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МИНИСТЕРСТВО НАУКИ И ВЫСШЕГО ОБРАЗОВАНИЯ
РОССИЙСКОЙ ФЕДЕРАЦИИ

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Международная научная конференция

«ЭНЕРГЕТИКА XXI ВЕКА: ЭКОНОМИКА, ПОЛИТИКА, ЭКОЛОГИЯ»

СБОРНИК ДОКЛАДОВ

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Под редакцией
доктора экономических наук, профессора И.А. Максимцева,
кандидата экономических наук Д.В. Василенко

ИЗДАТЕЛЬСТВО
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Международная научная конференция «Энергетика XXI века: экономика, политика, экология» проводится по инициативе А.Б. Миллера и при поддержке ПАО «Газпром» с 2008 года. В среде ученых, представляющих ведущие университеты, экспертов научно-исследовательских институтов, представителей международных организаций и бизнеса из России и других стран обсуждаются наиболее актуальные проблемы мирового сообщества в энергетике.

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Приветственное обращение
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экономического университета

Уважаемые коллеги и дорогие друзья!

Я очень рад приветствовать вас на конференции «Энергетика XXI века: экономика, политика, экология»! Эту конференцию мы начинали в 2007 году, и на сегодня она стала одной из самых интересных и самых востребованных. Я очень горжусь, что в эти годы лучшие эксперты, лучшие исследователи, лучшие люди, которые посвятили свою жизнь энергетике, участвуют в работе нашей конференции.

Мы с вами переживаем непростое время, поэтому, к сожалению, конференция в этом году проходит в онлайн-режиме, но я надеюсь, что пандемия пройдет, и в 2021 году мы снова сможем встретиться в одном из красивейших городов мира, в моем любимом городе – Санкт-Петербурге и вместе обсудить все те проблемы, которые, конечно, будут нарастать с учетом пандемии. Мы видим, как происходят изменения в ценообразовании, поставках, добыче, какие новые появляются альтернативные источники энергии, и все это, конечно, остается в зоне нашего внимания, нашей конференции.

Я хочу поприветствовать всех участников: российских, зарубежных участников, традиционных партнеров: Оксфордский институт энергетических исследований, ведущие энергетические компании мира, которые участвуют в нашей работе (ПАО «Газпром», ООО «Газпром экспорт», Uniper и др.). На сегодняшний день мы с вами стали такой высокопрофессиональной командой, которая думает, которая действительно заботится о том, чтобы мир стал лучше, чтобы климат на планете стал чище, чтобы энергия привносила в нашу жизнь только хорошие, положительные эмоции.

Желаю всем здоровья, успехов, хорошей и интересной работы и до новой встречи!

Фото с официального сайта ПАО «Газпром»

Приветственное обращение заместителя Председателя Правления ПАО «Газпром», Генерального директора ООО «Газпром экспорт» Е.В. Бурмистровой

Санкт-Петербург, ноябрь 2020 года

Уважаемые коллеги!

Для меня большая честь приветствовать вас на конференции «Энергетика XXI века: экономика, политика, экология», которую уже многие годы организует Санкт-Петербургский государственный экономический университет. Это мероприятие стало традиционной площадкой для встреч ученых, политиков и бизнесменов со всего мира, занимающихся развитием энергетической отрасли. Я очень рада, что, несмотря на обстоятельства, конференция проходит и в этом году, пусть и в новом онлайн-формате.

Главной темой обсуждения на этот раз станет будущее глобальной энергетики после пандемии коронавируса. Этим вопросом сейчас озабочены ведущие мировые эксперты и аналитические центры. Уверена, что нынешняя конференция внесет значимый вклад в понимание происходящих процессов, даст возможность услышать разные точки зрения и сформировать всесторонний взгляд на проблему.

Это особенно важно сегодня, когда во всем мире набирают силу устремления по реформированию энергетической отрасли, строятся амбициозные планы по достижению в будущем углеродной нейтральности. Благородные цели по сокращению вредных выбросов можно только приветствовать. Но, как мне кажется, на этом пути важно сохранять холодный рассудок и не впадать в крайности, как это делают некоторые радикальные политики и активисты. Энергетический переход не должен угрожать экономическому развитию и рыночной стабильности, его нужно осуществлять продуманно и постепенно. Было бы недальновидно в одночасье отказываться от проверенных десятилетиями надежных технологий в пользу порой экзотических проектов, еще не доказавших свою жизнеспособность на практике.

Именно это, на мой взгляд, стало одним из главных уроков пандемии. Она выявила уязвимость мирового сообщества и глобальной экономики перед лицом непредвиденных угроз и продемонстрировала, насколько хрупко казавшееся незыблемым равновесие, насколько нестабилен наш привычный порядок жизни. Многие считали, что мы всесильны в противостоянии любым вызовам и можем строить четкие планы на десятилетия вперед. Теперь становится очевидно, что всегда надо быть готовыми к чрезвычайным ситуациям, иметь в запасе альтернативные подходы и решения. Решая насущные проблемы современного мира, в том числе экологические, нужно вместе с тем сохранять его стабильность и запас прочности для экономического развития.

Уверена, что две эти цели – формирование новой энергетики и укрепление стабильности экономики – вовсе не противоречат друг другу. Нужно лишь разумно сочетать одно с другим. Мы должны планомерно развивать перспективные наработки, не отказываясь от успешно действующих технологий. Необходим взвешенный и оптимальный подход, выработать который можно только сообща. Например, на таких конференциях, как эта. Отрадно, что внимание на ней уделяется как сегодняшнему состоянию энергетических рынков и нефтегазовых компаний, так и новым технологиям, например, водороду. Это позволяет рассмотреть проблематику современной энергетики во всей ее полноте и с разных сторон.

Хочу пожелать участникам дискуссий и семинаров успешной работы, увлекательного обмена опытом и новых конструктивных идей!

Спасибо за внимание!

Prof. Dr. Andrey Konoplyanik

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

The topic of this article is how to create a bridge between Russia and European Union in developing energy transition, in particular in developing cooperative efforts, how best effectively my country Russia – the sovereign state with its national sovereign interests – can help European Union in developing its national strategy of decarbonisation with its sovereign aims and with its national interests in this area. What will be the common denominator area between the two, and whether it will be possible and manageable, which is nor less important, to expand this area of common denominator to the mutual benefit of the two.

EU Green Deal & EU vision of cooperation in H2

The European Green Deal adopted in 2019 sets the goal to achieve carbon neutrality in the EU by 2050, relying on the development of RES and decarbonized gases, and hydrogen (H_2) as a priority. The EU Hydrogen Strategy of 08.07.2020[1] is focused on "renewable" H_2 produced by electrolysis using (mostly surplus) electricity from renewable energy sources. However, it is recognized in the EU that the predicted amounts of "renewable" H_2 to be produced by 2050 will not be sufficient for achieving the goal of zero emissions[2]. Therefore, both imports of H_2 and its production from natural gas are deemed acceptable. The latter is allowable solely by methane steam reforming (MSR) with mandatory CO_2 capture and sequestration technologies (CCS). Nonetheless, it is firmly stated that H_2 from natural gas is only a temporary (unwanted but forced) path to "renewable" H_2. Thus, the ultimate goal of the EU hydrogen philosophy in terms of hydrogen sources is using only/mostly "renewable" H_2 that can be produced within the EU or imported.

Meanwhile, in order to make domestic production of "renewable" H_2 in the EU as efficient as possible, European producers of equipment (high-capacity electrolysers) need to secure a capacious market, both in the EU and beyond, to benefit from the economy of scale and learning curve, i.e. to reduce unit costs with the growth of equipment capacity and accumulation of experience in its operation. This is the aim of the concept of foreign economic cooperation with neighboring countries in the field of hydrogen energy, which is promoted by the EU, its member states (for example, Germany) and their business associations (for example, the German-Russian Chamber of Foreign Trade and the German Committee on Eastern European Economic Relations)[3].

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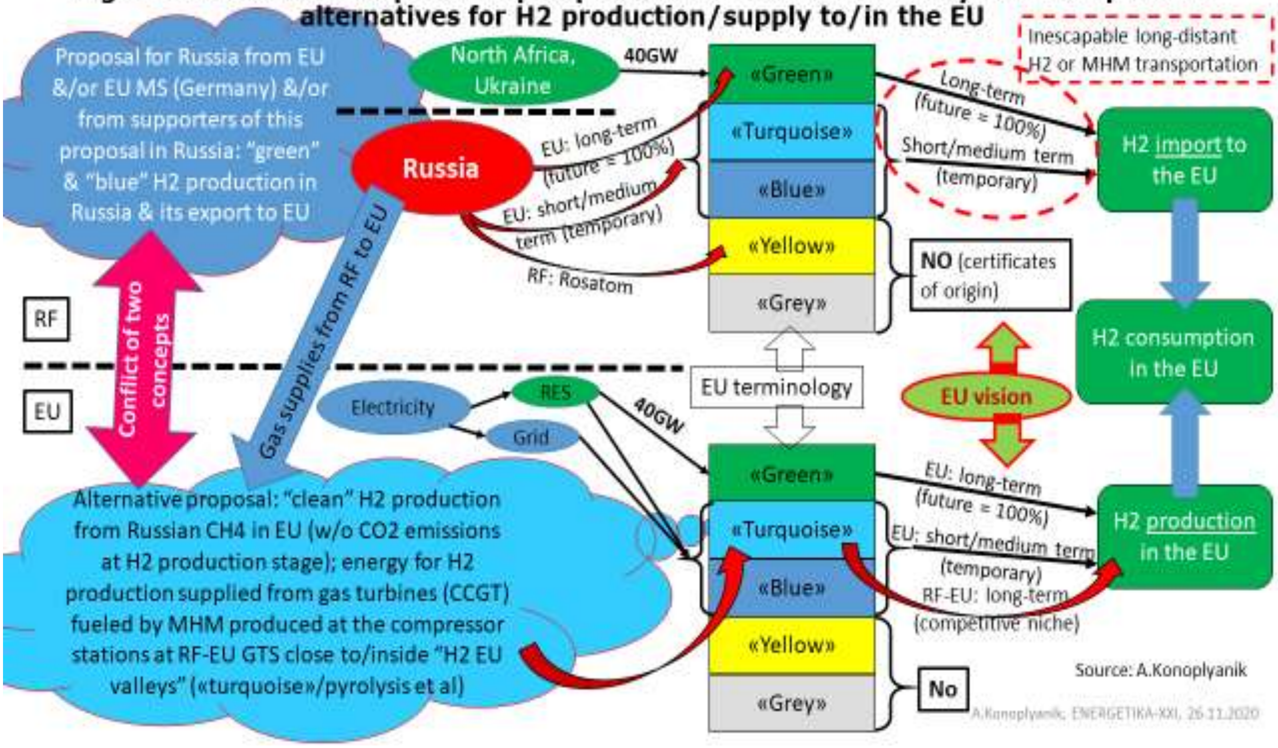
[1] COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS A hydrogen strategy for a climate-neutral Europe. Brussels, 8.7.2020 COM(2020) 301 final (https://ec.europa.eu/energy/sites/ener/files/hydrogen_strategy.pdf)

[2] R.Dickel. Blue hydrogen as an enabler of green hydrogen: the case of Germany. // Oxford Institute for Energy Studies (OIES), OIES Paper: NG 159, June 2020 (https://www.oxfordenergy.org/wpcms/wp-content/uploads/2020/06/Blue-hydrogen-as-an-enabler-of-green-hydrogen-the-case-of-Germany-NG-159.pdf#page=17&zoom=100,92,440)

[3] ВТП выступает за партнерство РФ и ФРГ в сфере водородной энергетики. Пресс-релиз. Москва, 7 июля 2020 (https://russland.ahk.de/ru/mediacentr/novosti/detail/vtp-vystupaet-za-partnerstvo-rf-i-frg-v-sfere-vodorodnoi-

The EU, primarily Germany (using the funds allocated by the German government to promote the interests of German business abroad, which are two billion euros out of total nine billion euros earmarked to facilitate the creation of large-scale production, starting with large-scale pilot plants based on German technologies and equipment) proposes to build hydrogen cooperation with Russia based on developing H_2 production in Russia, either by electrolysis with electricity generated by nuclear and/or hydro power stations, or by MSR+CCS from natural gas produced in Russia's main gas production regions (Nadym-Pur-Taz, Yamal). In the latter case, it is proposed to inject CO_2, thus generated, into the productive formations of oil fields in Western Siberia to enhance oil recovery, and to export H_2 or methane-hydrogen mixture (MHM) to the EU. But one need to bear in mind the placement at the geographical map of Russia locations of nuclear and hydro power stations (where it is proposed to produce green/renewable H_2), as well as major gas fields (where blue H_2 is proposed to produce by MSR) and oil fields (in which CO_2 emitted by MSR facilities located at the gas fields is to be injected to increase oil recovery) – all of them are located deep inside Russia, in thousands of miles far away from key potential H2 consumption centers (EU H2 valleys) deep inside the EU, mostly in North-West Europe.

Figure 1. Russia-EU cooperation prospects in H2 area as it seen by different parties: alternatives for H2 production/supply to/in the EU



This means that such proposal will necessitate long-distance transportation of H_2 or MHM and, therefore, profound modernization or even complete replacement of the existing cross-border gas transportation system (GTS) between Russia and EU to shift from transporting methane to transporting H_2/MHM; most of the work will have to be done outside the EU, that is, inside Russia (see **Figure 1**).

ehnergetiki); Позиция ВТП по партнерству РФ и ФРГ в сфере водородной энергетики. 07.07.2020 (https://russland.ahk.de/ru/mediacentr/novosti/detail/pozicija-vtp-za-partnerstvo-rf-i-frg-v-sfere-vodorodnoi-ehnergetiki)

Some hotheads suggest to begin with adapting Nord Stream-2 gas pipeline (now at the end of its construction stage) for H_2 transportation (simple-heartedly suggesting that this will ease US exterritorial sanctions against this gas pipeline) and then, probably, to build a Nord Stream-3 or even Nord Stream-4, each comprising two lines dedicated for H_2 transportation[4].

Russian vision of developing hydrogen economy

The "Energy Strategy of the Russian Federation Until 2035" (09.06.2020)[5] is the first document of its kind to include a "Hydrogen Energy Economy" section. The stated aim is that Russia to become one of world leaders in H2 production and export. Key measures to achieve these aims are: state support for development of infrastructure for transport and consumption of H2 & methane-hydrogen-mixes (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 is indicated as "export of H2". And the key objectives are formulated as bringing H_2 exports to 0.2 mln.t and 2 mln.t by 2024 and 2035, respectively.

For comparison: today global H2 market is around 75-80 million tonnes per annum (MTPA). In Europe it is currently about 8.3 MTPA with the aim to reach in 2030 about 20 MTPA (in the programme "2 X 40 GW" incorporated now in the EU H2 Strategy).

Export-oriented provisions in Russian Energy Strategy have been clearly interpreted in Russia and abroad as a focus on producing H_2 inside Russia and subsequent export of H_2 or MHM, which, unfortunately, reflects the imposed on Russia (this is just what German colleagues are proposing) and, in my opinion, counter-productive concept for developing the foreign economic segment of Russia's hydrogen strategy. Such reading is clearly demonstrated, for instance, in the international comparison of H2 strategies[6] (see **Figure 2**) 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.

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[4] В.Б.Белов. Водородная энергетика – новая ниша российскоз-германской кооперации. Аналитическая записка №37, 2020 (№220) (http://www.instituteofeurope.ru/images/uploads/analitika/2020/an220.pdf); Steve Cowan. In Russia, they started talking about "Nord stream-3". // "Free News", 04.10.2020 (https://freenews.live/in-russia-they-started-talking-about-nord-stream-3/); В.Белов. Новые водородные стратегии ФРГ и ЕС: перспективы кооперации с Россией. // «Современная Европа», 2020, № 5, с. 65–76 (DOI: http://dx.doi.org/10.15211/soveurope520206576)

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

[6] 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)

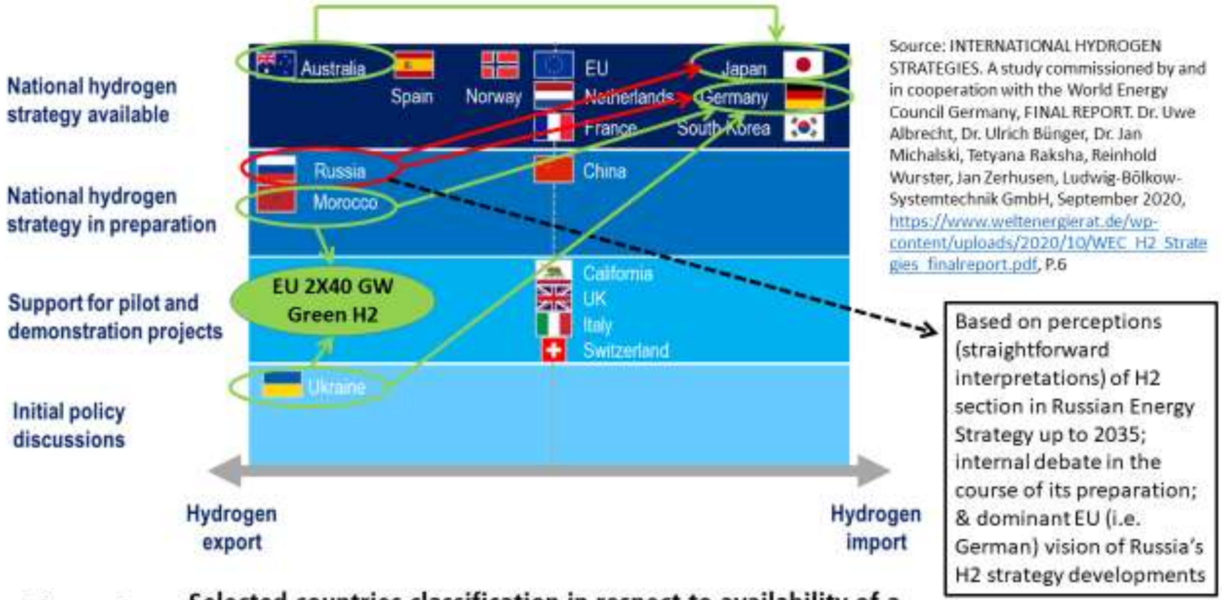

Figure 2. Selected countries classification in respect to availability of a dedicated strategy and hydrogen imports/exports

A.Konoplyanik, ENERGETIKA-XXI, 26.11.2020

Though this same source identified Russia as the only state in the analyzed list, which until 2050 plan to utilize all available options for H2 production and not limit them only to green H2 route (see **Figure 3**).

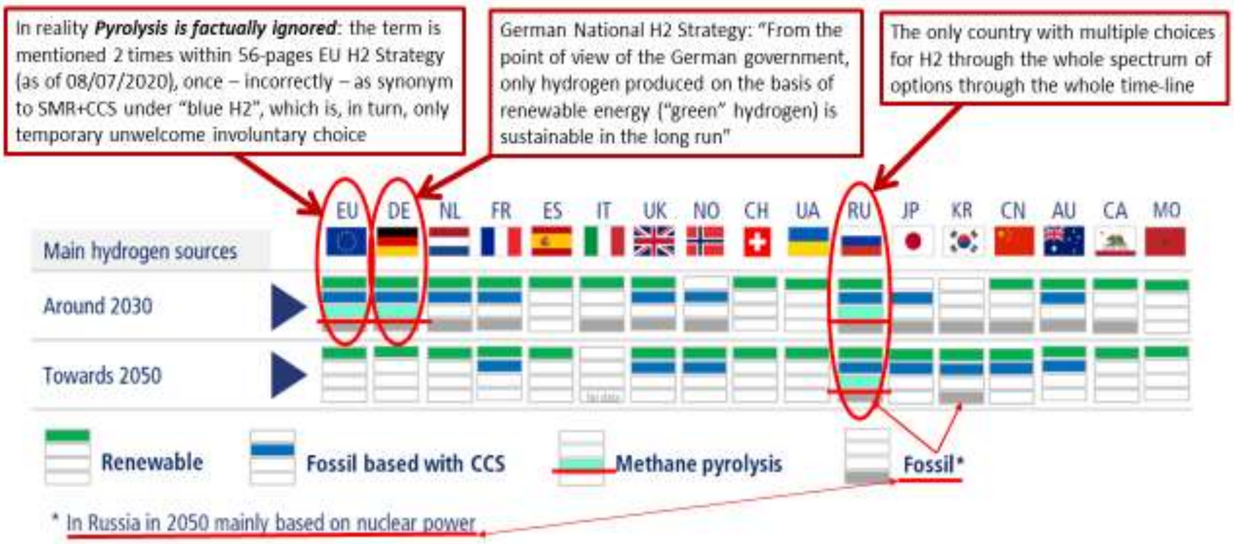

Figure 3. Considered medium- and long-term hydrogen production options by country

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 A.Konoplyanik, ENERGETIKA-XXI, 26.11.2020

Nevertheless, the same study has made wrong perception on long-distance transportation of H2 considered it to be as available (technologically proven) as long-distance transportation of CH4 (see **Figure 4**) – which is not the case!!!

Figure 4. **Principle technology availability of main export/import technologies**

A.Konoplyanik, ENERGETIKA-XXI, 26.11.2020

Alternative vision for Russia

The "RF Government Action Plan for Developing Hydrogen Energy Economy Until 2024" (12.10.2020)[7] in fact corrects the distorted perception of the Energy Strategy's goal-setting, for it no longer talks about exports, but about "creating a highly productive export-oriented segment of hydrogen energy," and paragraphs 39-43 of the Plan require submitting proposals for international cooperation (see **Figure 5**).

This means that the Government Action Plan has laid a foundation to form an alternative model of cooperation between Russia and the EU in this area. The above concept of RF-EU hydrogen cooperation proposed by our EU partners (and supported by a number of Russian "experts") is counterproductive, from my view. After all, it has been demonstrated and convincingly proven (for example, in the works by V.S. Litvinenko and his colleagues from St. Petersburg Mining University[8]) that, due to objective physical and chemical reasons and unresolved technical problems (flow density, energy obtained from equal volumes, energy consumption for compression, storage volumes in comparable containers, problems of hydrogen embrittlement and stress-corrosion), long-distance transportation and storage of H_2/MHM in gaseous and/or liquefied form is drastically inferior, in terms of reliability,

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

[8] Литвиненко В.С., Цветков П.С., Двойников М.В., Буслаев Г.В. Барьеры реализации водородных инициатив в контексте устойчивого развития глобальной энергетики // Записки Горного института, 2020, т. 244, с. 428-438. DOI: https://doi.org/10.31897/pmi.2020.4.421 (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. DOl: 10.31897/PMI.2020.4.5).

safety and economy, to long-distance transportation and storage of natural gas in gaseous state or in the form of LNG (see **Figure 6**).

Figure 5. Hydrogen action plan in Russia up to 2024: some key elements related to clean H2 from CH4 and to international cooperation (acc. to RF 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

At the same time, a number of recent studies published in the EU/Germany (e.g. the April'2020 publication of the Hydrogen Europe association[9]; the July'2020 publication of eleven EU GTS operators[10]; the September'2020 report of four German companies led by Siemens[11]; etc.) are trying to prove the opposite.

But as it appears to me after their attentive reading, these works contain obvious overstatements and internal contradictions (see **Figure 6**, right part). They tries to convince both sides of the acceptability of the proposed model of RF-EU cooperation on hydrogen: to produce H_2 domestically in Russia and to export it to the EU either through dedicated hydrogen infrastructure or through gas infrastructure modernized to long-distance transport of H_2 or MHM.

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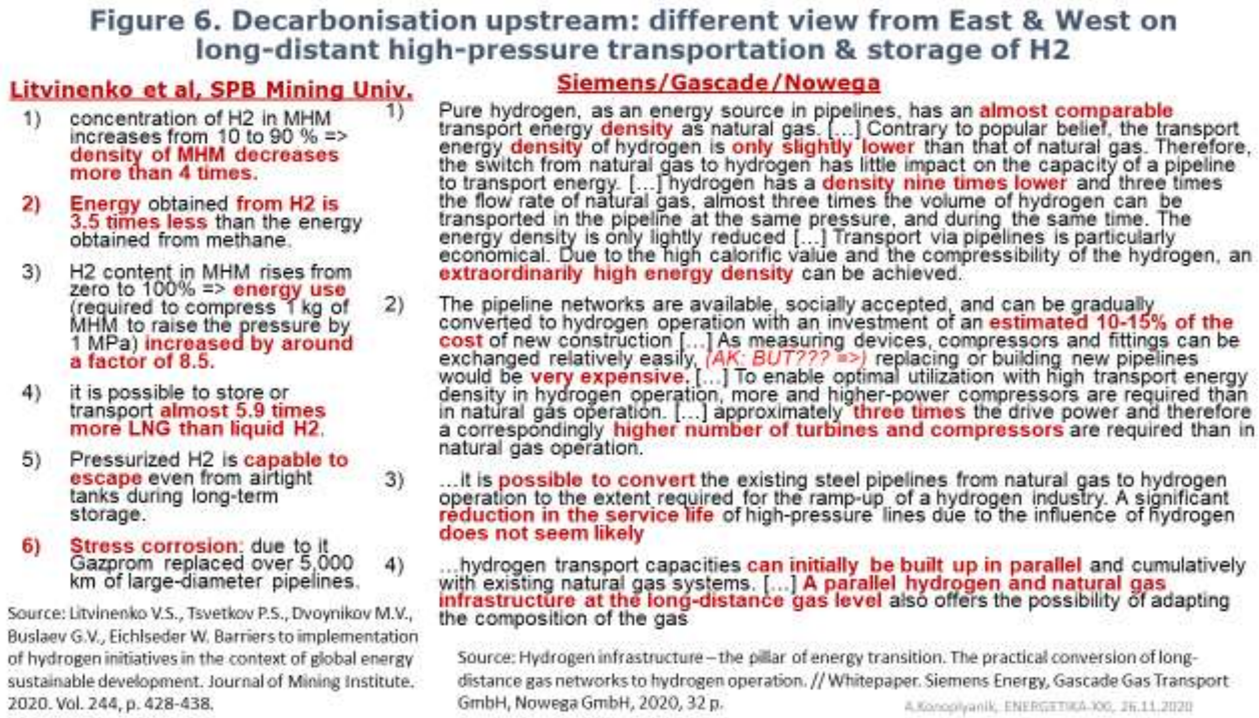
[9] Prof. Dr. Ad van Vijk, Jorgo Chatzimarkakis. Green Hydrogen for a European Green Deal. A 2X40Gw initiative.// Hydrogen Europe, 03/2020, 41 pp. (обнародовано 15.04.2020) (https://hydrogeneurope.eu/sites/default/files/Hydrogen%20Europe_2x40%20GW%20Green%20H2%20Initative%20Paper.pdf)

[10] European Hydrogen Backbone. How a Dedicated Hydrogen Infrastructure Can Be Created. // Enagás, Energinet, Fluxys Belgium, Gasunie, GRTgaz, NET4GAS, OGE, ONTRAS, Snam, Swedegas, Teréga, July 2020, 29 pp. (https://gasforclimate2050.eu/sdm_downloads/european-hydrogen-backbone/)

[11] Peter Adam, Frank Heunemann, Christoph von dem Bussche, Stefan Engelshove, Thomas Thiemann. Hydrogen infrastructure – the pillar of energy transition The practical conversion of long-distance gas networks to hydrogen operation. // Siemens Energy, Gascade Gastransport GmbH, Nowega GmbH, Whitepaper, 2020, 32 pp. (https://assets.siemens-energy.com/siemens/assets/api/uuid:3d4339dc-434e-4692-81a0-a55adbcaa92e/200915-whitepaper-h2-infrastructure-en.pdf)



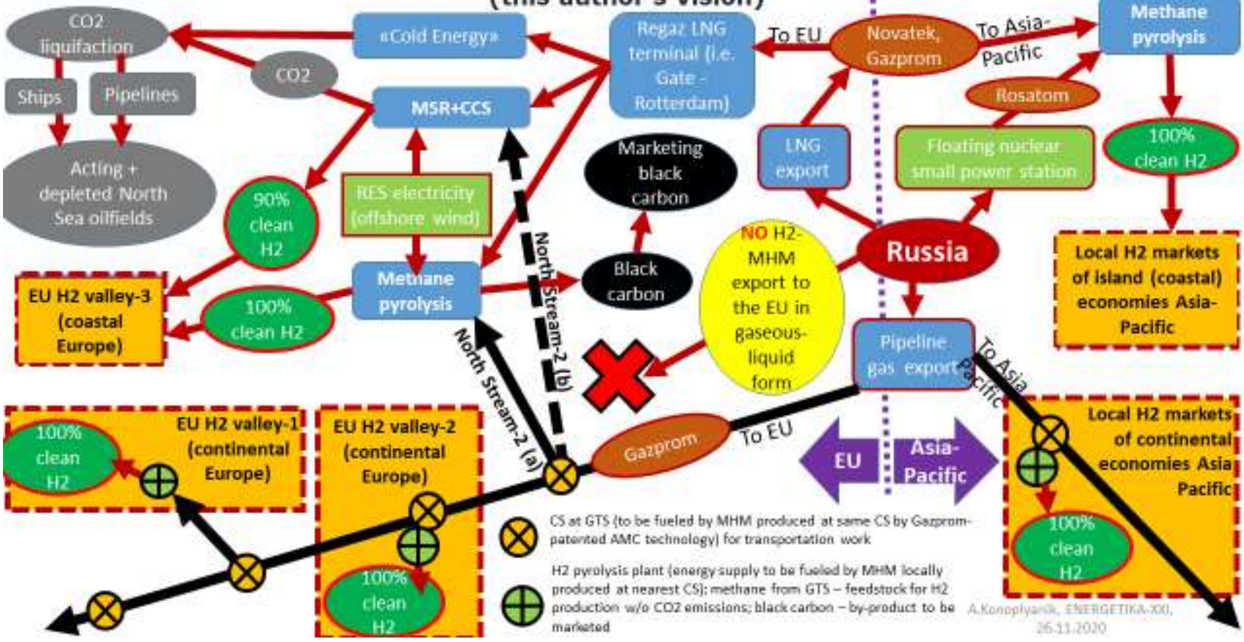
Incidentally, the authors of these studies are the main potential beneficiaries of the proposed hydrogen infrastructure. They are either direct hydrogen promoters by their statute (Hydrogen Europe), or equipment manufacturers (Siemens et al) looking for expansion of their market share, or GTS operators for whom implementation of the idea will increase the amount of assets under their management. But all risks and responsibilities, including those resulting from a complete change in the equipment, logistics and contractual structure of supplies when switching from natural gas to H_2/MHM, will be borne by shippers, including those from outside the EU. In case of Russia, these risks and responsibilities will be borne by Gazprom – the economic agent of the Russian government (the sovereign owner of non-renewable natural resources – gas), entrusted to monetize these resources when transporting produced gas to foreign markets through pipelines.

