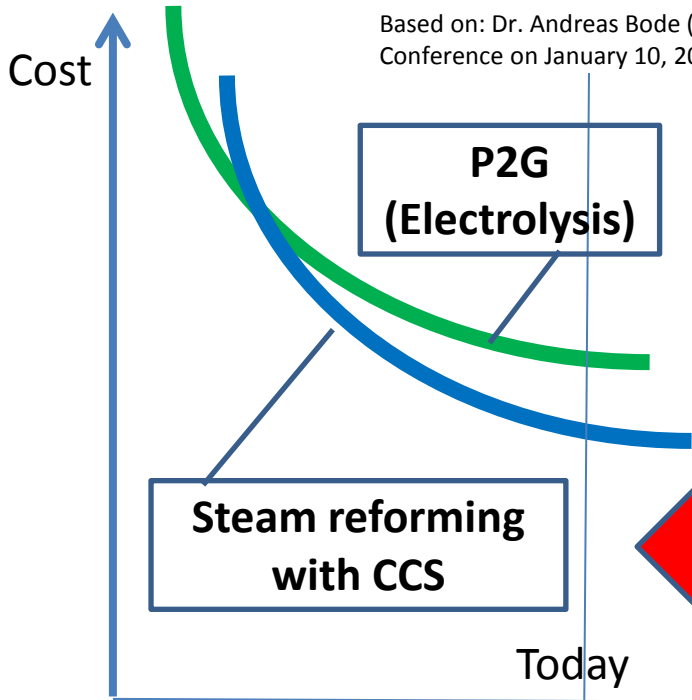
CO₂ emissions in kg CO₂/kg hydrogen



energy demand in kJ/mol hydrogen*



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>)









Methane pyrolysis: major task – to speed up commercialization (scaling effect) to enter & move through “learning curve” for this technology(ies)

Major task

Methane pyrolysis

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

-  P2G wind
-  P2G solar
-  P2G hydro
-  P2G nuclear
-  Steam reforming plus CC(U)S
-  Methane pyrolysis & similar (w/o CO2)

Based on conversations with Ralf Dickel

Source of map: ENTSOG 13



Draft proposals for joint RF-EU research (3)

- Prospective topic:
 - Quantitative and qualitative assessments of economic & ecological effects for the three H2 production technologies
 - Analyzing alternative system approaches for the 3 technologies
 - Where to do this in EU/in RF/..
 - Who to do this (Producers, mid-streamers, TSOs,..)
 - How to progress on the learning curve (large pilots)
 - How to finance pilot ?
- Prospective participants:
 - RF side: Tomsk, Samara, etc...
 - EU side: Karlsruhe, BASF, Madrid, etc...

Possible Additional Cooperative Measures ?

**Thank you for your
attention!**

WS2 GAC Co-chairs