Therefore, in my opinion, the concept of hydrogen cooperation proposed by our European partners (the export section of the emerging hydrogen strategy of Russia) is unacceptable, because it does not serve Russia's national interests, specifically, the task of effective monetization of Russian natural gas resources and effective use of the existing gas infrastructure, first of all, the cross-border GTS between Russia and the EU. Though this concept completely reflects the national interests of the EU (Germany) and the businesses of these countries. But the mutually beneficial cooperation roadmap should be based on the balance of interests of both parties involved, and not on unilateral interests of one side only.

Mutually beneficial roadmap for hydrogen cooperation

Based on existing developments, including those of Gazprom, I propose an alternative concept of hydrogen cooperation between Russia and the EU (see **Figure 7**). It is based on exporting Russian natural gas to the EU via the existing GTS as well as in the form of LNG, and H_2 production inside the EU in areas of most rapidly growing demand for H_2 ("hydrogen valleys") by methane pyrolysis (or similar technologies that allow producing "clean" H_2, i.e. without any CO_2 emissions at the production stage, like with electrolysis) or by MSR+CCS in the coastal areas of North West Europe with CO_2 removal.

Figure 7. Alternative concept for export-oriented segment of Russian hydrogen energy economy – based on clean H2 (w/o CO2 emission in production) from natural gas (this author's vision)



In case of LNG supplies to regasification terminals in the coastal areas of Northwestern Europe as well as pipeline gas supplies via Nord Stream 1 and 2, RES electricity from offshore wind farms in the North Sea can be used to produce H_2 by pyrolysis or MSR. Carbon dioxide emitted in the MSR process can be liquefied using the "cold energy" generated by LNG regasification plants and transported by tankers or via the existing pipelines (operated in reverse mode) to both operational and abandoned oil fields in the North Sea for injection into the productive formations either for increasing oil recovery in the first case, or for CO_2 sequestration in the second case (Gasunie, Equinor, Shell and some other companies are working on this option). In case of H_2 production by pyrolysis or similar methods, i.e. without oxygen access and hence without CO_2 emissions (first prototypes of such installations are projected to appear in Russia by 2024, according to Government H2 Action Plan, but might appear earlier in case of Russia-EU cooperation), the opportunities for H_2 production will expand dramatically, especially in continental Europe.

In this case, natural gas supplied via the RF-EU GTS will be used within continental Europe (see **Figure 8,** area circled by black dotted line):

- as an energy resource:
    - to perform transportation services: for producing MHM at GTS compressor stations (CS) along the routes of Russian gas transportation to the EU and using MHM at the same CSs as fuel gas (instead of methane) for further gas pumping through the network. Such substitution (based on adiabatic methane conversion (AMC) technology patented by Gazprom; pilot plants should be presented up to 2024, according to Russian Government H2 Action Plan, but in case of Russia-EU cooperation can be, most

probably, commercialized earlier) will result in a one-third reduction of CO_2 emissions at the compressor stations[12];

- to produce "clean" H_2 from natural gas at pyrolysis plants to be built in the immediate neighborhood of these CSs in areas of particularly rapid growth of demand for H_2 ("hydrogen valleys" of the EU) in amounts corresponding to expected demand for H_2 in the neighborhood of these "valleys". Fuel supply to gas (steam-gas) turbines of appropriate capacity can be arranged according to the same pattern as specified in the previous paragraph, although methane will be substituted with MHM not for the purpose of performing transportation work, but for generating electricity and/or thermal energy needed for producing "clean" H_2;

- as a feedstock:
  - for new pyrolysis plants producing "clean" H_2 from methane, which will be located near these CSs and aimed at satisfying local (rather than all-European) demand (within the nearest "hydrogen valleys") in order to minimize the need for long-distance transportation of H_2 as well as for the creation of new specialized transportation systems.

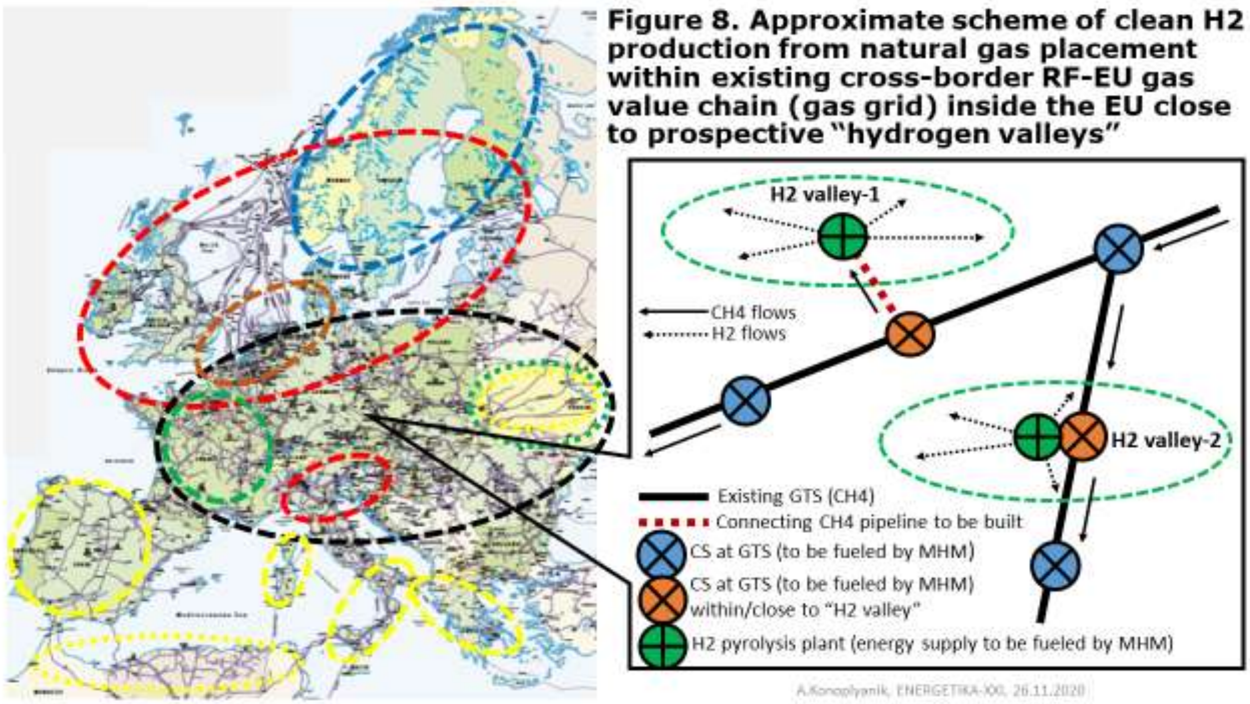


Figure 8. Approximate scheme of clean H2 production from natural gas placement within existing cross-border RF-EU gas value chain (gas grid) inside the EU close to prospective "hydrogen valleys"

Complementarity of H2 production technologies in Europe

Other options for H2 production in Europe will also possess their competitive niches if technology neutral regulation within the EU is provided (geographical areas for their preferential use are presented at **Figure 8**):

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[12] Dr. Oleg Aksyutin. Future role of gas in the EU: Gazprom's vision of low-carbon energy future. // Presentation at the 33rd round of Informal Russia-EU Consultations on EU Regulatory Topics (Consultations) & 26th meeting of the EU-Russia Gas Advisory Council's Work Stream on Internal Market Issues (GAC WS2), Saint-Petersburg, 18.07.2018 (https://minenergo.gov.ru/node/14646)

- renewable H2 from hydro power – mostly within Scandinavian states which are entitles, according to UN classification, as hydro-power states (area circled by blue dashed line);
- renewable H2 from wind energy – first and most in the shallow waters of North Sea, firstly in the offshore areas of North-West Europe (area circled by brown dashed line);
- renewable H2 from solar energy – Iberian Peninsula, south Italy and Balkans, Mediterranean islands (areas circled by yellow dashed line). On top of this EU H2 Strategy assumes that renewable H2 will be produced beyond the EU and be transported then to the EU. In case of H2 from solar energy such production areas beyond the EU mentioned in its H2 Strategy are North Africa and Ukraine (areas circled by yellow dotted line);
- in case of H2 produced with nuclear electricity this can be definitely France (circled by green dashed line) and Ukraine (circled by green dotted line);
- the area for MSR+CCS is definitely the North and Baltic seas and their coastal areas from where CO2 could/would be utilized and transported to depleted oil and gas fields (for sequestration) or to still producing oilfields (to be injected to increase oil recovery).

Green H2 is not a clean H2

Carbon black, a byproduct of methane pyrolysis, is not a climate pollutant, unlike CO_2. Carbon black monetization creates additional revenues in the scheme of pyrolysis production of hydrogen, as opposed to the additional cost of CCS in case of H_2 production by MSR. Both technologies of H_2 production from natural gas are 3-4 times (according to Gazprom[13]) or 10 times (according to BASF[14]) less energy intensive in terms of direct energy consumption compared to H_2 production by electrolysis. Therefore, they require much less installed energy capacity for producing equivalent amounts of H_2.

In order to reduce the cost of producing "renewable" H_2 by electrolysis, the EU is advising its companies to use "surplus" RES electricity, which may be available at zero or even negative price. However, this approach may help to reduce the cost of purchasing electricity, but not the cost of creating the RES generating capacities. It has been proven (for example, by Olivier Vidal[15], who performed a study based on four primary construction materials - cement, steel, aluminum, and copper - used in 13 NRES/RES-based power industry technologies) that material intensity of RES power generating capacities is several times higher than that of conventional fossil fuel-based power generation (see **Figures 9-10**).

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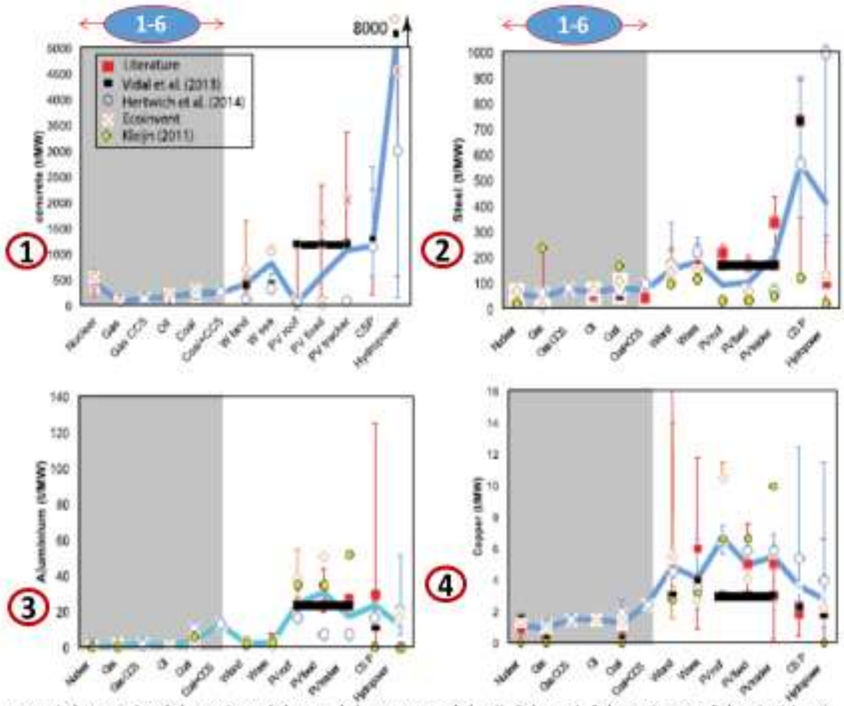
[13] Предложения ПАО «Газпром» в рамках процедуры получения комментариев по «дорожной карте» стратегии Европейского союза в области водорода. Дискуссионный документ. Июнь 2020 г., с. 5 (PJSC GAZPROM'S PROPOSALS for the Roadmap on the EU Hydrogen Strategy, Discussion paper. June 2020, p. 5).

[14] 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)

[15] Olivier Vidal. Mineral Resources and Energy. Future Stakes in Energy Transition. // ISTE Press Ltd - Elsevier Ltd, UK-US, 2018, 156 pp.

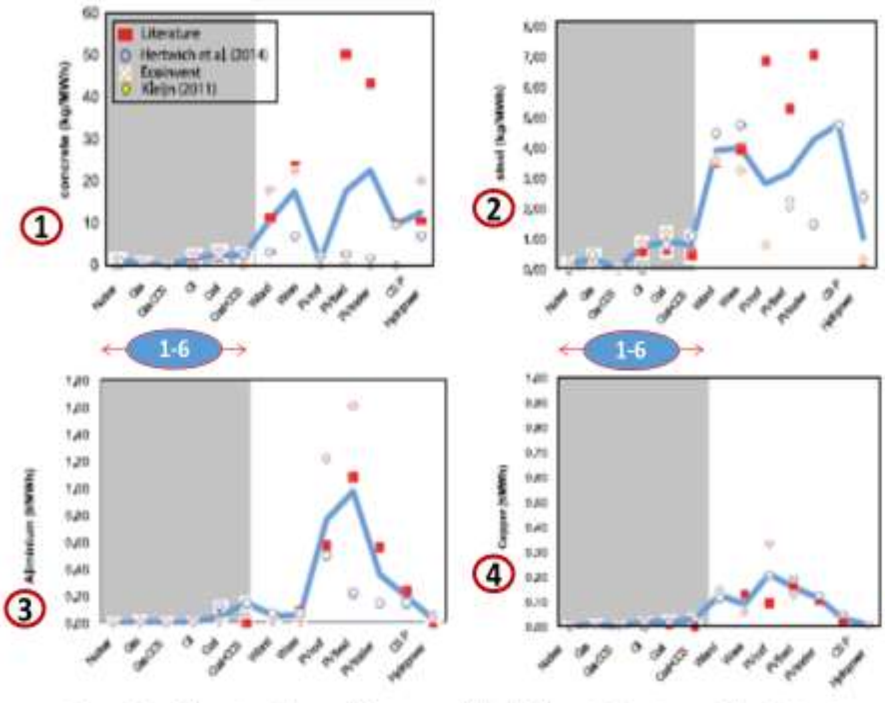


From left to right: (1) Nuclear, (2) Gas, (3) Gas+CCS, (4) Oil, (5) Coal, (6) Coal+CCS, (7) Wind land, (8) Wind sea, (9) PV roof, (10) PV fixed, (11) PV tracker, (12) CSP, (13) Hydropower

Figure 9. 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)

A.Konoplyanik, ENERGETIKA-XXI, 26.11.2020



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

Figure 10. 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)

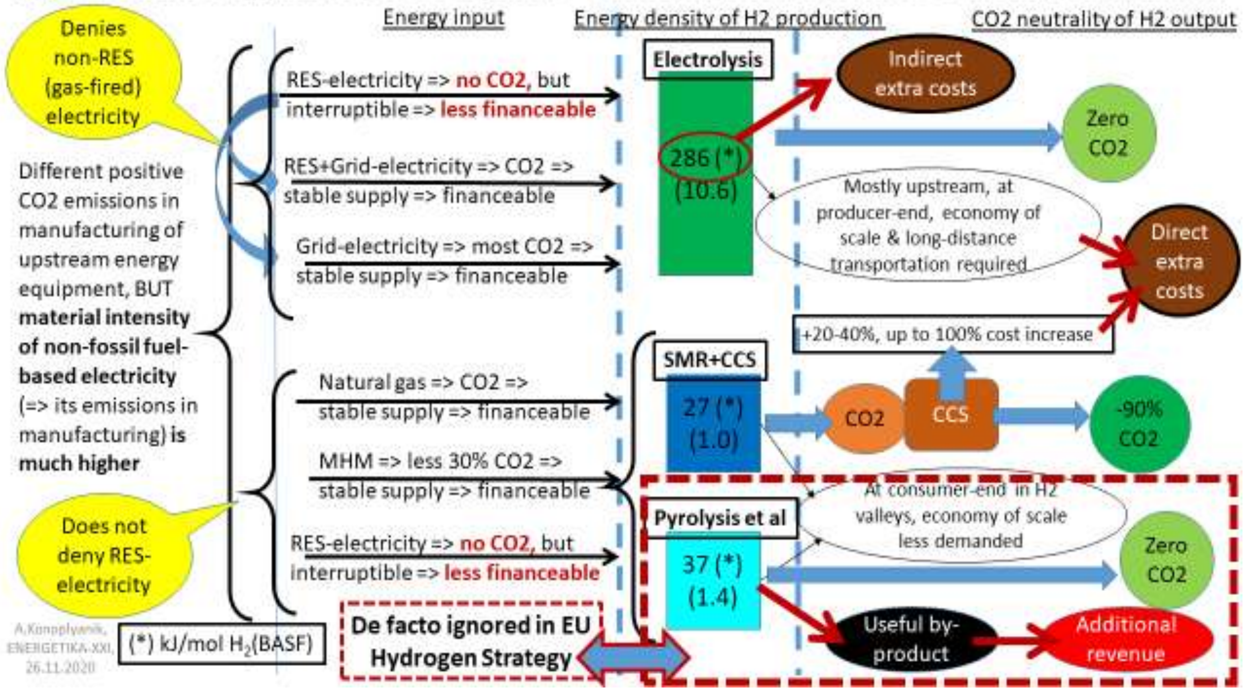
A.Konoplyanik, ENERGETIKA-XXI, 26.11.2020

Therefore, the thesis accepted as a basis in the EU that the only “clean” H_2 is the “renewable” H_2, for which, as stated in the EU Hydrogen Strategy, “greenhouse gas emissions over a full lifecycle are close to zero,” loses its meaning. As Dan Yergin has correctly stated: “New supply chains for net-zero carbon requires carbon” (see **Figure 11**).

Figure 11. What is clean energy? Depends on how you calculate/consider it…

Furthermore, the naturally irregular character of solar/wind power generation significantly worsens the conditions for commercial funding of "renewable" H_2 compared to H_2 from natural gas. This means, renewable H2 has lost its perceived absolute dominance as if the only "clean" H2 (this is not the case anymore), so the corridor of competitive opportunities has to be broadened to other sources of H2 production technologies, including from natural gas with the same "clean" results as with electrolysis, i.e. without CO2 emissions in the course of its production (see **Figure 12**). What should matter – is the relative carbon track through the whole energy value chain, to be correctly measured, thus including energy equipment production life cycles.

Figure 12. 3H2: Input-output CO2 options – no totally clean alternative through value chain



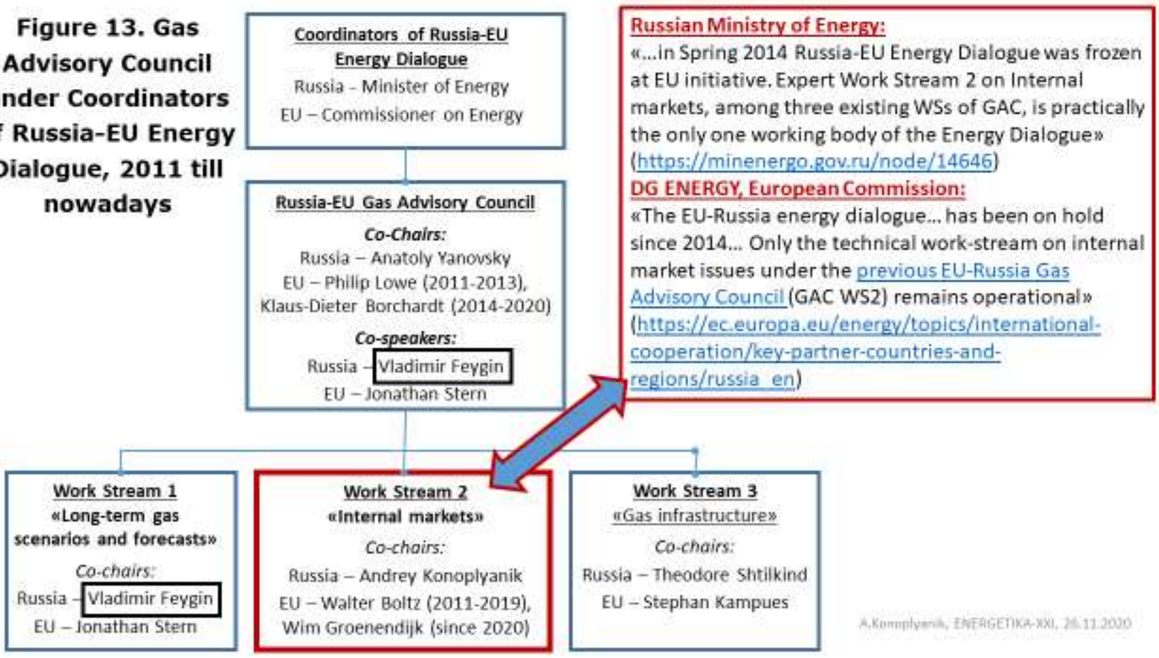
Let's all technologies work

The above proposal leave the open space for complementarity of different H2 production technologies within the EU – each of the three key ones can/will/should find its competitive niche in the "technological mix" based on "technologically neutral" (as was multiply proclaimed in the EU) regulation (see **Figure 8**).

Therefore, in my opinion, the proposed alternative concept not only reflects a balance of interests of the parties, but also is a cheaper tool for the EU to achieve the goals of their decarbonization policy, and will allow Russia to secure a new demand niche in the EU market as part of its participation in the EU decarbonization program — a new market segment of demand for natural gas to be used for producing "clean" H_2 (without direct CO_2 emissions).

We are developing and discussing this concept within Work Stream 2 "Internal Markets" of the EU-Russia Gas Advisory Council (WS2 GAC)[16] which today stays as the only one working body of the Energy Dialogue which remains operational, as stated both at the sites of Russian Ministry of Energy and DG ENERGY of European Commission (see **Figure 13**).

Figure 13. Gas Advisory Council under Coordinators of Russia-EU Energy Dialogue, 2011 till nowadays



The views presented in this article do not necessarily reflect the official position of Gazprom Group and/or Russian authorities and are **the sole responsibility of this author**.

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All publications and presentations of this author are available from his website www.konoplyanik.ru.

[16] Work Stream 2 "Internal Markets" of the EU-Russia Gas Advisory Council (WS2 GAC) webpage at the website of the Russian Ministry of Energy: (https://minenergo.gov.ru/node/14646)

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EU AND CHINA – COMPETITION ON THE RENEWABLE ENERGY MARKET

The competition between European Union countries and Chinese business perhaps won't be a discovery. This kind of relationship between these two regions is a long-established and well-known fact, but we would like to state all the facts we have collected and make some development forecasts in this issue.

It is worth starting with the fact that in the energy sector, innovation and investment are two interrelated things. So, practically any implementation of innovative technologies is attractive for investment and it's at the service of many countries. The first evidence came from the energy crisis in the 1973, when countries began to look for new energy use options and develop their energy security. This led to the situation when in the early 1970s European and Asian countries began to develop nuclear energy, and now we can see that today they are one of the main producers of this type of energy. The largest numbers of reactors are located in these countries, for example, there are 58 reactors in operation and 1 reactor under construction in France; and there are 48 reactors on operation and 11 – under construction in China. These two countries are the leaders of nuclear energy production after USA.[17]

Then in the 1990s, all the countries started to introduce renewable energy sources and technologies. It was the time when the total production of solar and wind energy in the world did not exceed 5 terawatt-hours. However, starting from European countries such as Norway or Sweden in 1990 during the next 20 years this type of energy began to spread to the whole world. Nowadays, due to the interest in the technology development for the production of this type of energy, the share of primary energy from renewable sources constantly growing, even in non-developed countries. The leaders of the production now are only strengthening their positions, especially as we can consider – it's China (the energy capacity of solar and wind power approximately – 450 000 MW). And only one European country can be competitive against it, and it is Germany with the solar and wind energy capacity of 110 000 MW.[18]

The beginning of the 21 decade is driven by attempts to use natural gas, and it led to the LNG emergence on the global energy market. Now we suppose that LNG is a steadily developing type of energy. There are 24 terminals in operation in Europe and even more than 18 terminals in China, plus terminals in other Asian countries: Japan, Taiwan, South Korea and etc. In the beginning of 2010, China began to become a major economic actor, by this time it has already actively penetrated both nuclear and renewable energy and even in LNG transportation, with its capital and technologies, conquering the Global energy market.[19]

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[17] Source: IEA / The Database on Nuclear Power Reactors / URL: https://pris.iaea.org/pris/

[18] Source: Ourworldindata / Energy consumption and production / URL: https://ourworldindata.org/energy

[19] Source: Snamatlas / LNG Global market / URL: http://www.snamatlas.it/global_lng_market

The main instrument of influences is capital. China's investments in the energy sector around the world for the period from 2012 to 2020 almost reach $500 billion.[20] It's not surprisingly that the direction of investment also can be easily explained. Firstly, these are the third world countries, with a huge amount of resources and a practical lack of state control. Secondly, these are the countries, which are in the zone of the New Silk Road initiative. And thirdly, these are European countries with their innovative ideas and technologies. Apropos, the investment policy of China for this period covered almost all EU countries and even took some superiority. And now it continues growing, for example: at the present days, the comprehensive strategic partnership between China and Denmark is developing, and China has good cooperation relations with the Autonomous territory of Denmark - Greenland. The Chinese government encourages and supports companies interested in developing the Arctic in accordance with law, ecology, cooperation and market principles.

Despite the fact that many countries oppose China's investment intervention in their projects, the development of a hydrogen economy is on our agenda. It requires funds and technological modernization, so most likely this will lead to a new development of economic relations between the countries. There are countless business opportunities related to the hydrogen economy, from equipment for the production and processing of green hydrogen to national and international transportation by pipeline or ships to its end-use in various applications such as fuel cells. The competition between Europe and China for emission-free hydrogen technologies could be one of the defining business stories in the global effort to stop climate change. Having a painful experience in the production of solar photovoltaic cells, Europe does not take risks with hydrogen.

In an effort to surpass China realizes its ambitions to become a climate-neutral country, Europe has launched a massive push for clean hydrogen to decarbonize industry and aviation and provide promising export opportunities. Green hydrogen is seen as the key to achieving "net zero" emission targets, but global adoption of this technology will not be possible without a sharp drop in prices. This could make competition between the EU and China critical to global decarbonisation efforts.

Having studied the doctrine of July 2020, it is obvious that the European Union is ready to invest its funds, but other countries also focused on this, as it is shown in the Figure 1.

European manufacturers are clearly leading the way when it comes to efficiency, scalability and flexibility, while Chinese competitors use simpler technologies but enjoy cost advantages. Currently, Chinese manufacturers of electrolyzers have begun to compete with European companies, because they mainly sell them domestically and to markets other than Western Europe, Australia and the United States, BNEF reports. Moreover, the country is a major importer of European hydrogen technologies.

China with its capital cannot stand aside the energy development. They are interested in investment attractive projects both within the country and abroad. As example: Chinese-Finnish (paroheimer

[20] Source: AEI / Chinese Investments / URL: https://www.aei.org/china-global-investment-tracker/

Eco-City Design Co., Ltd.) ecological map of Mentogou vision valley 30 km from Beijing in 2016. In the field of environmental science and technology, a low-carbon city and a green Beijing will be built.

At the same time, while the production of green or blue hydrogen in sufficient quantities seems to us an impossible task, the interests of European countries and China may collide on the territory of African countries. There, the prospects for the production of gray or black hydrogen are unusually high. The fight for green hydrogen with Europe will be determined by the decisions of the Chinese government. The country began to promote hydrogen technology through policies at the national, provincial and municipal levels. However, China has not committed to becoming climate neutral, unlike Europe; it has placed much less emphasis on green hydrogen.

Figure 1 – The examples of Hydrogen prospects

Frankfurt am main (in Italy, Denmark, the Netherlands)	UK	Japan in cooperation with "RusHydro»	Tokyo, Japan	North Of The Netherlands	South Korea with China
Hydrogen produced from renewable energy sources is mixed into gas transmission and distribution networks 2% hydrogen to the local gas distribution network	Hydrogen as a way to radically reduce household emissions (85% of households in the country burn natural gas for heating)	Kawasaki Heavy Industries should update the feasibility study for this project. With the development of infrastructure in the far East and cheaper technologies for electrolysis and hydrogen logistics, interest in such projects will obviously only grow.	the Olympic village was built for the 2020 Olympics. The main source of energy in the village will be hydrogen: cars, gas stations, fuel cells, heat and electricity in homes, gas in stoves and boilers — all this will run on hydrogen.	The Chemport Europe project, the main goal of which is to create a full-fledged gas chemical cluster operating exclusively on local bioresources and hydrogen with zero CO2 emissions.	Hyundai Motor has signed a Protocol of intent with the Beijing industrial research Institute and Tsinghua University (BTIRDI) to establish a hydrogen energy Fund. According to this Protocol, the partners will expand their presence in the hydrogen energy sector and contribute to the creation of a new "hydrogen society".

Source: European Commission

China does not yet have a specific "green hydrogen" strategy or detailed targets, but the local industry predicts a growing role for emission-free gas. For example, an official document from the Chinese hydrogen Alliance, which consists of companies, universities and research institutes, predicted in 2019 that by the middle of the century, most of the hydrogen production will switch from fossil fuels to renewable energy sources.

To conclude we would like to draw the attention that two poles are being formed on the world energy markets. These are the EU countries against China with Japan. Despite the fact that they are rivals, they still have to cooperate at this stage of innovative energy development.

Alex Barnes, *Independent Consultant*
www.alexbarnesassociates.co.uk

The EU Hydrogen Strategy: Challenges and next steps

In July 2020 the EU Commission launched its Hydrogen Strategy as a key part of its plans to be net zero by 2020. In December 2020 the EU Council, representing Member States, broadly endorsed the Commissions strategy, and tasked it with developing more detailed proposals to put it into practice. A number of European countries including Germany, Netherlands, France and Spain have launched their own hydrogen strategies. The UK, which is no longer a member of the EU but still a major player in European energy markets, will launch its hydrogen strategy in spring this year having highlighted the importance of hydrogen in its recent Energy White Paper. All these strategies share similar grand ambitions for hydrogen as a means to decarbonising the economy; they also all face the same challenge, namely, how to develop policies and regulation which will enable a hydrogen market to develop from scratch.

A number of commentators have fallen prey to the temptation to think of hydrogen market regulation in terms similar to the gas market liberalisation that has been implemented in the last 20 plus years in European markets. Indeed, the EU Strategy talks about a desire for a liquid market with commodity-based hydrogen trading and cross border trade. Recent German proposals appear to mimic elements of the Third Gas Directive with calls for 'ownership unbundling' to be maintained in the new hydrogen world. It is easy to understand the temptation given the gaseous nature of hydrogen, and proposals for European pipeline networks to transport hydrogen from centres of production such as electrolysers linked to offshore wind to customers far away. However, it is always worth asking what is the problem, that regulation is trying to fix? In the case of natural gas markets, the problem was vertically integrated incumbents who controlled both the supply of natural gas and the infrastructure used to transport it, and who were therefore able to stifle competition. New entrants could not easily access either supplies of gas or the means to deliver it to customers. Customers had no real alternatives to their use of natural gas, and hence were dependent on the incumbents. Fortunately, for European natural gas consumers EU regulation has solved these problems, and the EU now has a thriving competitive natural gas market.

Clearly, the situation is very different for hydrogen. Other than a few niches in the chemicals and refining sector, there is neither widespread demand for, nor supply of, hydrogen, let alone a developed pipeline network controlled by dominant incumbents. Many consumers wishing to decarbonise have alternatives such as electrification or Carbon Capture and Storage, as well as different hydrogen suppliers. Whilst it is conceivable, that the hydrogen market could become controlled by a few players, this seems unlikely unless competition authorities and regulators are asleep at the wheel over the next thirty years. In this light copying and pasting existing natural gas regulation seems pointless, or even counter-productive. This is because anything which makes it more difficult for hydrogen value chains to develop will delay the hydrogen's widespread deployment, and hence delay the decarbonisation which all the hydrogen strategies wish to enable. Hydrogen already faces very great obstacles. Unlike natural gas, which was a profitable and self-financing industry when it was liberalised, hydrogen will need government support to develop. Natural gas was competitive with alternative fuels as the gas market developed in Europe, hydrogen currently is not. Governments will need to subsidise the production or consumption of hydrogen, or make alternatives such as unabated fossil fuels more expensive, or compel the use of hydrogen by consumers.

Given these challenges it makes sense to try and minimise any other burdens on those companies trying to develop hydrogen value chains, such as regulation. Current EU regulation for natural gas was developed for a mature and profitable industry. Even so the legislation recognises circumstances where the full framework may be either undesirable or unnecessary. Article 36 allows exemptions for natural gas infrastructure projects such as LNG terminals or interconnectors, which are too risky to go ahead without an exemption. Many projects such as the TAP pipeline between Greece and Italy or the Gate LNG terminal in the Netherlands have benefitted from such exemptions. Article 49 allows derogations for 'emergent' markets or where the market is not mature enough to support competition based on the full regulatory framework. Finland benefitted from such a derogation until 2020. Both Article 36 and 49 therefore offer useful precedents for policy makers considering how to regulate hydrogen markets. Hydrogen projects would certainly qualify as risky, and as noted above a hydrogen market does not yet exist, let alone qualify as emergent. Both approaches also have the advantage of ensuring that regulatory oversight is maintained to prevent the entrenchment of dominant incumbents, either through time limits on the exemption period or by the use of economic tests. But crucially they would give hydrogen project developers one less thing to worry about, and regulatory certainty within the parameters of their exemption or derogation.

Grand ambitions for future liquid hydrogen markets are admirable, and hopefully such markets will develop. It is clear hydrogen has a key role to play in enabling us to decarbonise economies. But policymakers should focus on what they can do today to support the development of hydrogen. An approach based on the thinking underpinning Articles 36 and 49 of the Gas Directive could be one way forward. What policy makers should not do is create a framework based on that of natural gas when the conditions for hydrogen today are so completely different. It is no good worrying about the creation of future dominant incumbents in hydrogen if the solution means that a hydrogen market fails to develop in the first place.

***Michael Kranhold**, 50Hertz Transmisssion GmbH*
*Co-author**: Polina Sokolnikova**, M.Sc., Berlin, Germany*

From 60 to 100 by 2032 – New energy for a strong economy

50 Hertz is a part of a European network

As one of four transmission electricty network operators in Germany, 50Hertz is responsible for transporting electricity at the highest voltage level. 50Hertz network area includes the east Germany, Berlin and Hamburg. The grid area of 50Herz is shown in the figure Fig. 1.

50 Hertz is a part of a European network and cooperates directly with colleagues across Europe. In 2010 50Hertz was sold to the Belgian transmission system operator Elia and the Australian IFM Global Infrastructure Fund. Elia initially held 60% of the shares, IFM the remaining 40%. In 2018

IFM sold its shares to Elia and the KfW banking group. The shareholders of 50Hertz are currently the Belgian holding Elia Group (80 percent) and the KfW banking group with 20 percent. Eurogrid holds 100 percent of the shares in 50Hertz Transmission GmbH. 50Hertz Transmission GmbH has an interest in 50Hertz Offshore GmbH ("50Hertz Offshore") and other companies such as Elia Grid International, European Energy Exchange AG ("EEX"), Joint Allocation Office SA ("JAO"), TSCNET Services GmbH (" TSCNET ") and Coreso SA (“ Coreso ”) (see Fig. 2).

Fig. 1. 50Hertz grid area

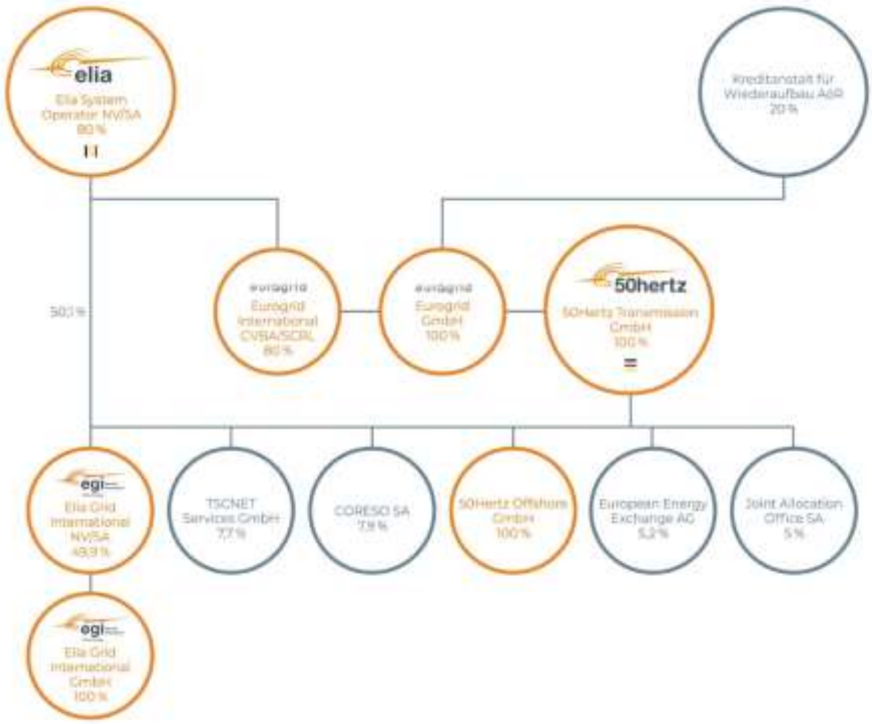

Fig. 2. The company structure of 50Hertz and its company shares as of 4th March 2020

As part of the European network, the 50Hertz transmission network is directly linked to the neighboring countries: Poland (PSE), the Czech Republic (ČEPS) and Denmark (Energinet.dk). The European transmission system operators work closely together. The goal of EU is to create an internal electricity market. 50Hertz is involved in a variety of European projects and initiatives. European Network of Transmission System Operators for Electricity (ENTSO-E) coordinates these activities and 50Hertz is very active in this association. The coupling of the national electricity markets in Europe creates perfect conditions for constantly growing cross-border electricity trading. The transmission capacities between the countries lead to a lively exchange of energy, the electricity supply in the EU is becoming more efficient and more climate-neutral. In addition, the cross-border lines contribute to balance fluctuation in generation. The requirements for cross-border electricity transport are constantly increasing due to the growing European electricity trade. As a part of the European electricity market, 50Hertz is working closely with the other European transmission system operators on various projects [1].

However, the existing transmission capacities of the cross-border interconnectors are often not sufficient for this. Therefore, the available line capacities must be managed in a non-discriminatory manner according to market-oriented and transparent procedures [1].

The Transmission System Operator 50Hertz. Tasks

50Hertz operates the electricity grids of 150, 220 and 380 kV, which are used to transport electrical energy over long distances. 50Hertz grid has a circuit length of around 10,490 kilometers. Due to the central location of 50Hertz in Europe, it plays an important role in international flow of electricity. That is why, the company keeps optimizing the interconnection and grid expansion. 50Hertz is working consistently on the successful energy transition - as grid owner, system leader, market developer and trustee. 50Hertz connects large-scale generators and consumers (including offshore) to the grid. With the energy transition, the energy supply system has fundamentally changed and has become much more complex. Renewable energies are increasingly being fed into the grid directly or via the distribution grids. Wind energy is the most important renewable energy in Germany. Around 36 percent of the completely installed wind power of the country is fed into 50Hertz's grid, which is around 18,346 MW onshore and 1,068 MW offshore, mostly in northern Germany. 21 MW of wind power are expected by the year 2020. Today, the share of renewable energies in electricity consumption in the 50 Hertz grid area is 60 percent (see Fig. 3).

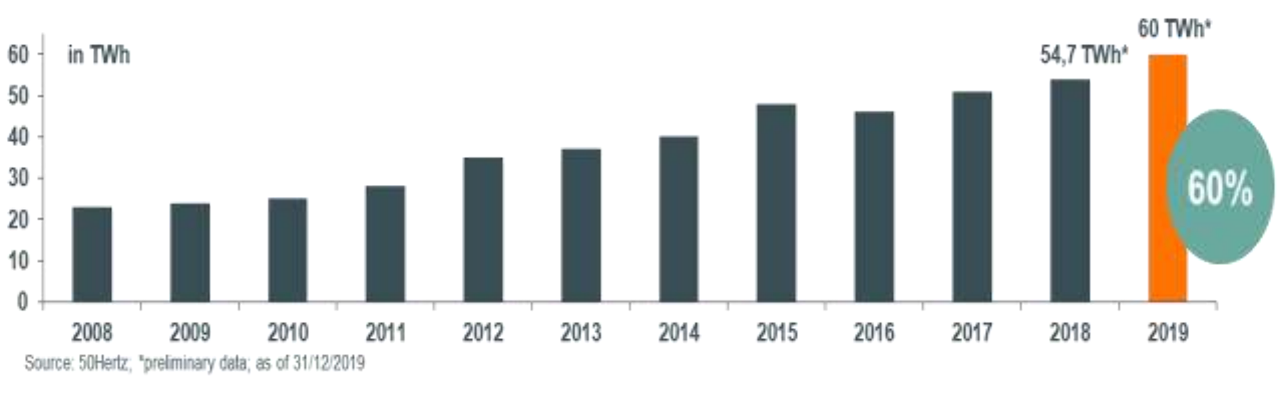

Fig. 3. Development of RE generation in the 50Hertz grid area

The share of RES in total gross electricity consumption in Germany in 2019 was already 43 % [2] . For comparison: In 2010 the share of renewable energies was 16.9 percent (see Fig. 4). It can be seen that wind, sun and biomass are already the most important sources of power supply in Germany [2].

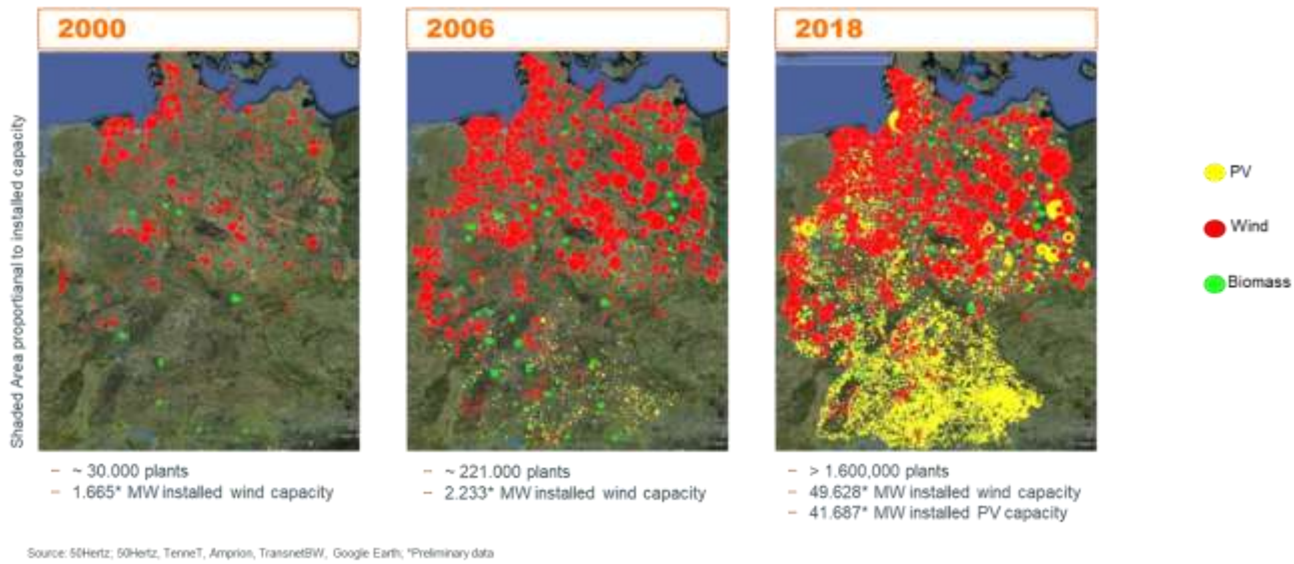

Fig. 4. RES development in Germany

From 60 to 100 by 2032 - New Energy for a Strong Economy

Renewable Energy Sources Act (EEG) promoted a rapid expansion of renewable energies in Germany. By 2030, the share of renewable energies in the electricity supply should be increased at least to 65 percent [1]. The most ambitious energy policy goal of EU, according to the European Green Deal, is a climate neutral continent by 2050 [3]. To achieve this goal, a cooperative work of all German TSO is needed. That means: the faster the goal of a power supply based predominantly on sustainable energy sources is achieved in a region, the more attractive this area will be as an industrial location. That is why 50Hertz have launched the initiative with the title "From 60 to 100 by 2032 - New Energy for a Strong Economy". By the year 2032, the entire electricity consumption in the 50Hertz grid area should be 100 percent renewable energies over the year. In 2019 this proportion was 60 percent. Politicians are sending out not only an energy and climate policy, but also an industrial policy signal: Energy-intensive companies need green electricity if they want to produce in a climate-neutral manner. These companies will want to stay at the locations or settle there where they can cover their electricity needs entirely from renewable energies and thus decarbonize their processes [1].

One of the main challenges that Germany faces now is to balance the increasing distance between consumption of energy in the south and the production of renewable energy in the north of Germany. Therefore, increasing transmission capacities to connect consumption centers with RES generation needs to be in the focus in national and European energy policy with a strategic grid development in a European context for a successful energy transition. The power grids are increasingly developing into the central infrastructure for climate protection. They have to be optimized and expanded in order to be able to integrate and transport the increasing share of fluctuating renewable electricity sources.

The power grids becoming the central interface for sector coupling, namely in the transport and heating sector as well as in industrial processes [1]. 50Hertz participates in projects to use surplus renewable energy for power-to-heat and power-to-gas, where appropriate. Sector coupling is entering a crucial phase. In the future, electricity will not only be consumed directly and used for electromobility and heat pumps, but also as Power-to-X for district heating and industrial processes. Hydrogen in the medium and long term will be obtained exclusively from renewable energies. This requires infrastructures that can be set up efficiently in cooperation with network operators [3]

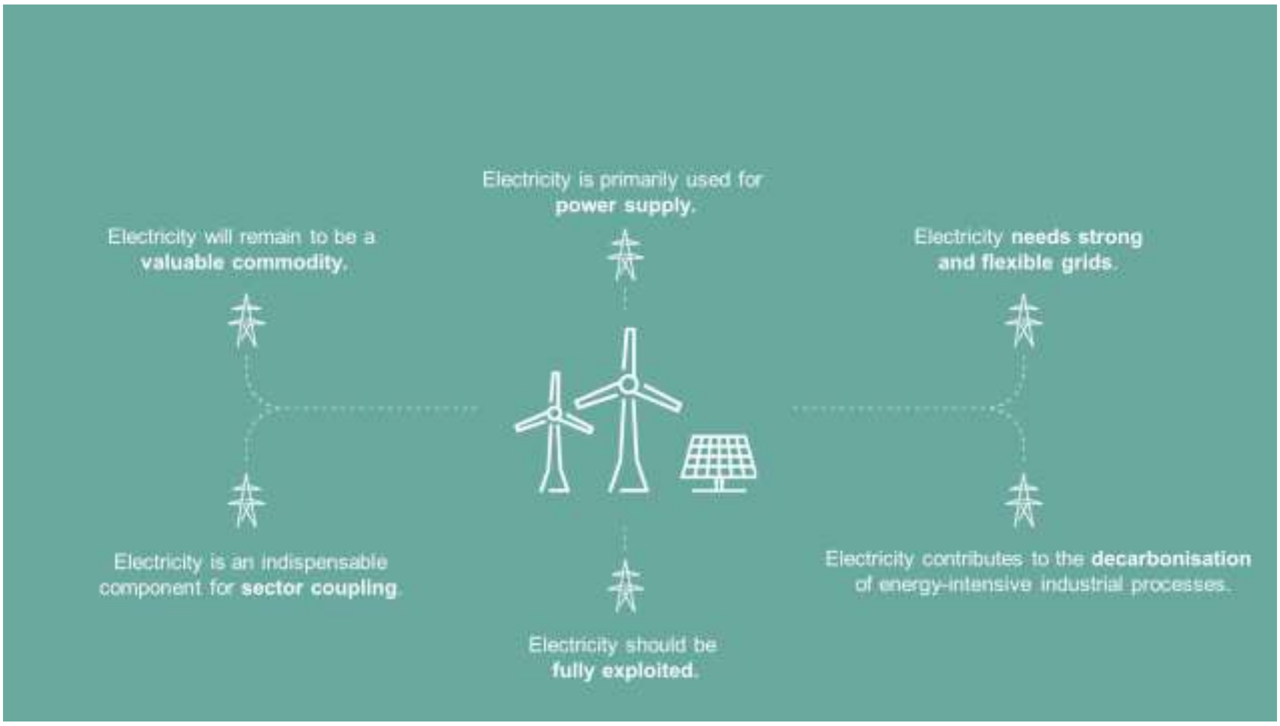

Fig. 5. Grids for power from renewable sources

Together with politics and society, 50Hertz will increase all of the potentials that is required for the 100 percent renewable target. This also means active support of developing further renewable energy potentials on land and at sea. 50Hertz is thus accelerating the energy transition and making it easier for established and new industries in its grid area to access green electricity. 50Hert is investing in a strong transmission network and is using all the technical possibilities that contribute to higher utilization of the networks and can therefore transport more electricity. 50Hertz is expanding its leading role in the control of the electricity grid and the company is developing innovative solutions to ensure that electricity supplies remain secure in a world with less fossil-fueled power plants [1].

Thanks to the big share of electricity from renewable energies in the 50Hertz network, the company helps ensure that the 50Hertz grid area will be attractive as an industrial location. Industry needs green electricity if it wants to produce climate-neutrally in Germany and Europe in the future. This includes not only the classic basic industries of steel, copper, aluminum, chemicals and cement, but also new players such as the digital industry with its energy-intensive data centers (Fig. 6). All of these companies will want to stay or settle there where they can meet their electricity needs entirely from renewable energies [3].

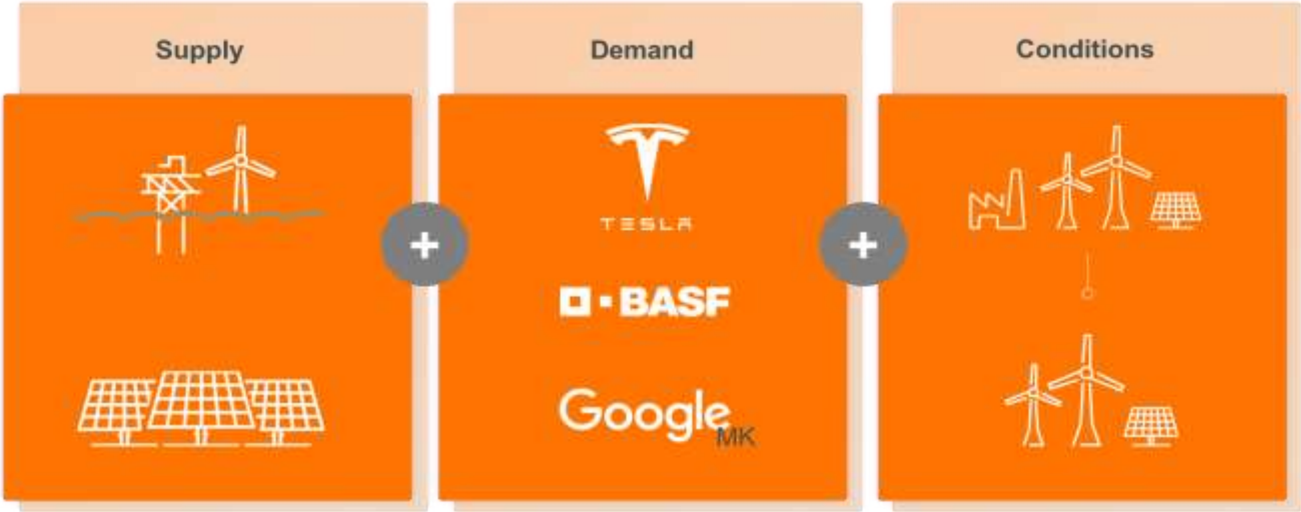

Fig. 6. An industrial policy initiative

The energy world of tomorrow is largely a world without conventional fossil fuel power plants. For the 50Hertz grid area, this means the challenge of keeping the electrical system safe and stable at all times with the help of the innovative technologies. 50Hertz is fully committed to digitalization when integrating renewable energies into the grid and controlling the electrical system. This is the only way we can achieve the necessary flexibility in a highly volatile environment. Complex digital technology plays an increasingly important role in an electrical grid that is becoming more flexible. When creating generation, consumption and load forecasts for the networks and operating resources, 50Hertz will increasingly use artificial intelligence in the future [3].

Conclusion

Global challenges such as increasing global warming shape the social and political goals. The 50Hertz initiative goes together with the new, ambitious European energy and climate policy: According to the "European Green Deal", Europe is to become the first climate-neutral continent by 2050. It is therefore important that 50Hertz has set itself the goal, namely 100 percent of the electricity demand in its grid area from renewable energies - and thus making a concrete contribution to achieving Germany's climate targets [1].

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Shifts in Russia – U.S. relations under the Biden administration: environmental and energy outlook

Speaking about prospects for Russia – U.S. relations under new American administration one can be certain about complex pattern of these relations without qualifying them as positive or negative. These relations are too sophisticated to be determined in such terms. However, certain regularities could be revealed in Russia-U.S. relations since 1990s. These relations if chronologically divided by the U.S. presidential administrations experience and demonstrate substantial optimism in the beginning and pessimism in the end of each U.S. president’s rule. Such optimism and pessimism is found on either side of the political fence. This regularity does not depend on the length of residence of the president in the White House: one or two terms and a visa-a-vis on a Russian side. Bill Clinton, George W. Bush, Barack Obama, Donald Trump wrap up their rule by completely losing mutual understanding in Russia – U.S. relations with Boris Yeltsin, Vladimir Putin, Dmitry Medvedev and Vladimir Putin again.

Joseph Biden administration possesses a potential to break this regularity offering no signals for optimistic beginning of a new phase of relations. Changed nature of bilateral relations does not allow anymore developing collaboration on strategic grounds only. The White House and Kremlin seek to preserve and extend the New START pact. However, consensus in strategic area cannot and is not set to revitalize full agenda of Russia-U.S. relations.

Current discussion leads us to 4 questions: 1) What has happened in the United States as a result of the 2020 elections? 2) What has not happen as a result of the 2020 elections? 3) What will not change in approaches to foreign policy and Russia in particular after the elections? and 4) What changes the Biden U.S. administration will introduce? All these issues will be examined through the prism of Russian foreign policy vector, energy and environment.

1) What has happened? The results of elections turned to be very controversial and reveled that instruments of political technologies worked better than party ideology within this election campaign. By the end of 2020 political struggle the United States obtained a powerful combination of executive and legislative branches controlled by the Democratic party. Such a combination provides for greater flexibility in decision making process in field of domestic and foreign policy. Washington bureaucracy and mass media momentarily have taken a course on detrumpinization of the U.S. political environment. Detrumpinization blitzkrieg will be enforced till the next congressional and gubernatorial elections to maintain current balance of Democratic-Republican power with the purpose to strengthen Democratic front by the next presidential elections. Democratic Party will avail itself of the opportunity to strengthen its positions within one electoral cycle. This strategy could push Trump electorate and moderate republicans to radicalization. So elections results contribute to a strong feeling of forthcoming substantial changes in policy making of a new administration. However, this feeling will not necessarily become true.

2) What has not happened? The election system of the United States has fallen in a systemic crisis, hasn't it? The answer is negative. Has it worked properly within existing limits? The answer is positive. Election system of the United States has not fallen and proved its sustainability. Regardless of all misinterpretations and criticism of its principles, claims about its inability to lawfully reveal political preferences not elites but voters, it has produced electoral products for legislative and executive institutions, which will be recognized by both parties. In other words value of statements concerning crisis of American election system seem to be exaggerated.

Another exaggeration relates to lack of confidence and distrust of American voters to electoral system. Distrust and lack of confidence may relate to political and economic elites and institutions, but definitely not electoral system. The 2020 presidential elections (congressional, state level and municipal elections as well) have demonstrated a record voter turnout for more than a century reaching 158,5 mln voters casting their ballots. Such striking indicators of electoral behavior prove that voters of different political camps trust in the fairness of the U.S. elections.

Regardless of the evident polarization of American society the results of elections will be gradually formalized and recognized according to the U.S. law. Polarization will not lead to any form of revolution.

3) What will remain as key characteristics of the Biden administration? Expectations of large scale political reforms will not necessarily meet significant changes domestically or internationally. It would be rather reasonable to anticipate succession, continuity and consistency especially in the U.S.

foreign policy. Regardless of all criticism of President Trump values and approaches many of them will remain as political instruments for the Biden administration.

i) Russian vector of the Biden administration foreign policy will not be significantly modified neither by executive nor by legislative institutions. A bipartisan and multi institutional consensus has been reached in Washington D.C. with regard to Russia. Russia is perceived as an adversary and the USA will continue policy of containment of Russia. China is also perceived as an adversary. However, these two actors are seen and treated differently. Russia is considered as a declining power, and that is why it is weaker opponent than China. Many American experts honestly believe that in a long run Russia will join the West striving for protection from rising China. Thus extension of the U.S. pressure on Russia and Russian projects to remain a feature of the U.S. foreign policy under a new administration.

ii) Besides bipartisan solidarity on Russian track that had been formed in Washington before the elections Joe Biden himself possesses a well-developed sense of priories, which he has inherited from President Obama administration. Russia will remain the issue of domestic policy in the United States. This relates to allegations of Russia about meddling into the U.S. elections, improper cyber activity and influencing U.S. energy market, human rights etc. This sends a warning signal to any friendly efforts on Russian track.

iii) Containment of both Russia and China will gain a new shape of multilateral efforts by the USA in collaboration with its allies. The role of the European Union in this filed will increase. However, the Biden administration will continue to consider the EU rather as an instrument than a partner for such containment.

iv) The U.S. will actively constrain and challenge Russia geopolitically in post Soviet area and economically in Europe limiting Russia's energy ambitions. Russian energy projects of different nature in EU will face countermeasures initiated by the United States. Any Russia-EU energy projects will be seen through the prism of securitization. This practice dates back to 1970-1980 when the U.S. efforts had been focused on preventing of Soviet gas import to Europe. Thus in 1980s Secretary of State George Shultz repeatedly discouraged Federal Republic of Germany from initiating gas projects with the USSR because of military security concerns.

v) Economic interests of Russian counterparts will fall in line with the concept of president Trump administration of fair trade dominating over free trade, which will be maintained by the Biden administration. Potential economic gains of the U.S. allies versus political, geopolitical and economic priorities of the Biden administration will be disregarded. In such a situation consensus hardly to be found. The U.S. approach to international energy mega projects could be illustrated by the Keystone XL long term construction. The project meets strong federal authorities' opposition and its destiny depends on the political party in control of the highest executive office and legislature. The Obama administration suspended the project, the Trump administration revived construction, the Biden administration promises to put the project on pause. Democratic presidents: Obama and Biden apply environmental and political agenda for preventing the project to be implemented. If environmental modus operandi is performed as a response to social-political demand than political opposition to the project rests on the economic grounds. Experts believe that Koch brothers (principle project beneficiaries) financial collaboration with the Republican party plays a crucial role in the Kestone XL destiny. In this context interests of Canadian beneficiaries are disregarded.

The “Nord Stream – 2” and “Kestone XL” projects cannot be technically compared because they are implemented in different geopolitical environments, however it would be reasonable to anticipate concurrent approaches to both projects.

With such a background there is no ground to expect that the President Trump approach to international trade as asymmetrical bilateral trade will be modified.

4) What novelties the Biden administration will incorporate? Inevitably, it will introduce certain upgrades of priorities for the next four years. Substantial part of them will concern a reconstruction and restoration of pre-Trump United States priorities while others will relate to modern challenges (e.g. pandemic, cyber security, ecological systems and technological ecosystems).

i) In the near future one will observe reemergence of a so-called “Collective West” (Consolidated West). The Biden administration will make substantial efforts to compensate four years of Trump decollectivization of the West by joint international initiatives. Initiatives may have existential nature such as climate change prevention and protection of human rights or situational character such as educating certain actors (China, Russia, Iran etc.) about their roles in international system. Western allies will be more than welcome to join collective efforts.

ii) Thus, the USA will face a challenge of reestablishment of international reputation and green leadership. This will lead to rolling back to environmental, energy saving, end carbon emissions policies domestically and to multilateral environmental protection mechanisms internationally. Climate change has become one of top priorities of Biden-Harris administration. In light of restoration of international image, the new administration will need to go far beyond rejoining Paris agreement. Paris agreement as a global environmental protection institution turned to be not that vulnerable without the U.S. membership, it has not collapsed after the U.S. withdrawal (as other international institutions after the U.S. has left). The U.S. return to Paris agreement reaffirms that in international environmental domain the role of the United States has been modified from a deal-maker to deal-taker.

iii) Institutional analysis and appointments to the key positions in the new administration confirm seriousness of electoral promises of Joe Biden in greening the U.S. policy. John Kerry, former Secretary of State (2013-2017), Democratic party nominee for president (2004) will become Special presidential envoy for climate. John Kerry will become a cabinet-level official sitting on the National Security Council. For the first time National Security Council will embrace an official who is responsible for climate change. On the one hand, such introduction to the National Security Council signifies recognition of a climate change as a national security challenge. On the other hand, this implantation is a child of political necessity. Securitization of climate change agenda on a federal level was raised by Bernie Sanders during presidential campaign in 2016. However, his enthusiasm was not shared by his fellow party members. Additionally the Biden administration has announced establishment of a White House climate director with responsibilities for domestic environmental issues.

iv) Environmental dimension of the Biden administration opens practical opportunity for Russia-U.S. dialogue in field of climate change prevention and environmental protection. Russia – U.S. agenda, if such positive agenda exists, is quite limited. Non-contentious character of collaboration in environmental domain puts it apart from other potential Russia-U.S. common agendas: energy supplies, Arctic, strategic and regional security, human rights, etc.

Wrapping up abovementioned hypotheses one can come to a conclusion that forthcoming foreign policy of the Biden administration will have confrontational characteristics: rhetoric, instruments and actions. Tension in Russia-U.S. relations will likely increase from the very beginning of the Biden administration term. Russian agenda in the USA, American agenda in Russia are perceived as toxic one. Modern Russia-U.S. relations are locked in a security agenda. Progress in Russia-U.S. dialogue will depend on other selected issues, potentially, environmental agenda.

Russia will continue experiencing difficulties with its energy projects caused by the US economic and political pressure. Pressure may be imposed by enacted sanctions or gain other forms: e.g. messages from the U.S. legislators to corporations involved into energy projects informing them about potential losses if collaboration with Russia continues.

As we speak Department of State, Department of Energy officers are calling EU corporations with a simple message: “We have an Offer You cannot Refuse”.

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EU´s ‘Green’ Policies in Central Europe: The Source of Conflict?

Introduction

In the past decade, the European Union (EU) has become the global torchbearer in introducing policies fighting climate change. It regularly sets goals for decreasing greenhouse gasses (GHG) and supports non-fossil fuels. In 2019, the EU stepped up the game by setting an ambitious long-term goal for the three following decades – to reach carbon neutrality by 2050. The deal did not come up easily and put the ‘old’ members at odds with several ‘new’, mostly post-communist, member states. Consequently, this ambitious goal revealed persisting cleavages within the Union and an over-arching and largely political nature of energy and climate policies. It became apparent that the East-West divide is still persistent after all, at least in areas tied to the economic model formerly implemented in the region. For its part, the Czech Republic has so far shown only a limited dedication to the EU-wide goals. The following text takes inventory of the Czech attitude in two recent years and puts it into a broader context.

Context

The EU´s goal of climate neutrality by 2050 essentially means that the EU and its members have to take actions to balance out its GHG emissions so that the final production of the entire Union will be net-zero. The path to this long-term goal will be paved by shorter-term goals, among which the most immediate one is set for the upcoming decade. The EU´s climate policies have always been a sensitive topic given the structural and energy mix differences among its members, however, since the fight against the climate change became the Union´s flagship policy, these differences became even more glaring, especially between the 'old' and the 'new' members. In this sense, the most apparent and impactful differences stem out of the economic structure. The central and eastern European (CEE) states that joined the EU after 2000 were mostly post-communist countries, typical for significantly different economic structure compared to the 'old' members. These new member states have been known for a generally higher share of industry in their economies, a feature stemming from a different economic model implemented in the second half of the 20th century when they focused on heavy industry and manufacturing. This developmental path, inspired mainly by the model implemented in the Soviet Union, has resulted in relatively higher energy intensity (i.e., unit of energy needed to produce a unit of GDP) compared to countries in western Europe ("How Efficient Are We in Our Consumption of Energy?" n.d.). The economic restructuring, which started in the 1990s, did result in a shift in the economic structure towards a more service sector-based economy, the difference is, however, still significant. Nowadays, the pressure to decrease GHG highlights these differences even more. Although the post-communist states in CEE have been able to cut their emissions significantly, much of this decrease came as a result of a downturn in the industrial sectors in the aftermath of the political changes in the early 1990s. Still, as many of the CEE states have continued to rely on manufacturing as the backbone of their economies, their energy intensity is still relatively higher compared to western EU members. As a result, we can still see the East-West divide in the EU.

On top of it, similarly to other countries, CEE states will also need to phase out coal-based power generation in the future, a task that seems especially daunting in countries like Poland, where coal-based production still assumes almost 80% of the mix ("Poland: Energy Production Mix 2020-2040 | Statista" 15 August 2019). Therefore, as cutting GHG emissions results in a relatively higher impact in energy-intensive, manufacturing-based economies, the CEE states are concerned that they will be disproportionally burdened. Recently, the issue is becoming politicized and may be detrimental to the EU´s image in these states. The EU´s effort to unite its members in a fight against the climate change may thus backfire in the form of heightened internal tensions. The Brussels now has to be wary of such development especially in times when its relations with the Czech Republic, Hungary and Poland soured over financial and legal disputes respectively[21].

[21] In the Czech case, the disputes are related to the PM´s conflict of interest and related EU subsidies while Poland and Hungary have been in a row for the proposed rule of law budgetary conditionality.

Pollution-Cutting Ambitions in Light of the Post-Pandemic Recovery and the Czech Position

In 2019, the European Commission came with a bold proposal that the EU should become climate-neutral by 2050, meaning that the emission impact on the climate should be net-zero ("2050 Long-Term Strategy | Climate Action" n.d.). The proposition of the plan commonly known as the European Green Deal entails emission curbing and offsetting or balancing out polluting production, which cannot be phased out (e.g., carbon sequestration, afforestation, etc.). It was apparent right from the beginning that this target is both very ambitious and potentially sensitive and that CEE countries will likely not be the most enthusiastic supporters of the plan for the reasons stated above. These pessimistic expectations were largely met as Poland, Czech Republic, Hungary, and Estonia were unwilling to come to terms with the rest of the EU on the plan´s features. The main sticking point was the deadline introducing the measures, but as it later turned out, there were also disagreements on which technologies will be accepted as the low-carbon energy solution. In any case, at the summit in June 2019, these four countries prevented reaching the consensus, and the final deal was thus postponed ("EU Climate Deal Falls at Summit, Four Countries Wield the Axe – EURACTIV.Com" 21 June 2019).

As for the Czech Republic, its resistance, similar to the other resisting sceptical states, was based on the concerns over the impact of the transition on the country´s industrial sector, economic structure and, consequently, employment. For the current Czech government, which closely follows public sentiments, the support for the EU´s plan posed a potentially sensitive, high-risk-low-reward option (Osička and Černoch 2017, 10–12). The Czech Republic also expressed its concerns about the deadline of the plan (i.e., 2050).

However, six months later, at the summit in December 2019, three out of the four originally resisting states - Czech Republic, Hungary, and Estonia – were aboard as the EU promised financial support to mitigate potentially harmful impacts of the transition on sensitive regions. What was instrumental, especially for the Czech Republic and Hungary, was the rather vague yet politically important promise that reads as follows: *"The European Council acknowledges the need to ensure energy security and to respect the right of the Member States to decide on their energy mix and to choose the most appropriate technologies. Some Member States have indicated that they use nuclear energy as part of their national energy mix."* ("European Council Conclusions, 12 December 2019" n.d.). This seemingly unimportant sentence hinted at the potential recognition of nuclear energy as a part of individual countries´ paths to climate neutrality. The political significance of this statement lies in the fact that both the Czech Republic and Hungary rely heavily on nuclear energy for their power generation and are poised to increase the share of nuclear energy even more. Additionally, the Czech Republic tries to win the European Commission´s (EC) approval for state aid for the project of the new nuclear unit in the Dukovany Nuclear Power Plant. The support for the Green Deal was thus seen as an important step towards the eventual EC´s support in a 'quid-pro-quo' manner. Poland, for its part, was still not part of the deal as it was promised to be given more time for the transition given its high dependence on coal-based power generation ("Poland - Countries & Regions - IEA" n.d.; Osička et al. 2020).

As unexpected as the coronavirus outbreak in 2020 was, the pandemic had a somewhat foreseeable impact on the Czech position vis-à-vis the European Green Deal. As soon as March 2020, the Czech Prime Minister let himself be heard that the EU should abandon the plan since the time is not right given the pandemic ("Czech PM Urges EU to Ditch Green Deal amid Virus – EURACTIV.Com" 17 March 2020; "Europe Should Forget about Green Deal, Focus on Coronavirus - Czech PM | Reuters" 16 March 2020). The Czech PM hinted that, in his view, the economic recovery and energy transition were two mutually exclusive goals. Such a position was hardly surprising given the previous, rather conditional, 'yes' to the EU´s climate plan. What was surprising, though, was the country´s government radical change of attitude, which took place only two months later when the Czech Minister of Environment backed the EU´s Green Deal-based recovery plan. Although the changed view was expressed by the Minister of Environment and not the Prime Minister at that time, it was nonetheless remarkable ("In Political U-Turn, Czechs Back EU's Green Recovery Plan – EURACTIV.Com" 26 May 2020). Nevertheless, it remains a question what was behind this change of attitude. The situation in the Czech power generation and the plan to build new nuclear unit may again provide a plausible explanation as the Czech government wants the European Commission´s approval for the state aid for the new nuclear unit in the Dukovany Power Plant. Furthermore, the Czech government has been pushing the EU to recognize nuclear energy as a possible path to decarbonization. Therefore, opposing the EU´s flagship environmental policy seemed like a sure way to alienate the Brussels against the government´s plans and thus a very shortsighted policy.

Despite the apparent appeasement between the Czech government and the EU on the 2050 target, differences remained in the short-term goal for the upcoming decade. Originally, the target was 40% cut in GHG compared to 1990 levels ("2030 Climate & Energy Framework | Climate Action" n.d.). However, in September 2020, the Commission proposed a more ambitious target - 55% reduction. In this sense, the goal was quite the opposite of what the Czech government was hoping for in spring. Instead of seeing the pandemic as an obstacle to the ambitious transition plan, the Commission saw the crisis as a springboard and an opportunity to rebuild the economy in a more environmentally friendly way. As much as the Czech Republic was on board in terms of the 2050 goal at that time, it clearly was not ready to agree with a stricter target for the short-term outlook. A month later, the government softened its position in a move, which resembled the spring turnover. Once it was made clear that the EU target will be collective and individualized GHG reduction goals for respective countries can be expected, Prague was on board again. It remains a question whether the former Czech position was not just a result of misinterpretation since individual targets within a broader framework are common in this regard and could have also been expected in this case. In any case, at the December summit of 2020, the stricter 2030 climate target as well as the 2050 goal, were legally established and agreed on respectively. The Czech Republic agreed on the deal while simultaneously pushing for financial support and a more detailed roadmap to the 2030 goal. These details will be a subject of negotiations the following year. Similarly, it is yet to be seen what the details of the Czech contribution will look like and what will be the concessions the country gets for the support ("EU Countries Agree 2030 Climate Goals before Battle with Lawmakers – EURACTIV. Com" 18 December 2020).

As much as the individual targets for the EU members are yet to be determined, what became apparent in 2019 and 2020 was that the Czech support for the EU´s climate goals is highly conditional. For that matter, the Czech Republic, or its current government for that matter, perceives its support as transactional and the support does not stem from the country´s own policy goals. Instead, it is based on more immediate-term targets and particular interests arising from the country´s internal issues. Any tightening of the proposed targets, as suggested by the European parliament, may undermine the support once again ("EU Countries Agree 2030 Climate Goals before Battle with Lawmakers – EURACTIV.Com" 18 December 2020).

Although the Czech country´s representatives originally maintained that they could not go higher than 45% in promising GHG cuts by 2030, evidence shows that it was not for the lack of potential. When taking a closer look, several areas appear to be ripe for improvements. The most glaring among them is energy efficiency and support for renewable energy sources. However, stronger support for renewables became a sensitive issue with a potential to alienate significant cohorts of voters ("Kontrolní Závěr z Kontrolní Akce 18/22 Podpora Environmentální Politiky v Oblasti Příjmů Veřejných Rozpočtů" n.d.; Vlček et al. 2019, 141–44).

Conclusion

The development around the EU´s Green Deal amid the COVID-19 pandemic revealed the extent to which the EU members are dedicated to the project. The Czech case turned out to be a clear example of an opportunistic attitude, built on a transactional principle. As such, the Czech Republic showed a limited dedication to the project and used its eventual support as a bargaining chip in order to win the Commission´s approval for the country´s specific energy goals. It is apparent that the Czech attitude stems from the country´s characteristics, which represent the rigid feature, as well as short- to mid-term goals, which represent rather tactical bargaining aimed at gains in a more immediate future. The first factor entails mainly the Czech economic model, which is common in countries in central and eastern Europe given their past development, while the second one is determined by the current government´s goals. A thorough scrutiny of the Czech readiness to embark on a journey to a low carbon future revealed that the country even falls behind in meeting its own goals for the decade determined by the EU´s targets. In conclusion, the government's policies are, in no small extent, politicized and hinged on the public sentiment, which makes the country an unreliable partner on the European level.

The EU´s ambitious climate-related goals highlighted some deeply embedded structural differences between its members, and even though it seems that after almost two years the agreement was reached, the support is still rather uncertain. The central European members still see the impact of the measures as potentially detrimental to their economies. If the EU decides to answer the calls to push the measures further, the cleavages may appear too wide to be bridged. In times of less-than-ideal relations between the Brussels and some CEE countries, these discrepancies may easily turn into a much bigger political conflict.

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Russia and the global energy transformation post covid-19

Russia has been facing three economic recessions in the past 11 years. All were provoked by external shocks and amplified by domestic factors. There will be more such external shocks provoked by environmental degradations. Draughts, forest fires, floods but also, pandemics. Scientists of the IPBES estimate that 1,7 million unknown viruses are within animals. Many unknown viruses are also in Russia's Arctic permafrost which is heating up four times the world average. Russia is the world's largest country on earth. It will be one of the most hit by climate change and environmental degradations. There will be huge financial consequences. Adaptation is important but not sufficient: mitigation strategies are key.

Russia and the EU now share a similar achievement in terms of GHG emission reduction since 1990, and a similar historical responsibility as one of the world's largest historical emitter. While the EU and Russia both have achieved some emission reductions due to deindustrialization, a large part of EU's emissions is mainly due to public policies. There are no such policies in place in Russia.

Most of Russia's neighbours are now on a path to climate neutrality: USA, South Korea, Japan, China, EU. All members of the UN Security council are, except Russia. This is now becoming a liability for Russia's international image especially since Russia is a large historical emitter.

This also means: the competition for innovation, scale up, mass deployment of low carbon technologies, is exacerbating. Value will be created from technologies and transformed products, always less from raw materials and resources. Real winners are those than can build on both pillars and that are participating in the race. Latecomers will not be able to compete, or will pay a super high entry price.

1. Russia's assets for the low carbon energy transformation

Russia has key ingredients to be part of that race: knowledge & education, engineer skills, metals, critical metals, a cheap ruble. It misses two key things though: a strong domestic ambition and its internal market to drive demand, test these solutions and make these solutions and technologies best of their kind and ready for export.

When I look at all the oil and gas producers in the world, then Russia is the country that could win most from the global energy transformation and decarbonization.

- Russia is already taking part with its thriving nuclear industry, in several aspects, the best in the world. It needs to be more credible on safety, transparency and non-proliferation though.
- It could supply the EU and the world with low carbon steel and become a leader in low carbon steel production.

- It could become a leader in high efficiency sustainable mini grid systems.
- It could create hundred thousand jobs in building renovation.
- It could be a key digital solutions providers, which go hand in hand with the transition.
- It could become a leader in sustainable mining, exporting its solutions everywhere as this will be key when we move to wheel to grave carbon footprint measurements.
- It could turn its forests into one of the world's largest carbon sinks while also developing its agriculture more north, and with the resulting waste, produce biomethane that could be blended into pipelines or used for the transport sector. Russia's forest could enable it to export CO2 compensated LNG and part of its pipeline gas too, provided there is a transparent, verifiable accounting methodology in place that meets international standards. Hence why it is also adamant that Russia participates actively in the elaboration of such international methodologies, which by the way could be an opportunity for cooperation in the framework of the global climate and biodiversity governance.
- There are massive methane leakage reduction opportunities in Russia, which should be an absolute priority to address as the image of the entire gas industry is already severely impacted by the insufficient efforts and results in this field. While the US has become the world's largest problem in this respect, Russia or countries like Nigeria are also a major challenge. The US is now expected to move rapidly to address this daunting threat to the climate, and latest satellite and drone technologies allow an efficient monitoring of leaks. Flaring should be further reduced too.
- It could become the world's largest low carbon H2 hub, supplying to Asia and Europe with H2 from all the colours: Russia could be the rainbow H2 supplier of the world.
- Of course, Russia wants to continue supplying gas via existing pipelines to Europe so that others transform the gas downstream into H2. That will not work if Russia is not investing in the supply chain and sharing some of the risks to showcase its commitment.
- It could actively join global efforts to harmonize non-financial disclosures, and taxonomies.

So the point is: Russia should move on decarbonization much more than it did so far and has a lot to win from it.

2. When must Russia move?

Russia will not suffer economically in the coming ten years if it continues its status quo while others accelerate on their energy transformation. Gas prices will remain rather depressed in the coming decades but Russia's gas exports will remain strong, notably to Europe, and growing to China. Oil prices will rise again once economies are back on a sustained economic growth path and as investments will be subdued. The world needs high oil prices to successfully decarbonize.

What are the implications? Does it mean Russia can afford to sit and rest?

That would be dramatic for Russia's long-term stability and the world's stability.

Russia must move resolutely now through stringer environmental and climate regulation first. Russia could turn its fiscal reserves that will then be replenished into a decarbonization fund to spur public investments into decarbonization solutions. And rather than seeking to produce always more oil, reduce its production.

The world is changing fast and others will take the lead. A nation cannot run this marathon if it does not prepare for it. Now is the last opportunity to join the race for low carbon &digital transformation and help preserve our eco-systems as the climate threat is building up.

To wrap up, ahead of COP26, a significantly enhanced Russian NDC would be a huge winner for Russia, EU-Russia relations and the world.

Russia's long-term security policy cannot rely on military components only. It needs to rely also on resolute climate policies and participation in this global effort.

Let us no more waste energy criticizing renewables, public subsidies and rather work together on new win-win partnerships. Russia must remove the EU energy transition from its list of strategic threats.

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Impact of COVID-19 Pandemic on China's Energy Industry

Abstract: Compared with the rapid spread of the epidemic in the world, China has basically controlled the COVID-19. However, China's energy industry is also affected by this epidemic. Therefore, this study aims to explore the influence mechanism between COVID-19 and energy industry, and then provide a systematic analysis of the impact of COVID-19 pandemic on China's energy industry from various aspects: fossil fuels, renewables, and energy enterprises. The results imply that the impact of COVID-19 on the fossil fuels' supply side in China is not significant, however COVID-19 has taken a heavy toll on the fossil fuels' demand side. Moreover, considering the diminishing government subsidies and ongoing COVID-19, both risks and opportunities exist in China's renewables. Although Chinese NOCs' operating performance and free cash flow in early 2020 dropped significantly due to the COVID-19 and low oil price, they have made net profits from the previous loss later after the COVID-19 was successfully controlled in China (approximately since Q3 2020). Finally, though COVID-19 impacted China's energy industry through various aspects, its energy system can gradually recover due to the spontaneous market regulation and government guidance.
Keywords: COVID-19; Energy industry; Fossil fuels, Renewables; Energy enterprises; China.

JEL Classification: F18 L19 L70 O13 Q40

1. Introduction

The outbreak of Coronavirus Disease 2019 (COVID-19) has exerted profound and extensive influences on economic society and human life in the world (Klemeš et al., 2020; Tahir and Batool, 2020). Globally, as of 29 December 2020, there have been 79,931,215 confirmed cases of COVID-19, including 1,765,265 deaths, reported to World Health Organization (also see Figure 1; WHO; 2020). As the health and human toll grows, the economic damage is already evident and represents the largest economic shock the world has experienced in decades (World Bank, 2020). In addition to the economic society and human life effects, the COVID-19 has severely affected the global energy industry, as the energy industry is the essential pillar industry and extremely sensitive to emergency incidents (Lin and Su, 2020). Specifically, according to statistics from the International Energy Agency (IEA; 2020), in 2020, the world's investment in oil and gas exploration and development reaches about 328 billion US dollars, which is reduced by 155 billion US dollars compared with 483 billion US dollars in 2019, a drop of 32.1%. Accordingly, in 2020, the supply and demand volumes of oil and gas in the world significantly reduce. For example, compared with 99.76 million b/d in 2019, global oil supply continued to decline in the first three quarters of 2020, from 100.18 million b/d in the first quarter to 90.32 million b/d in the third quarter, based on the Monthly Oil Market Report (MOMR) published by the Organization of Petroleum Exporting Countries (OPEC; 2020). Meanwhile, in 2020, due to the COVID-19, the world oil and gas prices fluctuated at a low level.

Figure 1. COVID-19 situation across the globe. Dara source: WHO (2020).

Compared with the rapid spread of the epidemic in the world, China has basically controlled the COVID-19 owing to the great efforts of the Chinese government and people. Specifically, in China, from 3 January 2020 to 29 December 2020, there have been 96,513 confirmed cases of COVID-19 with 4,782 deaths (WHO, 2020). Similarly, China’s energy industry is also affected by this epidemic; however, the overall pandemic influences on China’s energy industry is not clear so far. Therefore, in this study, we aim to explore the influence mechanism between COVID-19 and energy industry, and then provide a systematic analysis of the impact of COVID-19 pandemic on China's energy industry from various aspects: fossil fuels, renewables, and energy enterprises.

The following part is structured as follows. Section 2 presents the influence mechanism between COVID-19 and energy industry. Section 3 provides a preliminary analysis on the impact of COVID-19 pandemic on China's energy industry. Section 4 concludes this paper.

2. Influence Mechanism between COVID-19 and Energy Industry

In this part, we analyze the influence mechanism between COVID-19 and energy industry from the following three aspects, i.e., fossil fuels, renewables, and energy enterprises (also see **Figure 2).**

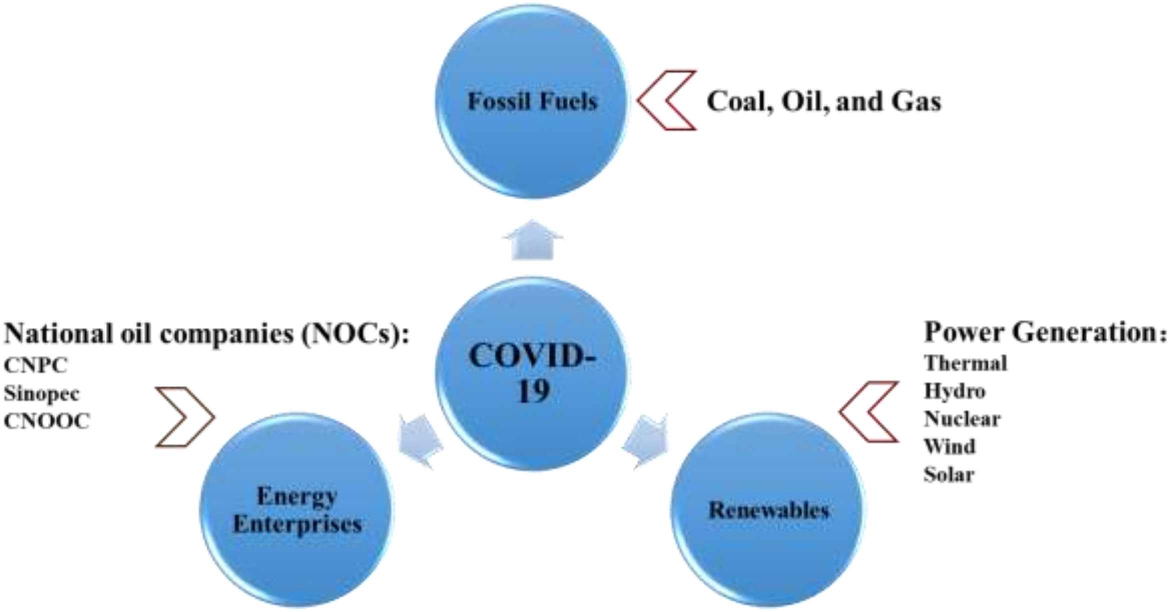

Figure 2. Influence mechanism between COVID-19 and energy industry.

1. **Effects on fossil fuels.** After the outbreak of COVID-19, the skyrocketing infection has restricted 30% of the global population from outdoor activities, which severely affects all walks of life from industries, tourism, manufacturing, transportation, tertiary, and the residential sector (Ghiani et al., 2020). The energy consumption in these sectors are seriously diminished around the world (Norouzi et al., 2020). Therefore, COVID-19 has a significant impact on energy consumption by affecting the total energy consumption and energy consumption patterns.

2. **Effects on renewables.** During the pandemic, the national governments have gradually been conscious of the vulnerability and limitation of traditional fossil fuels, and called for developing the renewables (Graff and Carley, 2020; Malliet et al., 2020). However, the development of renewable energy is also affected by COVID-19 pandemic. On the one hand, COVID-19 can stimulate the development of renewable energy by adding more investments, promoting the development of renewable technologies, and diversifying the energy operation and business modes. On the other hand,

COVID-19 also imposed some negative impacts on renewable energy. For example, due to the lockdown policy, international trade of renewable energy commodities (e.g., the export of China's PV modules) is inhibited.

3. **Effects on energy enterprises.** COVID-19 has a lasting negative impact on the global economy and energy enterprises (Aydın and Ari, 2020). Under the lockdown policy, the energy enterprises are full of uncertainties due to the sudden drop in crude oil demand. Thus, the fluctuations of the energy enterprises caused by COVID-19 can be manifested in two aspects: the volatility of energy price and stock price of energy enterprises as well as the variations of macroeconomic performance of energy-dependent countries.

3. Preliminary Analysis on the Impact of COVID-19 Pandemic on China's Energy Industry

3.1. Effects on Fossil Fuels

1. **Coal.** From Figure 3, the impact of COVID-19 on the coal supply side in China is not significant. Specifically, the accumulated coal output in the first three quarters in 2020 was 2.79 billion t, representing a 0.1% year-on-year decrease.

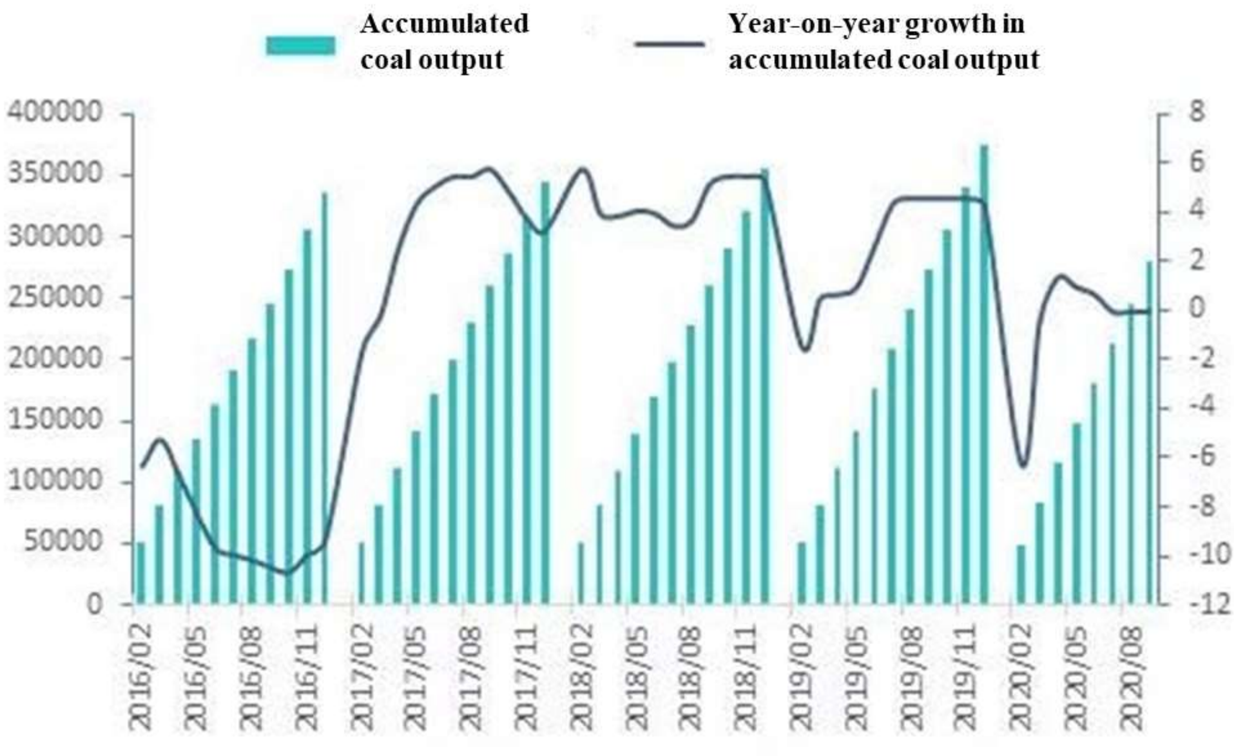

Figure 3. Impact of COVID-19 on the coal supply side in China. Dara source: National Bureau of Statistics (NBS) Database (2020).

Then, as shown in Figure 4, the COVID-19 has taken a heavy toll on China's coal imports, especially in Aug and Sep 2020, representing a 37.29% and 38.34% year-on-year decrease.

Also, COVID-19 significantly impacted the coal consumption in China, the growth rate of coal consumption dropped significantly, as reported in Figure 5.

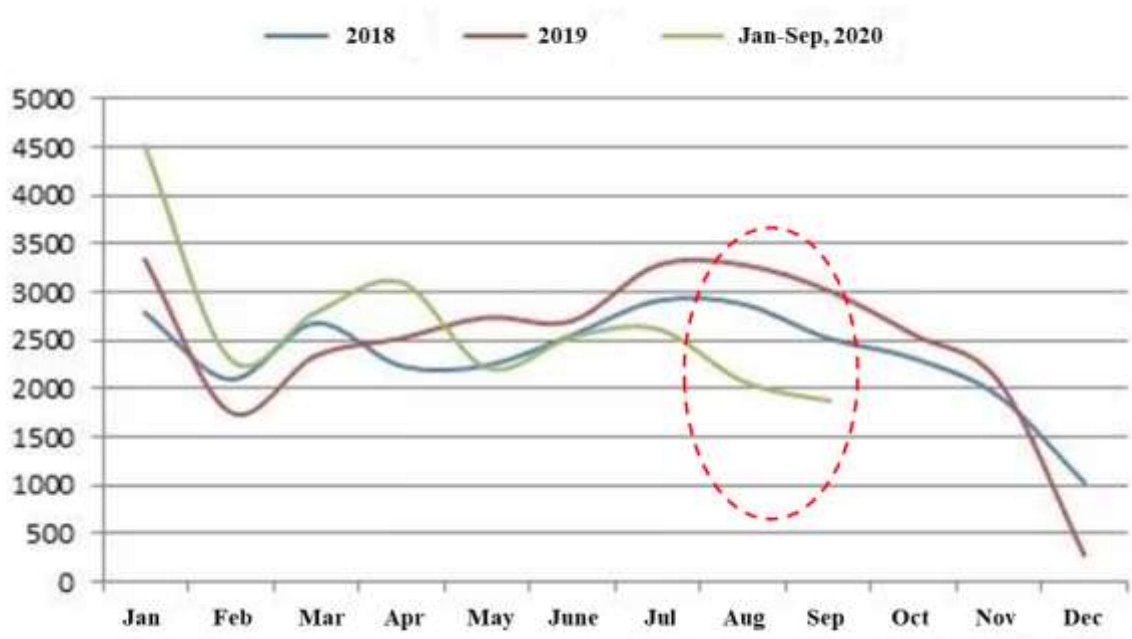

Figure 4. Impact of COVID-19 on China's coal imports. Dara source: NBS (2020).

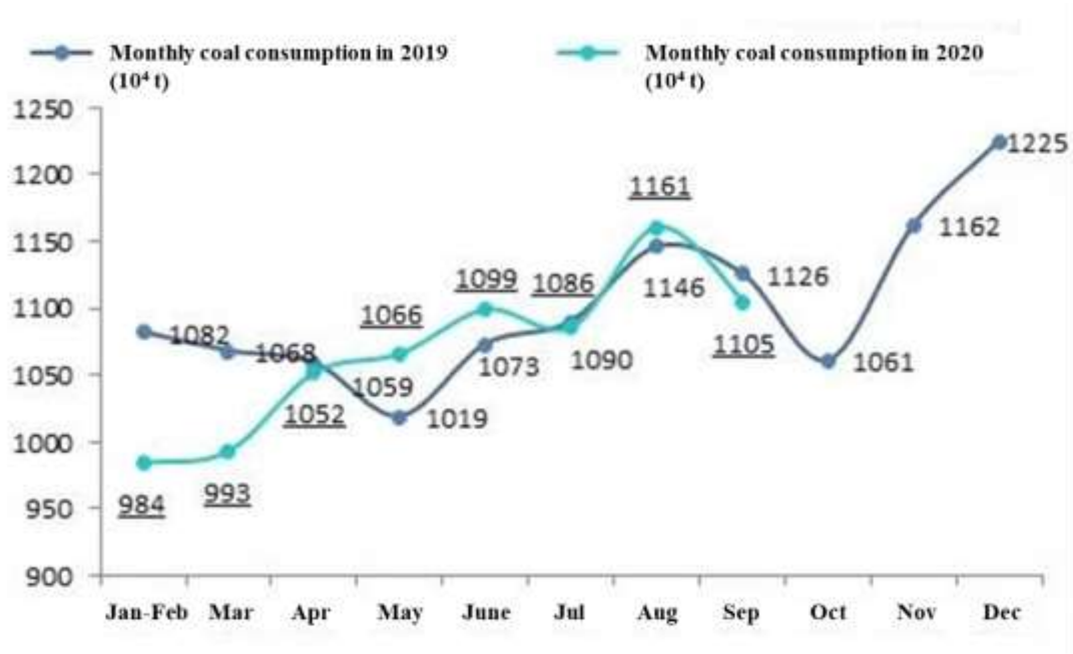

Figure 5. Impact of COVID-19 on China's coal demand. Dara source: NBS (2020).

2. **Oil.** First, the COVID-19 has taken a heavy toll on global oil prices, especially in the early 2020 (see Figure 6).

From Figure 7, though COVID-19 impacted oil production and operation in China, the crude oil output slightly increased.

Figure 6. Impact of COVID-19 on global oil prices. *Dara source*: EIA (2020).

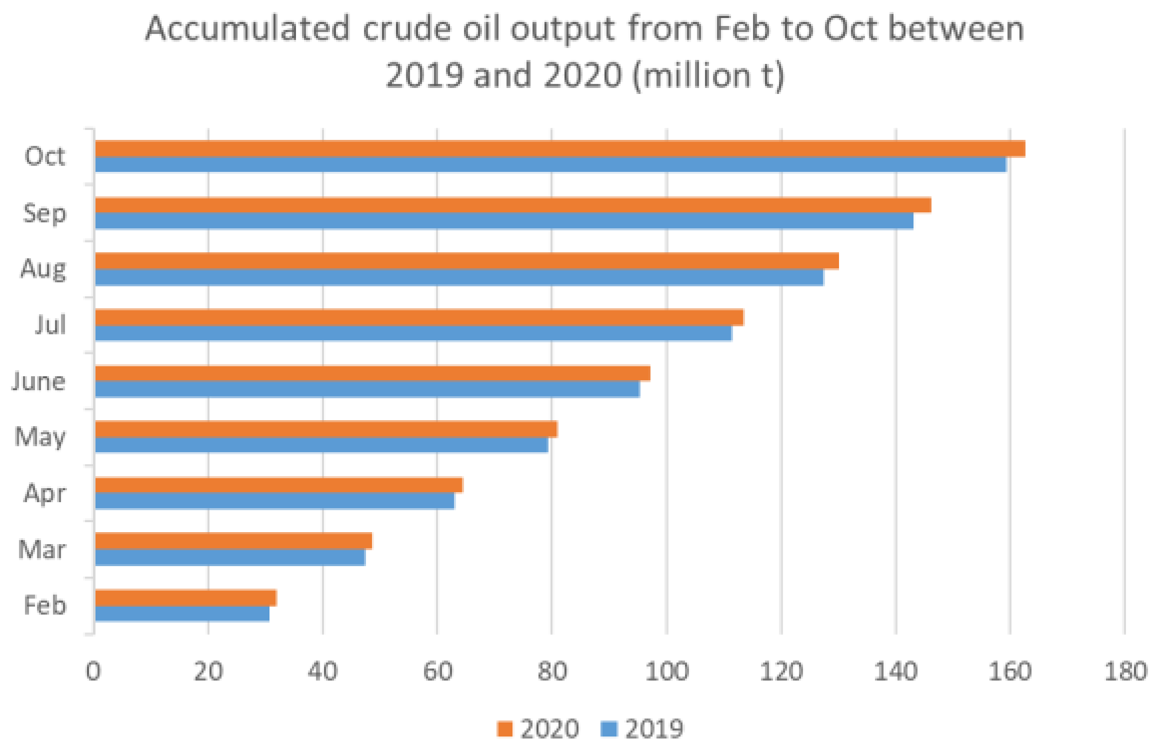

Figure 7. Impact of COVID-19 on the oil production and operation in China.

Then, as indicated in Figure 8, though the processing volume of crude oil in China decreased in early 2020 due to COVID-19, it gradually increased after the COVID-19 was successfully controlled in China (approximately since May 2020).

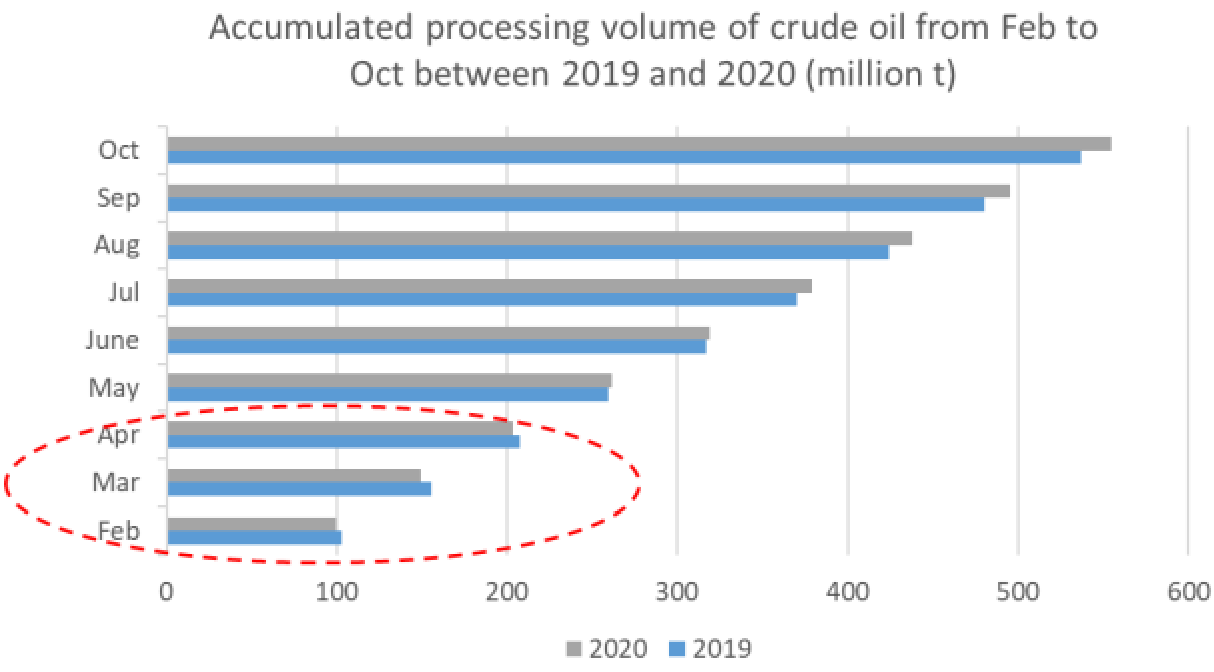

Figure 8. Impact of COVID-19 on the processing volume of crude oil in China.

Next, the COVID-19 significantly impacted the consumption of oil products in China, especially in early 2020, however the consumption is recovering after the COVID-19 was successfully controlled in China; please see Figure 9.

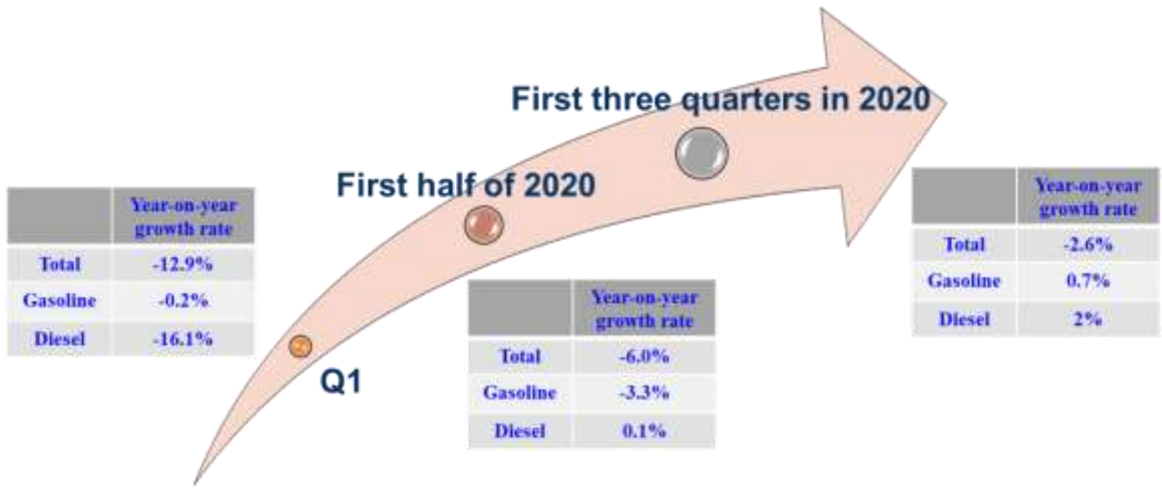

Figure 9. Impact of COVID-19 on the consumption of oil products.

3. **Gas.** First, the impact of COVID-19 on the gas supply side in China is not significant and, thus, the gas output increased steadily, including natural gas and LNG (see Figure 10).

However, COVID-19 significantly impacted the gas demand side in China (see Figure 11). Specifically, the growth rates of gas demand in Q1 and the first three quarters in 2020 are 1.6% and 3.6% respectively lower than the pre-virus outlook (8%).

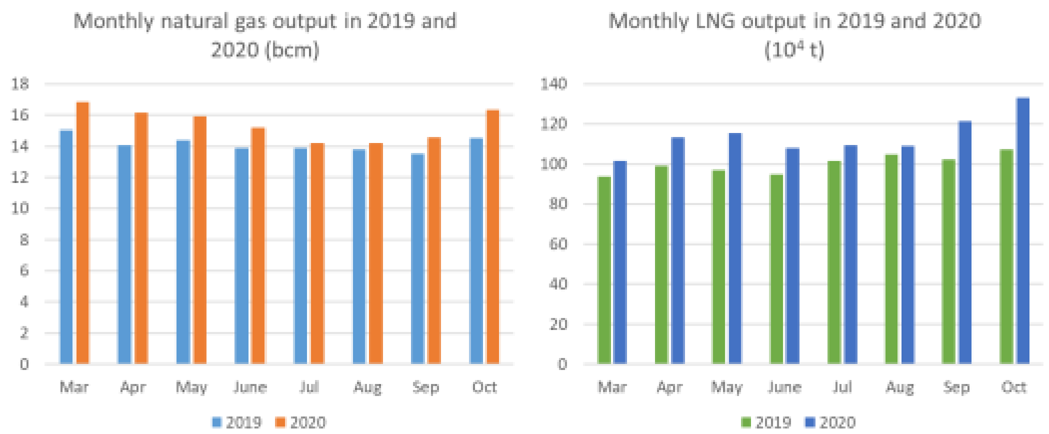

Figure 10. Impact of COVID-19 on the gas supply side in China. *Dara source*: National Development and Reform Commission (NDRC; 2020).

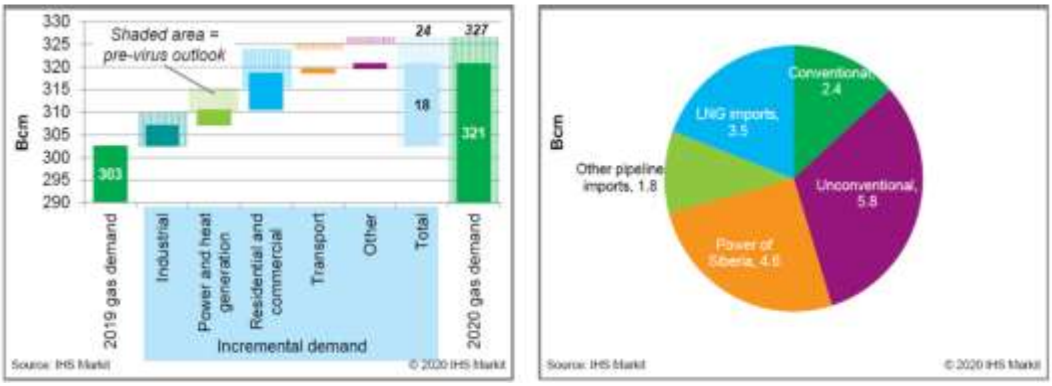

Figure 11. Impact of COVID-19 on the gas demand side in China. *Dara source*: NDRC (2020) and HIS Makit (2020).

3.2. Effects on Renewables

From Figure 12, though demand weakening caused by COVID-19 in Q1 2020, the accumulated power generation between Jan and Oct increases as compared with the same period of last year.

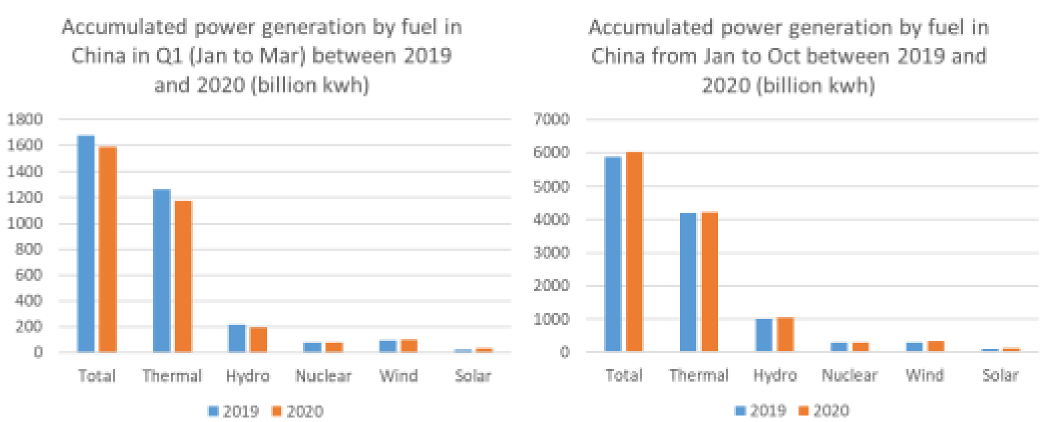

Figure 12. China's accumulated power generation by fuel. *Dara source*: NBS (2020).

Considering the diminishing government subsidies and ongoing COVID-19, both risks and opportunities exist in China's renewables (see Figure 13). Specifically, in early 2020, the growth of power generation by fuel significantly decreased as compared with the same period of last year (2019). Subsequently, the year-on-year growth of power generation by fuel gradually increased, especially the renewables.

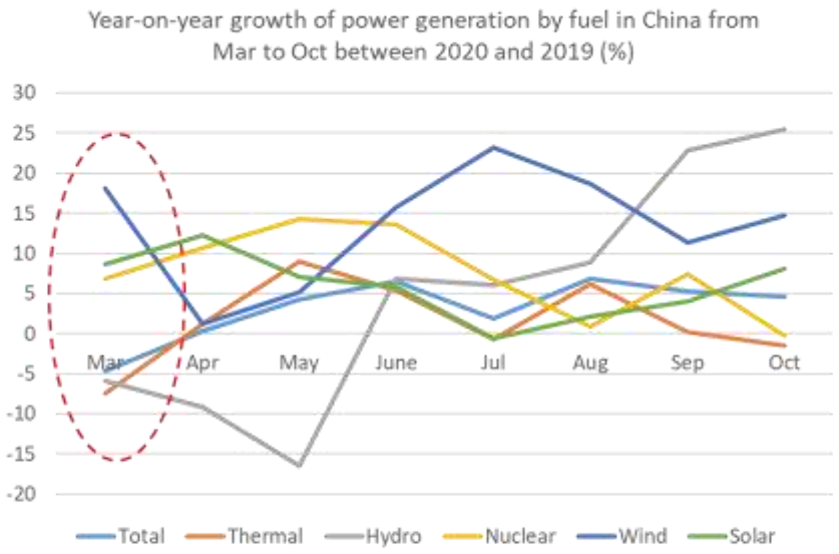

Figure 13. Year-on-year growth of power generation by fuel in China.

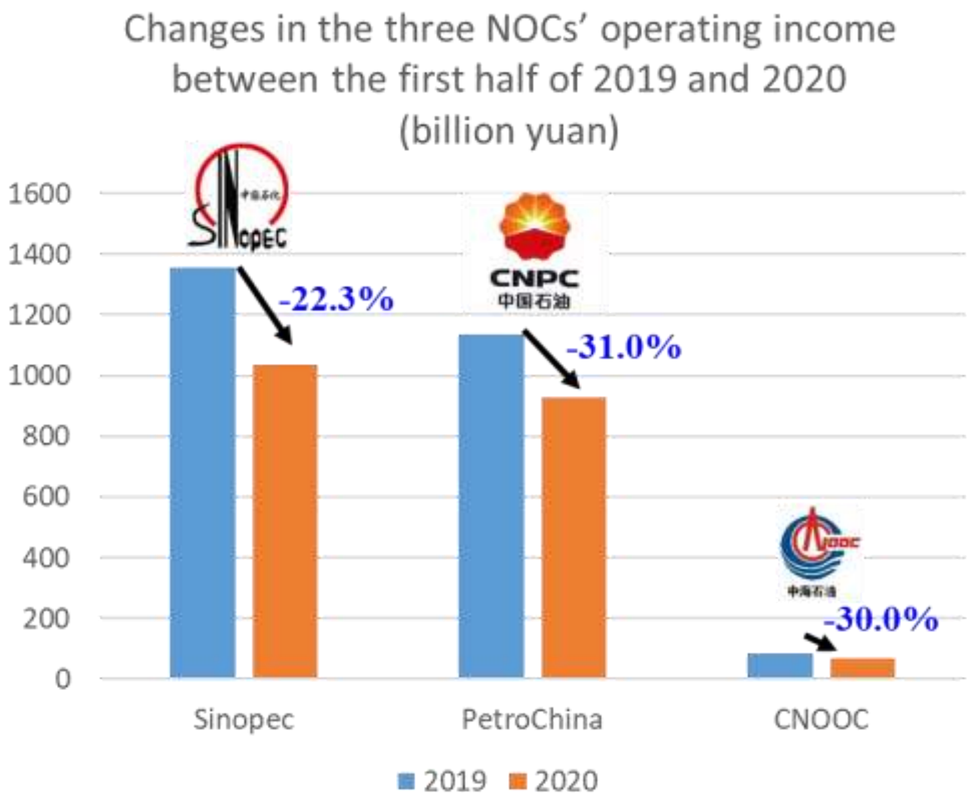

Figure 14. Chinese NOCs' operating performance and free cash flow.

3.3. Effects on Energy Enterprises

As shown in Figure 14, the operating performance and free cash flow of the national oil companies (NOCs) in China in the first half of 2020 dropped significantly due to the COVID-19 and low oil price. However, in the third quarter of 2020, Chinese NOCs conquer the COVID-19 and make net profits from the previous loss, especially CNPC and Sinopec. Specifically, the net profit of CNPC and Sinopec in the third quarter stood at RMB 40.05 and 46.18 billion, respectively. Conversely, the revenue of NOOC was RMB 35.55 billion, representing a 26.8% year-on-year decrease.

4. Conclusion Remarks

By exploring the influence mechanism between COVID-19 and energy industry and systematically analyzing the impact of COVID-19 pandemic on China's energy industry from three aspects (i.e., fossil fuels, renewables, and energy enterprises), several important findings are highlighted as follows:

(1) Generally, the impact of COVID-19 on the fossil fuels' supply side in China is not significant, however COVID-19 has taken a heavy toll on the fossil fuels' demand side. Among them, the demand for coal and oil decreased due to COVID-19. Though gas demand still increased, however the growth rate was lower than the pre-virus outlook.

(2) Considering the diminishing government subsidies and ongoing COVID-19, both risks and opportunities exist in China's renewables. It also meets China's carbon neutral goal and the forthcoming 14th Five Year Plan for energy structure adjustment.

(3) Although Chinese NOCs' operating performance and free cash flow in early 2020 dropped significantly due to the COVID-19 and low oil price, they have made net profits from the previous loss later after the COVID-19 was successfully controlled in China (approximately since Q3 2020).

(4) Though COVID-19 impacted China's energy industry through various aspects, its energy system can gradually recover due to the spontaneous market regulation and government guidance. This implies with the government guidance, the resilience of China's energy system is enough to respond to the COVID-19 shocks.

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Mark James
Energy Consultant

De-carbonisation of Natural Gas

This paper is based upon my presentation for Energetika on Nov 2020.

My name is Mark James I spent 35 years with ExxonMobil globally managing commercial LNG, gas, helium contracting, projects, powergen and upstream Joint ventures. I am an engineer by background, graduating from Oxford University. Until recently I was MD of the energy practice in Berkeley Research Group (BRG) based in London focusing on arbitration and Oil, gas, LNG and helium advisory services. I have made several presentations on Hydrogen at Energetika and the Energy Institute etc. the messages I plan to leave with this presentation are based upon the previous technical and commercial analysis in those presentations. I remember speaking on hydrogen over 4 years ago at Energetika and was one of the few, I am so pleased to see that I'm now one of the many.

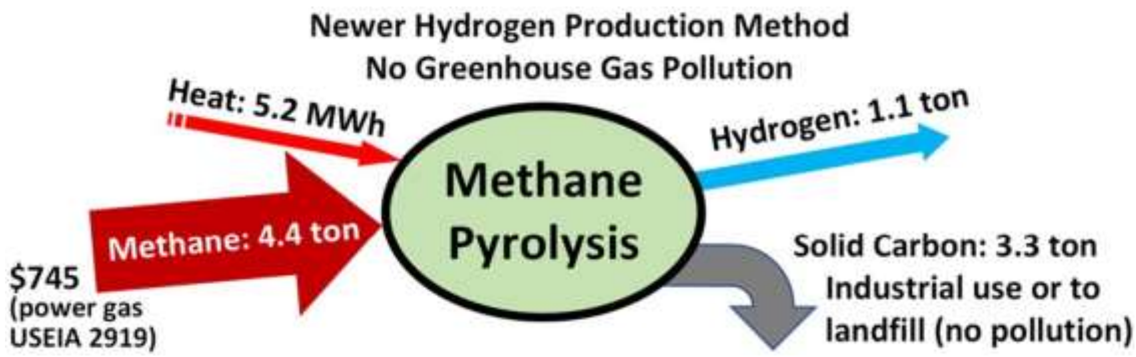
Hydrogen is Here! Водород здесь, Wasserstoff ist da, L'hydrogène est là"
My overall message is simple, hydrogen is here! The graphic highlights multiple projects in Europe and indeed globally that are under consideration or in the pilot phase or committed. For example, I have shown the Equinor CCS based blue hydrogen plant in the UK. I was incredibly pleased to see the recent EU support for hydrogen. It is focused on green hydrogen, which is produced from renewable (RW) electricity via electrolysis, however I believe blue hydrogen produced from methane with CCS can complement green hydrogen.

The EU support for hydrogen modifies the previous EU policy of an all-electric renewable future for Europe, which I believed at the time was both very expensive and unrealistic. This was in fact the driving force behind my initial work on Hydrogen.

I note the president elect Joe Biden's statements that he will re-join the 2015 Paris accord which President Trump left in January 2017, with a planned $2 trillion investment in clean energy to meet climate change objectives. This is an opportunity.

Pyrolysis

Many participants at Energetika discussed Pyrolysis as an alternative to SMR/ATR. It has the advantage of producing solid carbon black, which is environmentally benign and easy to store vs CO_2 gas which requires sequestration. Pyrolysis is still in the experimental phase and not commercially available. The schematic shows the overall process with approximate heat (renewable electricity) requirements



Unfortunately, however, Pyrolysis will require at least 50% increase in methane supply to provide the same amount of energy (kwh) in form of hydrogen as shown below.

16 kg CH_4 (I mol) = 4 kg H_2 (4 mol) + 12kg C (12 mol) 16* 15 kwh/kg = 4*40 kwh/kg
240 kwh CH_4 = 160 kwh H_2

Pyrolysis requires at least 1.5 kwh of CH4 + renewable electricity to provide heat, to produce 1 kwh H_2 assuming 100% conversion efficiency, in reality some methane will not be converted. The enthalpy equation is shown below.

$CH_4(g) \Rightarrow C(s) + 2H_2$ $\Delta H = 74.9$ kJ/mole (energy from renewable {RW} electricity.

Pyrolysis would be a useful technology for markets like the EU/UK located at LNG regas plants/ borders given the challenges of sequestering CO_2 within the EU/UK, as an alternative to the SMR/ATR process. Politically/economically however it may be exceedingly difficult for the EU/UK to accept an increase in natural gas imports to feed pyrolysis within the EU/UK (ref. debate on Nord Stream II). The big advantage for SMR/ATR* is that it is a mature technology and if collocated with gas production (say in the Yamal region), has very cheap methane feed stock for the 50% additional methane feedstock required. This is of course one of the reasons that Qatar LNG etc. is so competitive, because the significant amount of fuel used in liquefaction (15% in U.S. terminals is a guide) is very low cost, much lower than the delivered market price. The availability of massive CO_2 reservoir sinks in Russia is a major asset, which a pyrolysis solution will not monetise. Pyrolysis collocated with gas production, say in the Yamal region may compete with SMR/ATR if it can be commercialised and capex, opex and RW electricity costs are attractive.

Ultimately turquoise hydrogen (the latest colour descriptor) from Pyrolysis or blue hydrogen from SMR/ATR*will have to compete with green hydrogen, which is likely to become cheaper if renewable wind/PV costs reduce substantially. Of course, Pyrolysis also needs a significant amount of renewable energy ~60 GW+ (assuming a 50% load factor % 0.12 kwh_e/kwh H_2) to convert ~225BCM of Russian methane exports to Europe (150BCM*1.5). This equates to a capex + interest* of ~70Bn€ (* BEIS forecast). Of course Russia would also need a Nord Stream III (55bcm) ~10Bn€ to supply the extra 50% methane.

Assuming Pyrolysis will be built in Europe, Russia would be "betting the farm" on the EU/UK continuing to import 225 (150*1.5) BCM of methane from Russia for the next 20/30 years instead of developing blue hydrogen which the EU supports thereby curtailing natural gas imports. Many companies/countries took a similar bet on LNG imports to the USA and did not see the U.S. Shale gas revolution coming. They expected America to be importing massive quantities of LNG, the reverse turned out to be the reality!

Li-ion Battery Electric Vehicle (BEV) Energy Density kwh/kg is Incremental

I was surprised at the last Energetika how much support they was amongst many of the younger attendees for Battery Electric Vehicles (BEVs) , this was in spite of presentations by myself and others showing that the large amount CO_2 produced during battery manufacture can exceed the CO_2 reduction during the driving lifetime phase vs a diesel, unless 100% renewable (RW) electricity was used to charge the car or of course 100% RW electricity used to produce the batteries, most of which come China. Imported batteries effectively import CO_2 to Europe if produced using fossil fuels. We should remember that lithium-Ion technology, which was developed by an ExxonMobil chemist is now 30 years old.

The battery energy density kwh/kg is a key issue, a Tesla 100kwh battery alone weighs 500+ kg. Doubling the energy density would eliminate the range issue (if you can afford the extra cost) but improvements have only been incremental. Unfortunately, the CEO of Tesla, Elon Musk's battery day was quote "underwhelming" and there has been no breakthrough. We all know that de-carbonisation of the transport sector is essential to meet the Paris objectives.

We should remember that lithium and cobalt supplies, the key ingredients of lithium-ion batteries are limited and therefore raises the issue of practicality to convert over 1 billion Internal Combustion Engine Vehicles (ICEVs) to BEVs, especially in the short timeframe available. Of course, another way to mitigate the range issue is to have very fast challenging. However, I wonder how many people realise how expensive it is. IONITY a joint venture of the BMW group, Ford Hyundai, Mercedes, VW, Audi, & Porsche now charge €0.79 €/kwh. With diesel at typically €1.3/litre (€0.12/kwh) fast charging is six times more expensive than diesel. Of course, a BEV is approximately four times more efficient per km than a diesel, but this may not overcome, the price difference. Whilst battery electric vehicles are clearly fun to drive, they are expensive (even with subsidies) and unless they are charged with 100% renewable zero carbon electricity, cannot save the planet. A Fuel Cell Electric Vehicle (FCEV), which uses hydrogen, could be a solution.

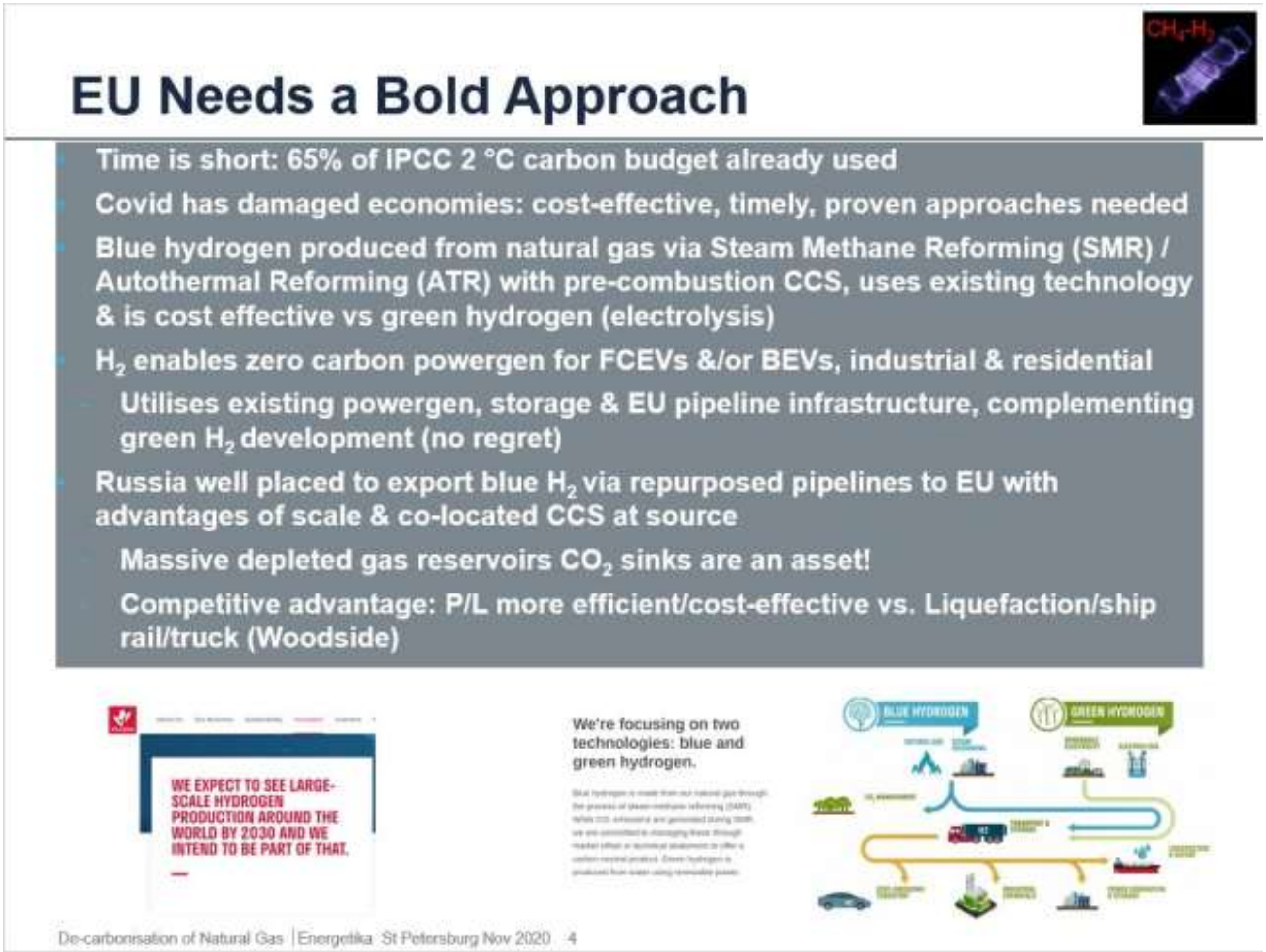
EU Needs a Bold Approach

Time is short, 65% of the IPCC 2-degree carbon budget has already been used. COVID-19 has damaged economies; therefore a cost-effective timely and proven approach is needed. Blue hydrogen produced from natural gas via Steam Methane Reforming (SMR) or Auto Thermal Reforming (ATR) with pre-combustion Carbon Capture and Sequestration (CCS), uses existing technology and is cost-effective versus green hydrogen produced from electrolysis.

A Hydrogen grid uniquely enables zero carbon power generation for FCEVs (which do not have a range problem) or BEVs but also the industrial and residential sectors. Hydrogen also utilises the existing Powergen, storage and EU/UK pipeline infrastructure thus complementing a green hydrogen development with no regret capital.

Russia is uniquely well-placed to export blue hydrogen via repurposed pipelines to Europe and has the advantages of scale and co-located CCS close to the wellhead source.

Russia has massive depleted gas reservoirs, such carbon sinks are a valuable asset, which Russia can monetise. Many major oil and gas companies are investing in hydrogen, I've shown the Woodside proposals below. Russia has a competitive advantage as pipeline export of hydrogen is much more cost-effective and efficient versus liquefaction and transport via ship rail or truck.



Conclusion

An all-electric renewable future will likely strand billions of €s of gas reserves in Russia, Norway, NL & UK etc. and existing plant/infrastructure, requiring substantial RW powergen/power infra-structure investments.

- It puts "all the eggs in one basket", with inherent natural disaster & cyber grid threat
- It's a bet on large cost reductions in BEV technology, RW powergen & grid battery storage due to RW interruptibility
- BEVs effectively import CO_2
- Gas needs effective advocacy
- SMR H_2 manufacture with pre-combustion CCS, collocated with large gas production enables zero emission powergen, heat & transport (BEV or FCEV) sectors needs study
- EU strategy for green H_2 is an opportunity for blue H_2 as they complement each other

"Do not go gentle into that good night" Dylan Thomas, 1914 - 1953

Disclaimer

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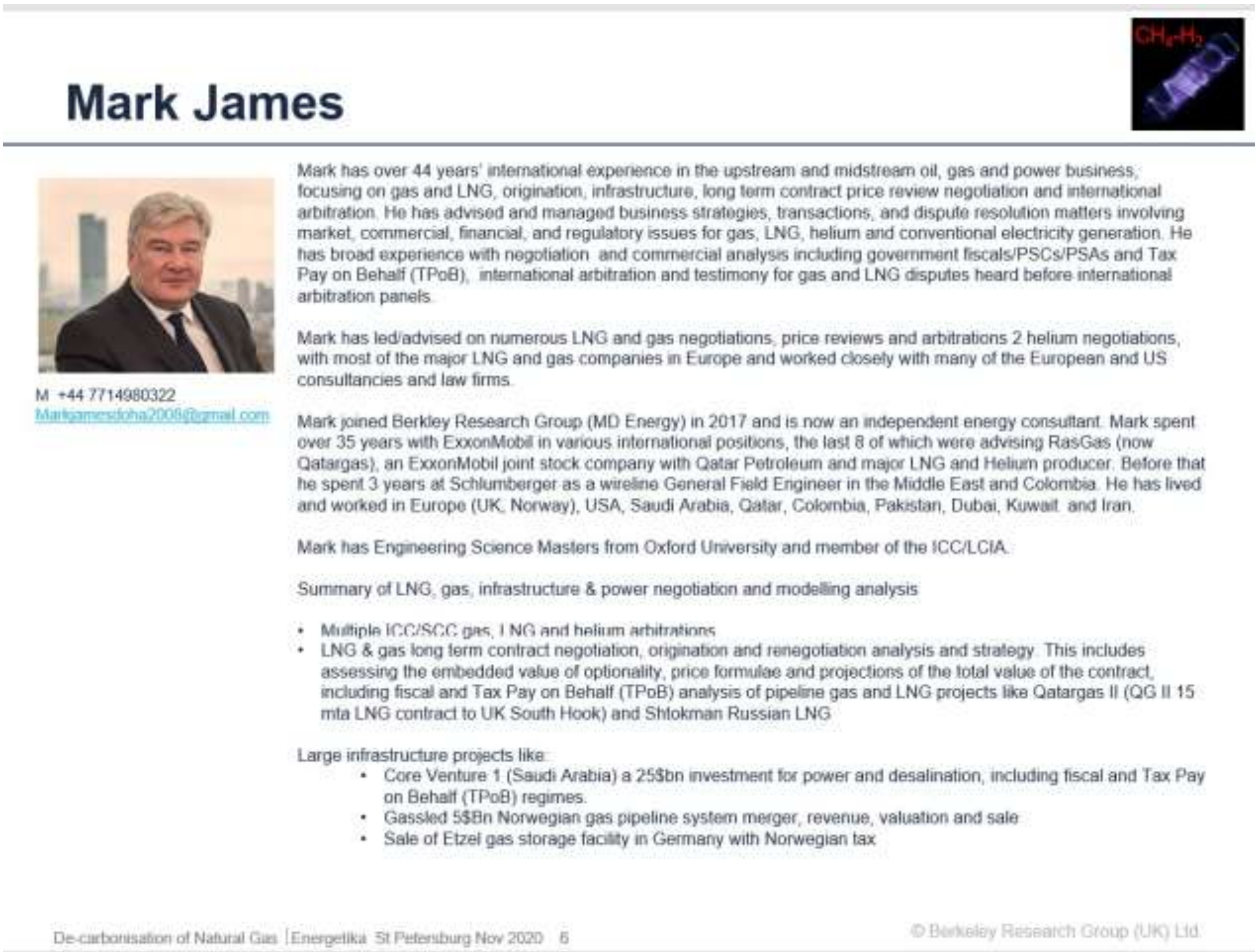

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Natural Gas Crisis and the way forward in Pakistan

Natural gas is the world's fastest-growing and widely used fossil fuel targeted for transitioning to a low-carbon future. Pakistan was ranked at seventh position among affected countries by climate change. Pakistan is also facing a challenge in meeting its growing energy requirements due to the expansion of rural and urban populations. The energy demand is expected to increase from 65 million tonnes of equivalent- MTOE in 2010 to 147 MTOE by 2022, reflecting a phenomenal increase of 126 percent. Natural gas is the largest energy supply component at 48 percent and is projected to decline from the existing 4.2 billion cubic feet per day to 1.6 billion cubic ft. in the year 2022, reflecting a deficit of 7 billion cubic ft. Pakistan's home-grown natural gas reserves are declining. If the current gas scenario prevails, Pakistan will bear a gas shortfall of 8 Bcfd by 2025-26. Therefore, substantial efforts are required to explore, discover, and produce additional oil and gas reservoirs for Pakistan's long-term and sustainable energy security. These steps would be crucial to meet demand and supply gaps. The government is endeavoring to reverse the decline in crude oil production, increase domestic gas supplies, and reduce the burden of imported energy, which can pose severe repercussions to the national wealth and foreign reserves. In addition to the production cost, low BTU gas utilization contains a large volume of undesirable gases like carbon dioxide, nitrogen, and hydrogen sulfide with low methane contents. Despite the availability of power generation technology, economic viability remains an impediment as it needs massive capital investment for drilling of over ten wells. While on the other hand, the cost of producing energy from these fields will be too high compared to a typical gas field. Opportunities for investors to explore and produce low BTU gas can increase their power generation capacity and reduce the energy deficit. They are improving the balance of payments position by reducing the need to import other fuels like LNG and fuel oil require massive foreign exchange outflow.

Pakistan's socio-economic situation is developing at a steady pace that results in increased power consumption while consequently putting stress on natural resource production. This third world country mainly depends on oil and gas resources to meet its energy requirements. On the other hand, indigenous resources can not quench the growing population's thirst and related industries. Hence, the government is forced to import substantial oil and energy-based products from abroad, mainly from the Middle Eastern states. Country's gas reserves are enough for immediate requirements as it plays a pivotal role in the power sector growth. In the oil upstream and downstream sectors, some local and international corporations are engaged, focusing on luring more foreign investors. The country has to import oil and its related products, mainly from Saudi Arabia. The pace of change, uncertainty, and unstable political situation of any country pose significant challenges and risks to foreign investment. The present status of the petroleum, oil, and lubricants industry and its prospects keeping in view the region's geopolitical condition, will be highlighted. Oil and gas reserves are estimated to be depleted within a decade. Meanwhile, Pakistan possesses substantial low-grade coal reserves that contain a large quantity of sulfur. This condition leads to the import of high-grade coal from neighboring states for power generation.

Matsuda Kuinori, Ambassador of Government of Japan to Pakistan, recently met Nadeem Babar, Special Assistant to Prime Minister on Petroleum at Petroleum Division, who shared critical areas of cooperation in the energy and petroleum sector between both the countries. The SAPM discussed oil and gas policy in line with particular areas of opportunities, including exploration and production activities, construction of new LNG terminals, expansion of the LPG sector, and setting up of oil marketing strategic storage and trading hub shortly. These incremental steps would revolutionize the petroleum sector of the country. The SAPM hoped that Japanese companies and investors would extend their business outlook in light of our new policies and improved ease-of-do-business steps in Pakistan's petroleum sector.

The introduction of Euro 5 standard fuels in a short length of time shows the Pakistan government's commitment to cut down air pollution for a clean environment. Our time is needed to adapt upgraded fuel standards that reduce the negative impact on our environment and help our country move towards a sustainable future. Improvement in fuel quality will ultimately benefit the consumer and help enable a cleaner environment with reduced pollution. Euro 5 standard fuels minimize the negative impact on our environment due to reduced sulfur and benzene content by a staggering 98% and 80%, respectively, reducing harmful vehicle emissions, providing health benefits, and improving engine performance. Reduction in benzene content will also significantly improve industry workers' occupational health involved in product handling.

Dollar 10 billion Turkmenistan-Afghanistan-Pakistan-India Pipeline (TAPI), Gas Pipeline project price, and delivery points are next for review and discussion with relevant counterparts. The estimated cost of imported gas from Iran would be $14 per MMBTU, and the project is also called the peace pipeline.

Two hundred kilometers of the pipeline have already been laid. Fourthly, the financial closure of Phase 1 is expected in 2021. Lastly, Phase 1 COD is scheduled to be completed in 2023. The Government of Pakistan is committed to the TAPI Gas Pipeline project. It has continued to emphasize its importance to diversifying Pakistan's Energy Mix and acting as a catalyst in improving regional connectivity and fostering better neighborly relations. It is also important to mention that laying of 28km 8-inch dia transmission pipeline from fields to SSGC system was delayed due to issues faced by SSGC in the acquisition of right of way from district governments.

The region of Sui boasts the largest natural gas reserves discovered in Pakistan. The reserves were found in 1952, and soon after, Sui became the largest natural gas field in the country, named after its location in Balochistan. The natural gas reserves discovered in Sui fall under the jurisdiction of Pakistan Petroleum Limited. Even though there are quite a few other hydrocarbon gas reserves in

Pakistan contributing to the country's requirements, Sui is, hands-down, the most dominant contributor. New deposits of oil and gas in exploratory well Mamikhel South-01 have been found located in Tal block in Khyber-Pakhtunkhwa (KP). Well, the test has shown 3,240 barrels of condensate per day, 16.12 mmscf (million standard cubic feet) of gas per day, and 48 barrels of water per day. Similarly, the country produces less than 4 billion cubic feet of gas per day (CFD) against a total requirement of around seven bcfd. It partially meets local demand through imports and manages the complete need by conducting load-shedding for industries.

Pakistan Petroleum Limited – a state-owned oil and gas exploration company – has successfully found a massive gas reserve in Margand Block in Kalat – a small region in Balochistan. This discovery, which is being hailed as the second-largest gas reserves in Pakistan, results from consistent drilling since June 30, 2019. Pakistan Petroleum Limited carried out a Modular Dynamics Testing (MDT) in Margand Block at a depth of 4,500 meters, which led to discovering this natural reserve. The experts at PPL followed the lead, and after further studying and conducting a Drill Stem Test (DST), they concluded that these gas reserves could exceed 1 trillion cubic feet. However, the actual size of hydrocarbon reserves in Margand Block is kept secret for now.

In June, OGCDL publicly announced that they have been successful in finding hydrocarbon reserves in Sindh. The company is yet to estimate the production number. In August, OGCDL found another hydrocarbon reserve in Kohat, which will produce 240 BPD of crude oil and 12.7 MMSCF of gas. During October, the company discovered oil and gas reserves in Kohat – a district in KPK. As per the preliminary findings, the well can produce around 50 BPD of crude oil and 4.1 MMSCFD gas. In 2019, reserves of natural gas for Pakistan was 14.19 trillion cubic feet. Natural gas reserves fell gradually from 21.6 trillion cubic feet in 2000 to 14.19 trillion cubic feet in 2019.

Despite reducing its natural gas production, the Punjab province's gas consumption increased by 76 MMCFD from 1515 MMCFD to 1591 MMCFD during 2018-19. In Balochistan province, the consumption increased by just one MMCFD from 64 MMCFD in 2017-18 to 65 MMCFD in 2018-19. In Sindh province, the consumption improved by 17 MMCFD from 1163 to 1180 MMCFD, while in KPK province, it was increased by eight MMCFD from 265 MMCFD to 273 MMCFD. The gas utility companies expanded their transmission and distribution network to cater to its new consumers' demand. SNGPL and SSGCL have extended their transmission network by 81km and 24km, respectively, during FY 2018-19.

Pakistan's energy imports stood at $9.8 billion, which constituted around one-fourth of total imports of $40.86 billion in the first 11 months (July-May) of the previous fiscal year (FY20), according to the Pakistan Bureau of Statistics (PBS). The brokerage house said the drilling of exploratory well Mamikhel South-01 started in October 2019, and it reached a total depth of 4,939 meters on May 23, 2020, before encountering hydrocarbon deposits. Pakistan has resources of 164 million barrels of oil and 24.6 trillion cubic feet of natural gas. Pakistan depends principally on oil and gas for over 70 percent of its primary energy and has become increasingly dependent on oil and gas imports. Although Pakistan produced about 90 thousand barrels of crude per day in 2018, this only accounts for 18pc of total oil consumption. The growing oil-import bill puts tremendous pressure on budgets and reserves. Pakistan's 2017-18 oil imports stood at $14.6 billion, or about a quarter of the total estimated current account imports. The ever increasing demand for the commodity was being met through the import of Liquefied Natural Gas (LNG) and Liquefied Petroleum Gas (LPG). Besides, extensive efforts were underway to accelerate oil and gas exploration activities in the country's potential areas to achieve self-sufficiency in the energy sector. There has long been a gap of over 2 Billion Cubic Feet per day gas between production and demand of the commodity to meet the requirements of more than 9.6 million consumers across the country. The country has an extensive gas network of over 12,971km transmission, 139,827km distribution, and 37,058km services gas pipelines to provide the commodity to more than 9.6 million consumers. There are currently 11 LPG producers, and 200 LPG marketing companies operating in the country have more than 7,000 authorized LPG distributors. Rising demand from various sectors, particularly power, domestic, fertilizer, captive power, and industry, resulted in insufficient gas supply to cater to the need. The demand-supply gap during the financial year 2017-18 was 1,447 MMCFD, and this gap is expected to rise to 3,720 MMCFD by the financial year 2019-20. The gap between the supply and demand is expected to increase to the tune of 4,600 MMCFD in the financial year 2022-23 and 6,700 MMCFD by the financial year 2027-28 without the imported gas.

Pakistan Petroleum Limited (PPL) has recently discovered mega gas reserves in Margand Block in Kalat, Balochistan, one of Pakistan's largest gas reserves since Sui. Pakistan has around 19 trillion cubic feet (Tcf) of proven gas reserves. The consumption rate of natural gas per year has been recorded at 1,590,904 million cubic feet (Mmcf). Pakistan exports around 3% of the natural gas produced in the country, while Pakistan's share in the global natural gas production is 0.28%.

Pakistan has secured a long-term gas supply with Qatar, and several private-sector entities are building terminals in Port Qasim. The Russia-constructed Karachi-Lahore natural gas pipeline will be online by the second quarter of 2020. Through China–Pakistan Economic Corridor-CPEC, China is also financing and constructing an LNG terminal in Gwadar and a pipeline from Gwadar to Nawabshah in Sindh. At Gwadar, a floating liquefied natural gas facility, with a capacity of 500 million cubic feet of LNG/ per day, is planned to be built as part of the $2.5 billion Gwadar-Nawabshah segment of the Iran–Pakistan gas pipeline. Presently, this is stalled due to US sanctions on Iran. The government started having 600 MMCFD re-gasified LNG from the Port Qasim terminal in 2017 under the off-take guarantee under a 15-year contract at a $0.4177 per MMBtu tariff. The tariff of 41.77 cents per MMBtu is the lowest in the region. The LNG terminal set up by Engro is charging the tariff of 66 cents per MMBtu.

These energy issues could be addressed by creating a sound policy, legal, and regulatory environment, developing efficient institutional and market structures, achieving a cleaner and more resilient generation mix, expanding electricity access to the poor and rural areas, collaborating with neighbors on regional electricity and gas networks and markets and attracting international investment and financing.

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New Strategies for the "Big Three" Oil Producers

Summary
The strategies of the "Big Three" global oil producers have been changing in response to three crises that rolled over oil markets in the past seven years. While the problems related to the cyclical calamities are familiar, the challenges associated with energy transition to low carbon economy are new. The paper reviews the responses and strategy adjustments by Saudi Arabia, Russia, and the US and outlines the new areas of uncertainty.

Three Crises: Cyclical versus Structural Changes

Three crises have shaken oil markets in the past seven years. The first crisis was a supply-side shock during 2014-2019 triggered by the "shale miracle" – tremendous growth of unconventional oil production in the US. The second crisis was an unprecedented demand-side shock in 2020-21 caused by the COVID-19 pandemic and the resulting lockdowns and decline in economic activity across the globe. The third crisis is unfolding now as the narratives of the transition to non-carbon sources of energy are predicting a radical overhaul of the global economy.

The challenges of the first two crises could be characterized as primarily "cyclical". Both crises resulted in glut of oil in the markets. This glut (irrespective of the cause) was moving oil prices out of equilibrium, from the levels that ensured sustainable business operations for most producers to the levels that were only sufficient for near-term survival of some producers but not all. In effect, markets have introduced a live experiment, testing the pain thresholds of the oil-producing nations with respect to the economically viable cost of production, fiscal break-evens (oil prices at which national budgets balance), and elasticity of supply and demand in a rapidly evolving business environment.

The third crisis is different. Energy transition to low-carbon energy means a fundamental structural change for the oil industry and oil markets as oil demand will have to shift from transportation to petrochemicals and as regulation is likely to impose a heavy toll on carbon emissions (in the form of stricter rules for polluters and cross-border carbon taxes). By fast-forwarding "peak oil demand", the low-carbon economy scenario poses an existential threat for the holders of the world's largest oil reserves that may be left with stranded assets and the necessity to experiment with new economic models for their economies.

The "Big Three" and the Roles They Play in the Oil Market

Saudi Arabia, Russia, and the United States – the so-called "Big Three", – account for over one-third of the global oil supply and have been the main driving forces for the oil market in the twentieth and twenty-first centuries. Each of the "Big Three" represents a distinct vector in the overall configuration of market developments. The remarkable feature of the past decade has been a dramatic change in both magnitude and direction of these forces.

Owing to their importance to the global economy, international oil markets have been subject to heavy management for most of their history: by the so-called "Seven Sisters" (Exxon, Mobil, Gulf, Chevron, Texaco, British Petroleum and Shell) – the largest international oil companies (IOCs) from the end of the 1920s till 1973, by OPEC from 1973 till now, and most recently by OPEC+, or the Vienna Alliance – an expanded group of OPEC and ten non-OPEC oil producers and exporters (including Russia, Kazakhstan and Azerbaijan among others) who jointly expedite production cuts to balance the market. Oil market management plays a stabilizing role in volatile circumstances, albeit bringing higher prices than would otherwise be the case (but so does the insurance fee that people are willing to pay to avoid unacceptable risk).

For almost fifty years Saudi Arabia has been the global manager for the oil market volatility. It is a key driving force within OPEC and indispensable swing supplier (capable of quickly increasing or decreasing its output). This position is based on abundant low-cost oil production and readily available spare production capacity.

Russia, another country rich in oil reserves and heavily dependent on oil revenue, experienced a dramatic production decline after the breakup of the Soviet Union, but since the beginning of the 2000s managed to grow its oil output steadily, from 7 mbd in 2000 to over 11 mbd by the mid-2010s. The outlooks for Russia suggest a relatively flat and stable oil production. Unlike Saudi Arabia, Russia does not have significant spare production capacity and cannot quickly increase its oil output. Russia joined OPEC+ in the beginning of 2017.

The USA is the largest global oil producer outside of OPEC+ and also the world's largest oil consumer. The US "shale miracle" which contributed to the growth of total US oil and condensate production from 7.6 mbd in 2010 to staggering 17 mbd in 2019 (by 125 percent over the period) turned the US into a net petroleum exporter and also allowed it to capture more than two-thirds of the incremental increase in global oil demand during the past decade. The technological advances by the US shale producers have been spectacular, bringing productivity gains and giving a new lease of life to the old oil provinces in the US. Shale production became a game changer for the global market since it has a short production cycle and can respond to price signals relatively quickly. The costs of shale oil production, however, are significantly, three to five times higher than the before-tax costs for conventional oil produced by the Saudis and the Russians.

"Big Three" Reformulate Their Strategies

The three shocks have caused big changes in the strategies of the "Big Three". The adjustments happened as each of the key players has had its own challenges to tackle in relation to its own set of strengths and weaknesses.

Saudi Arabia

For Saudi Arabia, the greatest concern is the sustainability of the budget and spending programs. Saudi Aramco has the world's lowest cost of oil production. Yet, the Saudi economy is dependent on oil revenues, and Saudi budget has had fiscal breakeven oil prices exceeding market prices since 2014 which has forced the kingdom to draw down on its foreign exchange reserves and resort to debt to finance the budget deficit. IMF estimates that fiscal breakeven oil price for the kingdom was about $80/bbl in 2020 while Brent oil price averaged about $41/bbl. In spite of the Saudi efforts to adjust to a prolonged low-oil price scenario, it managed to reduce its fiscal obligations only partially. Very tight budgetary policies threaten the key goals of Saudi Vision 2030, a program of broad social and economic reforms that the Kingdom promotes. As a result, the kingdom might want to keep oil supply by OPEC+ in check for longer, trying push oil prices higher, closer to $70 per barrel.

Russia

The alliance between Saudi Arabia and Russia (that resulted in creation of OPEC+ in the beginning of 2017) surprised market watchers, but the Kremlin was apparently convinced that a managed and more predictable oil market gives Russia, as a relatively low-cost producer, more benefits than a destructive war for market share.

Russia’s main interest in the OPEC+ alliance has been to avoid extreme price volatility, especially on the downside. The oil price crash in 2015 became a game changer for Russia’s strategy. The emergence of US shale as a new giant source of supply with short production cycle which is highly responsive to price signals has become a challenge for the traditional management of the global oil market. The magnitude of additional output from shale oil meant that Saudi Arabia could not solve the overproduction crisis alone.

The Russian decision-makers have been convinced of the importance of having their say in formulating the OPEC+ pricing policies but envisaged a limited role for Russia in the alliance initially: reining in the increases in oil output planned by the individual Russian companies rather than forcing them to cut. In 2017-2018 this arrangement worked relatively well and helped price recovery. But the real test of Russia’s commitment came in 2020 when for the first time it had to introduce major production cuts and face difficult technical and economic trade-offs. In 2020, Russia’s oil and condensate output amounted to 10.2 mbd, 8.6 percent lower than in 2019, owing to the production cuts agreed among OPEC+ amid the “perfect storm”.

Russia's resilience to a prolonged period of low oil prices is quite high as a result of flexible exchange rate that allows Russia to balance its state budget by way of macro policies, high levels of foreign currency reserves, and self-adjusting tax take that protects oil producers in low oil price environment. Russia’s solution to its budgetary dependence on oil revenue has been a large-scale depreciation of the ruble and active import substitution, especially in the food market. Russia’s budget needed $42 oil to break-even in 2020, and the country’s Central Bank has managed to increase its foreign currency reserves even under the current extreme situation.

Russian oil companies, however, have been concerned about de-activating their producing wells for too long for fear of losing significant production volumes permanently. In these circumstances in January 2021 Saudi Arabia accommodated Russia’s interests by promising to cut its oil output unilaterally by additional 1 mbd thus assuming a greater balancing burden for itself while letting Russia to produce slightly more in order to meet a winter spike in domestic demand. This suggests a possibility of longer than expected cooperation between the two countries on the basis of mutual compromises.

Longer term, for Russia, the main challenge is to maintain stable oil output by managing declines at its legacy fields while transitioning to higher-cost new assets (deeper layers of the existing oil fields and remote new greenfields). To achieve this, Russia needs predictable and stable oil prices in the range of $50-60 per barrel, lower than the price desired by Saudi Arabia.

USA

For the US, the key problem appears to be finding a balance between output growth and profitability for the shale companies. In terms of production volumes and in technical improvements, US shale has produced a miracle, almost doubling output in the past decade. However, in financial terms, it has been a bust. As a group, shale producers generated negative cash flows in every of the past ten years. The US shale business model of delivering volumes while disregarding profitability has frustrated investors.

At the same time, US shale producers proved much more resilience to low oil prices than initially expected. This was partly due to highly competitive service sector and the spectacular technological advance. US producers have been able to produce more oil with fewer drilling rigs thanks to their focus on the most prolific sections of the fields (the so-called “sweet spots”).

Another explanation lies in the symbiosis of shale oil production and the US financial system. US oil producers successfully hedged their sales prices (bought financial instruments that guaranteed certain future price for their output) and achieved average prices at levels much higher than what the prompt market prices would have provided them, especially in 2015 and 2016. The availability of financing at low interest rates for US shale producers also has helped.

But what has been the tailwinds for the US shale sector might become the headwinds as the producers are running out of the lowest-cost opportunities and the “green agenda” is introducing “penalties” for financing oil and gas projects. Besides, the cycle of extra-low interest rates in the US may be reaching its limits amid plans for record-high spending in post-COVID economic recovery.

One of the lessons from 2020 has been that the US interests with regards to oil price have become more nuanced and complicated than before. In the past, the US policy (as a large net importer of oil) would be to unequivocally support lower oil prices as these would benefit the consumers. But the shale revolution has transformed the US into a net exporter of hydrocarbons and has made its oil and gas industry an important engine of economic growth and a domestic job creator. This makes extremely low oil prices potentially quite damaging to important parts of the US economy. Conversely, high oil prices are not desired as well since they punish US consumers.

Will the Old Conundrum Return?

As the world enters 2021, the timing for the return to “normality” remains uncertain amid the emergence of the new strains of the COVID-19 virus. Massive vaccination, however, will lead eventually to the re-start of the global economy and support oil demand and prices. But this raises an important question: Can the normalization of the situation bring back the same conundrum among the Big Three that existed before the crisis, when every time OPEC+ was reducing its output to support oil price it was also giving up its market share to higher cost producers (US shale operators, in particular)?

This calls for the uneasy task of finding a formula for the oil output targets, particularly between Saudi Arabia and Russia within the OPEC+ format. Calibrating the target oil price that would keep the market in balance in the near-term becomes a juggling act. If the market becomes too tight, it might result in a price spike and give US shale producers an opportunity to renew price hedges that would prolong the oversupply crisis rather than solve it. These are dozens of independent oil companies that do not act in concert, but rather as independent actors guided by Adam Smith's "invisible hand". Therefore, the response from US producers to $50 oil in the beginning of 2021 will be a key signpost to watch. If both oil service sector and oil producers focus on return to profitability, the US shale output may not grow as quickly as before, but it may become more sustainable.

The new democratic US administration has already indicated its focus on de-carbonization, setting the course for less friendly policies towards frackers. The impact of tougher economic terms (higher interest rates for oil and gas projects and greater investor scrutiny) and stricter regulation (with regards to flaring and venting of natural gas that often has to be produced along with oil) would increase the costs for US shale producers and set average breakeven prices for them at higher levels thus helping avoid the next unsustainable surge of US oil output. In sum, if US shale becomes more constrained by the financial self-discipline and the need to reduce carbon emissions, it would be less responsive to price signals. Counterintuitively, this would make it easier for Russia and Saudi Arabia to cooperate in managing global oil market. In this scenario, oil prices in the range of $50-70 per barrel can satisfy the main producing countries, as it allows them to reach their immediate goals.

The Divergence of Longer-Term Strategies of the "Big Three" Amid Energy Transition

However, decarbonization policies could also impact long term demand for oil and therefore in addition to reaching the immediate goal of bringing near-term supply and demand to equilibrium, the world's largest oil producers need to ensure long-term marketability of oil against the competitive market pressures of non-carbon sources of energy. With this in mind, Saudi Arabia has been calling for the advance of the Circular Carbon Economy approach and expanding its value chain via investing downstream – in petrochemicals, in particular. Russia has been up to a slow start on energy transition, looking instead at incentivizing demand for oil and gas at home. Its immediate efforts have been focused on diversifying its export markets in favor of Asia where energy transition's impact on reaching peak oil and gas demand is likely to take longer. The US is hoping to use its competitive advantage in greener technologies as it charts the path in its energy transition and foreign policy.

The question then is whether the increasing divergence in the long-term strategies of the world's largest oil producers in response to the energy transition creates new rounds of increased competition within the traditional energy markets such as oil and between the "old" and "new" sources of energy, which will not be only driven by economics but by regulation, carbon border adjustments, and trade restrictions. It is difficult to make a prediction as this depends on many factors including the speed of the energy transition, how disruptive the transition is likely to be and how successful each of the producers is in adjusting their energy sector to the transition. However, this does not necessarily mean that competition will prevail over cooperation in global oil markets. Increased pressures from the energy transition could bring Russia and Saudi Arabia closer together but the forms of cooperation will have to evolve if this cooperation is to persist.

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Перспективы развития водородной энергетики Казахстана

Сегодня будущее мировой нефтегазовой отрасли является предметом осмыслений, дискуссии, впрочем, как и всегда, однако фактор COVID-19 увеличил потребность анализа, как и неопределенность, в разы. Совсем недавно казалось – высокие цены на энергоресурсы пришли надолго, возможно, цены будут постоянно расти. В немалой степени этому способствовали некие правила спекулятивных ходов, управляемые глобальными инвесторами на площадках по торговле нефтью и нефтепродуктами. В результате высоких цен на энергоресурсы экономики развитых государств ослабли ввиду высоких уязвимостей, издержек производств, зависимости от стран производителей нефти. На короткий момент показалось, главным энергоресурсом является нефть, которая будет фактором изменения или балансировки экономического и политического влияния в мире.

Казахстан в 1990-е годы своевременно и умело привлек глобальных инвесторов в энергетический сектор страны. Эти мировые энергетические компании за короткий период многократно увеличили добычу нефти и газа, не так, как планировалось, но все же о Казахстане заговорили как об одной из энергетически обеспеченной стране, способной внести свой весомый вклад в обеспечение мировой и региональной энергетической безопасности по нефти и газу. Выстраивая открытую, миролюбивую внешнюю политику, Казахстану удалось установить экономические отношения с развитыми экономиками мира. Высокие цены на нефть способствовали непрерывному экономическому росту, поступления огромной валютной выручки, фактор слабого доллара в тот временной период позволили несколько улучшить социальное самочувствие граждан, элите почувствовать себя лидером в Центральной Азии. Экономический рост способствовал росту политического влияния, где Казахстан успешно начал приобретать опыт по внешней дипломатической линии. К этим достижениям можно отнести: саммит ОБСЕ в Астане, членство в СовБезе ООН, создание международных площадок в столице для дискутирования, сближения позиций в различных важных вопросах международной повестки. Ощущение по становлению в одного из субъектов мировой энергетики плотно укоренялось в сознание большинства – все проблемы страны должен решить энергетический сектор. Однако жизнь внесла свои коррективы, эпоха благоденствия, сверхвысоких цен на ресурсы прошла еще в доковидный период. Фактор COVID-19 показал, насколько нефтегазовый сектор важен, на кону стимулирование, создание и рост других секторов экономики, как и то, что сырьевая модель экономики очень уязвима перед лицом внешних обстоятельств. На мой взгляд, возможно, настало время обратить внимание вовнутрь, и, что жизненно необходимо, природный газ, добываемый в Казахстане, должен быть использован для большего числа населения, обеспечивая собственную, экологичную энергетическую безопасность, создавая модель внутреннего потребления с экономически проработанными подходами. В последнее время рост числа энергодобывающих стран в мире усиливает итак большую конкуренцию за рынки сбыта. Наращивание этими новыми участниками добычи, применение новых технологии в США (сланцевая нефть), резко растущая нефтегазовая экспортонаправленность в Африке, Мексике, Бразилии, увеличение поставок СПГ, противоречия членов картеля ОПЕК, точнее борьба за квоты в рамках стратегии ОПЕК+, в результате приводящая к активным ценовым войнам.

Таким образом, вероятный сценарий обвала невысоких в настоящее время цен, в ближайший период, весьма вероятен. Эти и другие факторы нельзя не учитывать в стратегических планированиях Казахстану.

В своих ожиданиях недалекого будущего Международное энергетическое агентство, уверяет – мир ожидает энергетическая революция уже к 2030 годам, в результате произойдет постепенный отказ от использования органического топлива. ОПЕК же, напротив, в своих докладах заявляет об использовании углеводородов до 2045 года и даже аргументирует о росте будущего потребления Азиатско-Тихоокеанского региона. Теоретически оба прогноза допустимы. Казахстан бы устроил, конечно, сценарий ОПЕК.

Тем не менее происходящие на практике события невозможно не замечать. Идет полным ходом реализация Стратегии ЕС по декарбонизации экономики, ряд развитых стран в своей приверженности к построению зеленой экономики предпринимает конкретные, осязаемые на практике шаги, научные разработки в области декарбонизации получают «зеленый свет» и получают всю необходимую законодательную поддержку. Происходит это почти синхронно, не оставляя оснований для озабоченности за будущее торговли углеводородами.

Энергетический потенциал возобновляемых природных источников энергии (солнца, ветра, использование водных потоков) имеет свои пределы. Основной альтернативой нефти может выступить водородная энергетика. Ее ресурс огромен и фактически неограничен. Технологии получения хорошо изучены. Помимо этого, водородная энергетика очень продуктивна, технологична и эффективна в использовании. Сфера использования: на транспорте, в быту, энергетике, ж/д транспорте. Все это объясняет выбор новой энергии – водорода, основного вида топлива, способствующего достижению нулевой углеродной нейтральности. Кстати, природный газ, в особенности переход на него и активное использование, входит в климатические планы стран Европы.

Следуя своей энергетической стратегии, Казахстан далее будет придерживаться возможности максимальной добычи нефти с применением мировых практик, технологии, для модернизации экономики, создания условий, устойчивого развития государства. Однако, учитывая тенденцию большинства развитых стран к масштабной перестройке своих экономик к нулевому выбросу парниковых газов, необходима выработка новой внешней энергетической политики. Ведь основным торговым партнером являются страны ЕС. Возникает повестка – новой адаптации в новой энергетической реальности.

Для реализации своей водородной программы у Казахстана имеется большая сырьевая база. Конечно, многие вопросы экономической обоснованности, проведение ряда прикладных исследований, изучения различных политических, климатических факторов еще предстоит пройти.

Огромный фактор неопределенности несет пандемия в оценках восстановления мировой экономики. Что представляет собой начинающаяся вторая волна, что она несет? Когда закончится? Можно ли найти универсальное решение этой напасти? Мировая экономика также нуждается в «вакцинировании», точнее колоссальных финансовых, институциональных усилий по ее оживлению. Все это будет отражаться на мировой энергетике, сотрудничестве стран, потреблении энергоресурсов. При сценарии резкого обвала цен на нефть и ее значительном удешевлении будут ли страны ЕС придерживаться своей климатической стратегии или рынок проголосует за дешевый бензин? Что тогда будет с водородной энергетикой? Как мы видим, на многие вопросы можно будет ответить только по окончании пандемии.

Принимая во внимание возможность получения водорода из различных источников сырья, экспертным сообществом, принимающим участие в формировании стратегии и концепции о национальной энергетической политике в вопросах производства и использования водорода, будут учтены обоснованность его производства в Казахстане, какие риски несет исключительно экспортная ориентированность водорода. Особенно важно не ставить очень большие и невыполнимые стратегии в водородной энергетике, завышая невыполнимые задачи, в результате чрезмерно раздутые ожидания опять приведут к критике Правительства со стороны населения.

В то же время в выводах всемирного энергетического совета и в исследованиях различных мировых и европейских мозговых центров показывают Казахстан и другие приграничные страны как потенциального экспортера водорода, выделяя роль ресурсного обеспечителя. Является ли это равноправным сотрудничеством? А что будет, если через 10 и более лет обеспечителей водорода будет настолько много, как, например, сейчас ситуация с нефтью, и цена упадет ниже себестоимости ее производства. Как здесь просчитать национальные интересы, думаю, весьма сложно.

Казахстан является участником Парижского соглашения по климату от 2015 года. Соглашение носит глобальный характер, охватывающее 195 стран и ЕС. Пока неизвестно, какие решения в своем национальном законодательстве задействованы в связи с этим соглашением. Развитие водородной энергетики логически пересекается, наверное, с исполнением этого Рамочного соглашения. Здесь нужно обратить на это внимание при формировании водородной стратегии. Интересным представляется технология получения водорода из сжигания мусора путем пиролиза, на выходе мы получаем производство электроэнергии и водорода. Проблема накопления мусора носит критический характер. Конечно, нужно выбрать именно такой синтез: науки, экономики и главное – воли государства. Инвесторам и государству эти проекты производства водорода будут интересными, где интересы обоих максимально совпадают. Государство решает вопрос с утилизацией, инвестор производит водород, учитывая, что ТБО в Казахстане накоплено в избытке.

Казахстану было бы полезно начинать изучение вопроса получения водорода из природного и попутного нефтяного газа. Известно, существует много способов получения водорода. На каком из водородов стоит остановить свой выбор? Вопросов по мере погружения в водородную тему становится больше.

И под конец главный вопрос потенциальным потребителям водорода. Когда водород превратится в стратегически важный товар, ну, допустим, как нефть сейчас. Производство этого продукта должно быть привлекательным. Сейчас все на стадии анализа, основным фактором будет, конечно, конечная цена, во сколько это встанет, сейчас использование ВИЭ является достаточно дорогостоящим для экономики Казахстана и без поддержки государства не выживет. Тогда на это невозможно не смотреть сквозь призму налоговых льгот и преференций, иначе для становления новой отрасли не будет смысла. Проблема хранения, а главное – доставки водорода никуда не делась, решение этих технологических вопросов остается пока неясным.

Конечно, на многие вопросы ответы будут по мере погружения в «тему» и исследования необходимо начинать. Вообще ожидалось уже, что в это время будет стоять жаркая дискуссия сторонников и скептиков водородной деятельности.

В настоящее время наблюдаем следующую фазу – Казахстан находится в начале своего пути по освоению «новой энергии», надеется получить свою нишу в мировых поставках водорода, продолжая вносить свой вклад в обеспечение мировой энергетической безопасности, возможно, в новом качестве и, конечно, ожидать скорого окончания пандемии.

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Российская угольная отрасль в контексте декарбонизации мировой энергетики

Аннотация. *В работе рассмотрены основные аспекты современного состояния российской угольной отрасли. Приведен сценарный анализ её развития в контексте складывающихся трендов на декарбонизацию мировой энергетики.*
Ключевые слова: *угольная отрасль, энергетика, декарбонизация, генерация тепло- и электроэнергии.*

Введение

До недавнего времени угольная отрасль в экономике большинства стран воспринималась в качестве одной из важнейших составляющих их энергетической безопасности, являлась ключевым поставщиком тепло- и электроэнергии для нужд населения всего мира. Использование угля в мировой энергетике было обусловлено его дешевизной в сравнении с природным газом, а в российской – исторически сложившимися инфраструктурными особенностями энергетического комплекса страны. В то же время процесс сжигания угольного топлива сопровождается негативными последствиями для окружающей среды, что приводит к снижению значения угля для ряда экономик развитых стран и, как следствие, их переходу на альтернативные источники энергии.

Россия, являясь одним из мировых лидеров угольной промышленности, в значительной степени зависит от меняющейся структуры глобального энергетического рынка. Движение основных потребителей российского угля за рубежом в сторону более экологичных альтернатив создает серьезные вызовы перед отечественными угледобывающими компаниями. Однако новой возможностью для традиционной отрасли становятся современные технологии в области переработки и использования угольного топлива, внедрение которых в перспективе позволит значительно «очистить» уголь и сделать его приемлемым для низкоуглеродного контекста энергетики будущего.

Основные тенденции

Отправной точкой в определении возможных траекторий развития угольной отрасли является продолжающаяся мировая тенденция, связанная с постоянным ростом мирового потребления энергетических ресурсов. Увеличение численности населения Земли, стремление людей к улучшению условий своего проживания становятся мощными драйверами развития мировой энергетики. При этом роль углеводородных ресурсов в процессе глобального энергопотребления по-прежнему является превалирующей.

Как уже было упомянуто ранее, главной проблемой в наблюдаемой тенденции становится не сам непосредственный рост энергопотребления, а негативное влияние производных продуктов на окружающую среду, образующихся при сжигании традиционных углеродосодержащих видов топлива. Поэтому для понимания перспектив российской угольной отрасли предлагается рассмотреть ряд и других тенденций, происходящих в мировой энергетике.

Так, стоит отметить, что активное развитие возобновляемых источников получения энергии (ВИЭ) привело к паритету долей ВИЭ (27%) и угольной генерации (26%) в мировом энергобалансе по состоянию на конец 2019 года.[22] Однако если сравнить между собой энергоресурсы, используемые в качестве топлива для производства тепловой энергии, то для ВИЭ мы увидим нулевые значения данного показателя, а для угля, газа и нефти – более 40%[23], поскольку в сложных погодных условиях эффективность использования солнечных и ветряных электростанций (СЭС и ВЭС) крайне низкая. И даже несмотря на текущий тренд, связанный с продолжающимся ежегодным ростом среднемировой температуры воздуха, перспективы использования ВИЭ для нужд теплогенерации пока остаются слабыми.

Второй значимой проблемой является то, что в условиях действующей в России единой энергетической системы ночью потребляется значительно меньше энергии, чем утром или днем. При этом утром наблюдаются наибольшие скачки потребления электричества. Подобный формат потребления изменить крайне сложно, поэтому пики напряжения в определенные временные интервалы в течение дня можно принять за величину постоянную. Системному оператору, отвечающему за работу электросетей, приходится предпринимать определённые усилия, направленные на постоянное распределение имеющихся мощностей на локальные нужды населения. В силу того, что человек до сих пор не научился управлять погодой, повсеместное использование ВИЭ создает очередные сложности. Так, производство энергии на ВЭС и СЭС значительным образом зависит от погоды, а не от потребностей человека. «Хорошая» погода является необходимым условием того, что солнечные панели работают, а лопасти ветрогенератора вращаются.

Согласно среднему прогнозу ООН, численность населения к 2040 году достигнет 9,2 млрд человек, а основной прирост обеспечат наименее развитые страны Азии и Африки, в которых вопрос доступности энергии превалирует над источниками её получения.[24] Таким образом,

[22] Производство электроэнергии в 2019 году в мире [Электронный ресурс]: Статистический ежегодник мировой энергетики 2020. – Режим доступа: https://yearbook.enerdata.ru/renewables/renewable-in-electricity-production-share.html

[23] Что такое теплоэнергетика? [Электронный ресурс]: Официальный сайт Дальневосточного федерального университета (ДВФУ). – Режим доступа: https://www.dvfu.ru/schools/engineering/structure/departments/the_department_of_heat_power_engineering_and_heat_engineering/

[24] World Population Prospect 2019 [Электронный ресурс]: Highlights, the official United Nations population. – Режим доступа: https://www.un.org/development/desa/pd/ru/news/world-population-prospect-2019

естественный рост населения в совокупности с увеличением ВВП ряда стран указанных регионов создает дополнительные потребности в обеспечении своих экономик электроэнергией и наращивает потребление традиционных видов энергоресурсов. При этом основной вклад в мировой рост генерируемой электроэнергии вносят Китай и Индия.

Мировое потребление электроэнергии

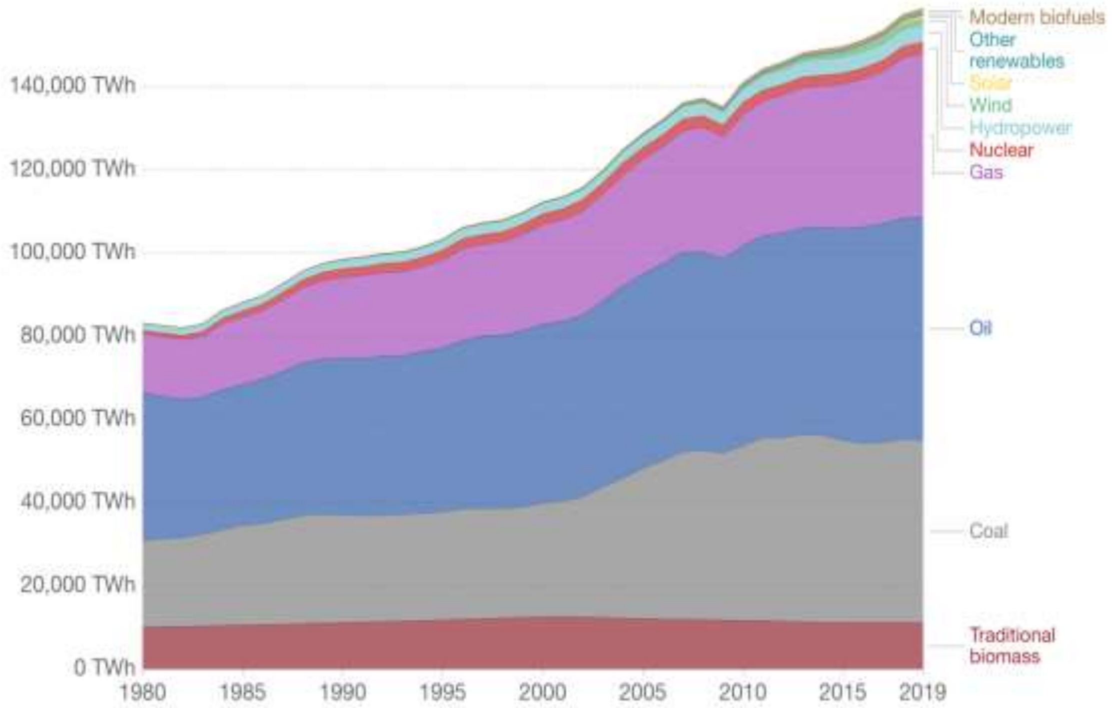

Рис. 1. Мировое потребление электроэнергии в разрезе используемых энергоресурсов, TWh
Источник: Our World In Data (1980-2019).

Производство электроэнергии по регионам

Основываясь на данных BP, представленных компанией в ежегодных энергетических отчетах, вклад стран Азиатско-Тихоокеанского региона в показатели роста мировой электроэнергетической генерации на конец 2019 года составил 47,9% (+5,4% к 2018 году). При этом совокупная генерация стран ЕС значительно ниже азиатской и находится на уровне 14.8% (-0,1% к 2018 году) [25].

Высокие темпы прироста производства электричества в Азиатском регионе подтверждают факт наличия значительного объема потребностей в дополнительной электроэнергии у его населения. Однако в некоторых азиатских странах по-прежнему есть люди, у которых нет какого-либо доступа к электричеству, и потому, по мере развития экономики этих стран, потребность в дополнительной генерации будет расти. За счет каких источников энергии будет удовлетворяться возрастающий спрос – вопрос открытый.

[25] World energy production [Электронный ресурс]: BP Energy Outlook (2019). – Режим доступа: https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html

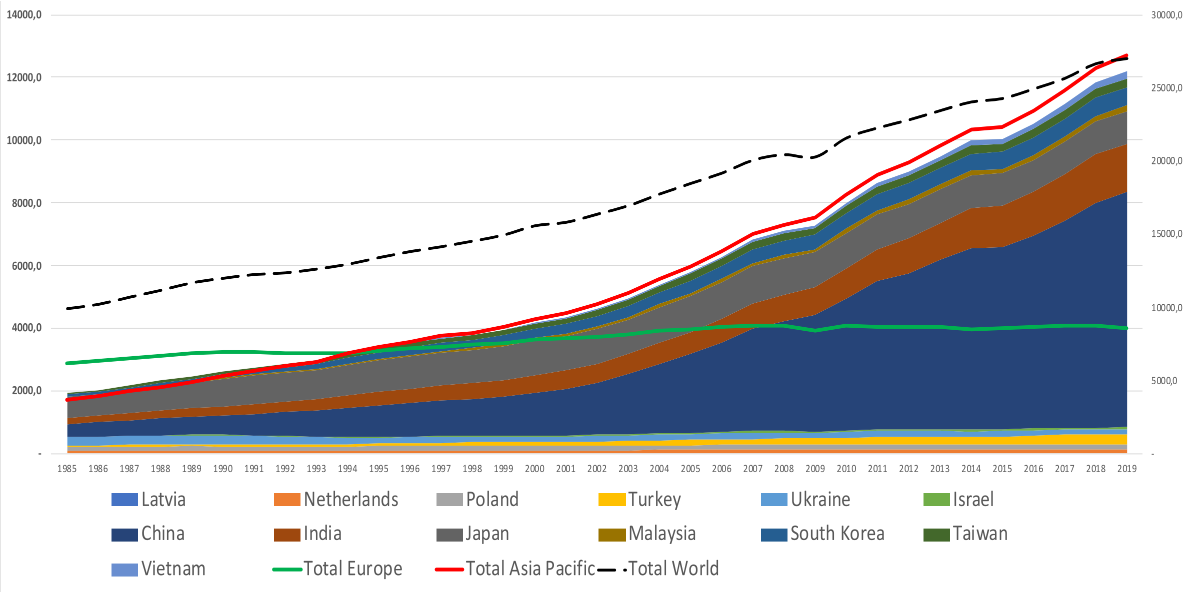

Рис. 2. Производство электроэнергии по регионам, TWh

Источник: BP Energy Outlook (1985-2019)[26].

В развитых странах такой проблемы не стоит, и потому у них меньше поводов задумываться над тем, каким образом обеспечить растущие потребности в электроэнергии своего населения. Мы даже можем проследить тенденцию к снижению потребления электричества на душу населения, например, в Германии, Франции или Японии. В Индии и Китае, напротив, рост промышленности и качества жизни населения приводит к противоположным результатам.

Потребление электроэнергии на человека

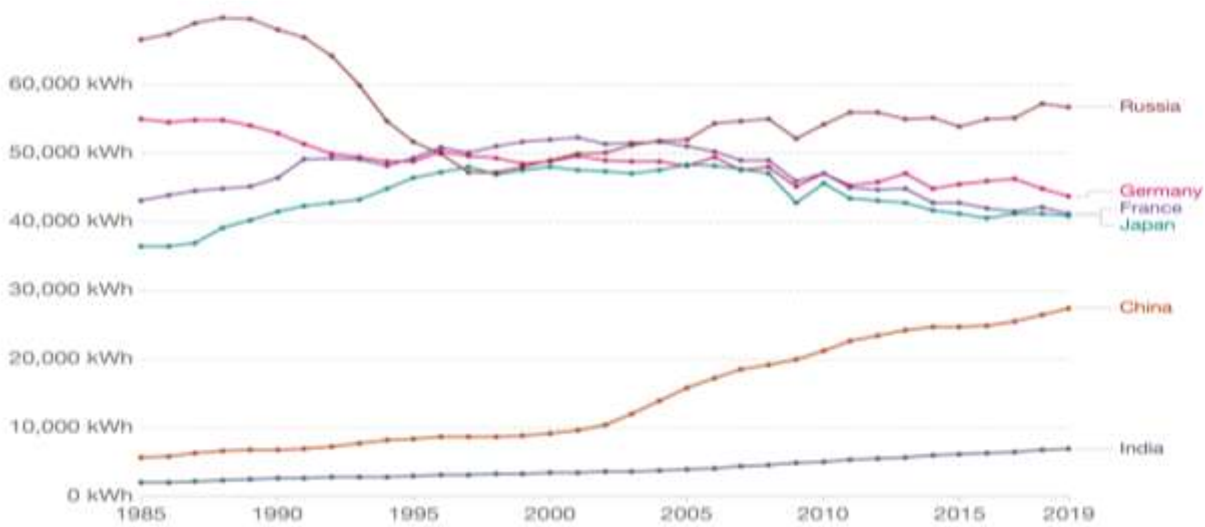

Рис. 3. Потребление электроэнергии в расчете на одного человека, KWh

Источник: Our World In Data.

[26] BP Energy Outlook 1985-2019 [Электронный ресурс]: The Knoema Data Workflow. – Режим доступа: https://knoema.com/atlas/sources/BP

Еще одной тенденцией является продолжавшийся в 2019 году общемировой рост электрической генерации, получаемой непосредственно от сжигания угольного топлива. Несмотря на явные колебания общего значения графика вниз в 2019 году, связанного с сокращением использования угля странами ЕС, очевидна и тенденция продолжающегося увеличения угольной генерации в странах Азиатско-Тихоокеанского региона, фактически нивелирующего усилия Европы.

Производство электроэнергии из угля по регионам

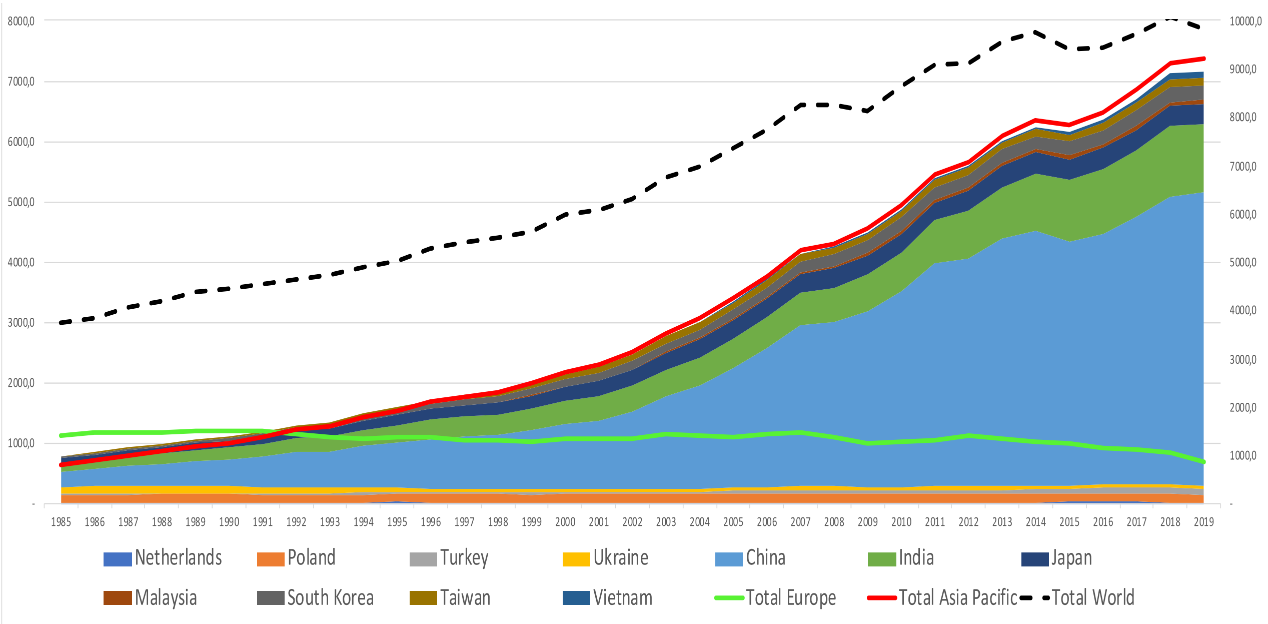

Рис. 4. Производство электроэнергии из угля по регионам, TWh

Источник: BP Energy Outlook (1985-2019)[27].

Даже если бы все страны Евросоюза в 2019 году отказались полностью от угля, его общее потребление для нужд электрогенерации снизилось бы всего на 7,1%. Поэтому можно предположить, что потребление электроэнергии будет в будущем только расти, уголь еще какое-то время будет продолжать занимать значительную долю в мировом энергобалансе. Самым сложным для экономистов в данном случае является определение тех переломных моментов, когда каждая отдельная страна начнет сокращать производство и потребление угольного топлива в пользу более чистых энергетических ресурсов.

Теперь перейдем к влиянию российской угольной отрасли на описанные тенденции мировой энергетики. Стоит отдельно отметить, что графики на рис. 2 и 4 были построены на основе данных отдельных стран и целых регионов, являющихся наиболее крупными импортерами российского угля. К их числу относятся: Китай, Республика Корея, Германия, Япония, Нидерланды, Польша, Турция, Тайвань, Украина, Индия, Вьетнам, Латвия, Малайзия, Израиль, Финляндия.

[27] BP Energy Outlook 1985-2019 [Электронный ресурс]: The Knoema Data Workflow. – Режим доступа: https://knoema.com/atlas/sources/BP

Российская Федерация поставляет энергетический уголь в двух основных направлениях – в Европу (на Запад) и в Азию (на Восток). Уже сейчас с высокой долей вероятности можно зафиксировать тренд сокращения угольной генерации в Европе, где по итогам 2019 года из угля было получено на 18,4% меньше электроэнергии, чем в 2018 году. Одновременно мы наблюдаем увеличение угольной генерации в Азии на 1,2% за аналогичный период. Главная проблема в данном случае заключается в том, что в АТР угля ежегодно сжигается в несколько раз больше, чем в Европе. Поэтому если предположить, что текущие темпы прироста будут сохраняться и далее, то даже при полном отказе Европы от угля Азиатский регион преодолеет разрыв уже к 2027 году.

Прогноз производства электроэнергии из угля на 2020-2040 гг.

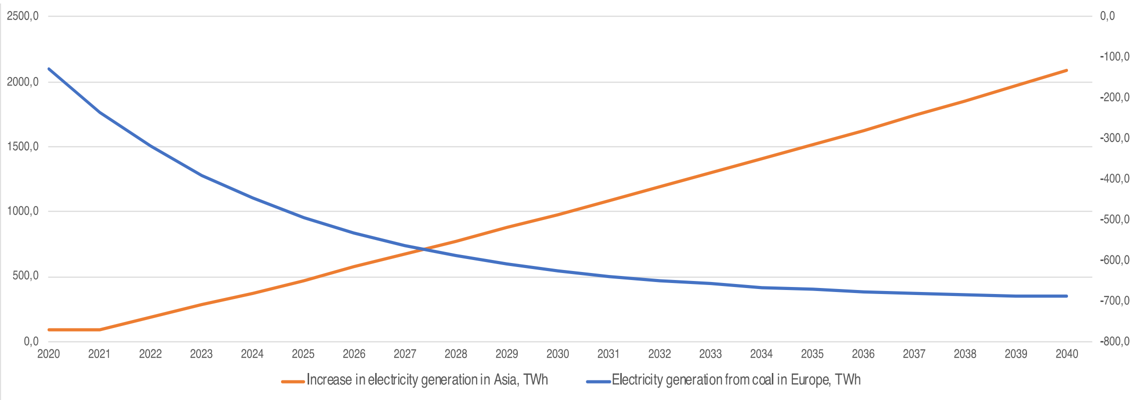

Рис. 5. Прогноз производства электроэнергии из угля на 2020-2040, Twh

Источник: вычислено на основании данных BP Energy Outlook (1985-2019)[28].

Из числа основных импортеров российского угля консенсус по достижению углеродной нейтральности не достигнут только в пяти странах – Индии, Вьетнаме, Малайзии, Турции и Украине (табл. 1).

Складывающаяся картина говорит не в пользу российской угольной отрасли, однако до 2050 года можно прогнозировать актуальность данного вида топлива для АТР с ростом потребления в ближайшие 5-10 лет.

Новой реальностью для угольной промышленности России стала подготовленная Правительством РФ Энергетическая стратегия Российской Федерации до 2035 года. Хотя её основной фокус направлен на нефтяной и газовый секторы, тем не менее российское правительство оптимистично смотрит на дальнейшее развитие отечественной угольной промышленности. В то же время оно полагает, что для обеспечения конкурентоспособности угля как на внутреннем, так и на внешнем рынке необходимо сдерживать рост цен на природный газ и продолжить программы льготного тарифообразования на его железнодорожную транспортировку. В целом до 2035 года планируется создание новых центров угледобычи в республиках Саха и Тыва,

[28] BP Energy Outlook 1985-2019 [Электронный ресурс]: The Knoema Data Workflow. – Режим доступа: https://knoema.com/atlas/sources/BP

Забайкальском крае и других регионах Сибири и Дальнего Востока, способных обеспечить при благоприятной конъюнктуре рост экспорта угля в 1,5 раза. Добыча угля в консервативном сценарии стабилизируется на достигнутых уровнях (375 млн тонн в год), а в оптимистическом сценарии вырастет в 1,3 раза (до 490 млн тонн). Экспорт угля при консервативном сценарии останется на уровне 160 млн тонн в год, а при оптимистическом – вырастет до 250 млн тонн.[29]

Динамика импорта угля в ключевых для РФ регионах

Таблица 1. Траектория движения основных импортеров российского угля к углеродной нейтральности

Asia	*Import in 2019, Mt*	*2019 to 2018*	*Carbon "zero" consensus*
China	32,8	119%	by 2060
South Korea	28,3	97%	by 2050
Japan	20,2	111%	by 2050
Taiwan	8,5	92%	(officialy no, by 2060 with China)
India	8,0	178%	officialy no
Vietnam	6,1	230%	15% reduction by 2030
Malaysia	3,3	106%	officialy no
Europe			
Germany	21,3	154%	by 2050
Netherlands	13,8	115%	by 2050
Poland	10,9	82%	officialy no, but consensus has been achieved
Turkey	9,4	79%	officialy no
Ukraine	8,1	74%	officialy no
Latvia	4,7	110%	by 2050

Источник: подготовлено на основании данных CDU TEK (2018-2019) и публикаций в СМИ[30].

Мировой вектор, направленный на декарбонизацию, в целом, никак не влияет на стратегию правительства и планы российских угольщиков. Подписанный Президентом РФ В.В. Путиным Указ № 666 подразумевает сокращение выбросов к 2030 году до 70 процентов от уровня 1990 года с учетом максимально возможной поглощающей способности лесов, т.е. минус 30 процентов от 1990 года к 2030 году.[31] В настоящее время Россия находится на уровне выбросов около минус 50 процентов от уровня 1990 года, включая поглощение лесов, и на уровне порядка минус 30 процентов без него. То есть, согласно новой цели, выбросов может быть больше.

Если посмотреть на структуру энергопотребления России, то существенное влияние на климатические изменения оказывают два региона – Сибирский федеральный округ и Дальнево-

[29] Об утверждении Энергетической стратегии Российской Федерации на период до 2035 года [Электронный ресурс]: Распоряжение Правительства РФ от 09.06.2020 N 1523-р. – Режим доступа: http://www.consultant.ru/document/cons_doc_LAW_354840/

[30] Таразанов И.Г., Губанов Д.А. Итоги работы угольной промышленности России за январь – декабрь 2020 года // Уголь. 2020. No 3. С. 54-69.

[31] О сокращении выбросов парниковых газов [Электронный ресурс]: Указ Президента РФ от 04.11.2020 N 666. – Режим доступа: http://www.consultant.ru/document/cons_doc_LAW_366760/

сточный федеральный округ. В них доли потребления угля составляют 84,6 и 54,2% соответственно. В остальном внутренний баланс российской энергетики выглядит вполне устойчивым.

В этой связи протекающие на текущий момент в мире процессы декарбонизации влияют в большей степени на экспортный потенциал российской угольной продукции. При сохранении снижающегося интереса европейских партнёров к углю уже через 10 лет, вероятно, все угольные грузопотоки из России с западного направления будут перенаправлены на восток, а объемы отгрузки угля будут определяться тремя основными факторами: пропускной способностью железных дорог, потребностью азиатских экономик в угле, ценой и конкурентоспособностью российского угольного топлива в сравнении с другими мировыми экспортерами.

Металлургический уголь на текущий момент не имеет полноценных заменителей, позволяющих удовлетворять потребность мировой сталелитейной промышленности. Доля его экспорта в абсолютном объеме поставляемых из России углей составляет порядка 10%, однако сфера его применения относится к металлургии, а не к энергетике.

<u>Топливно-энергетические балансы регионов РФ</u>

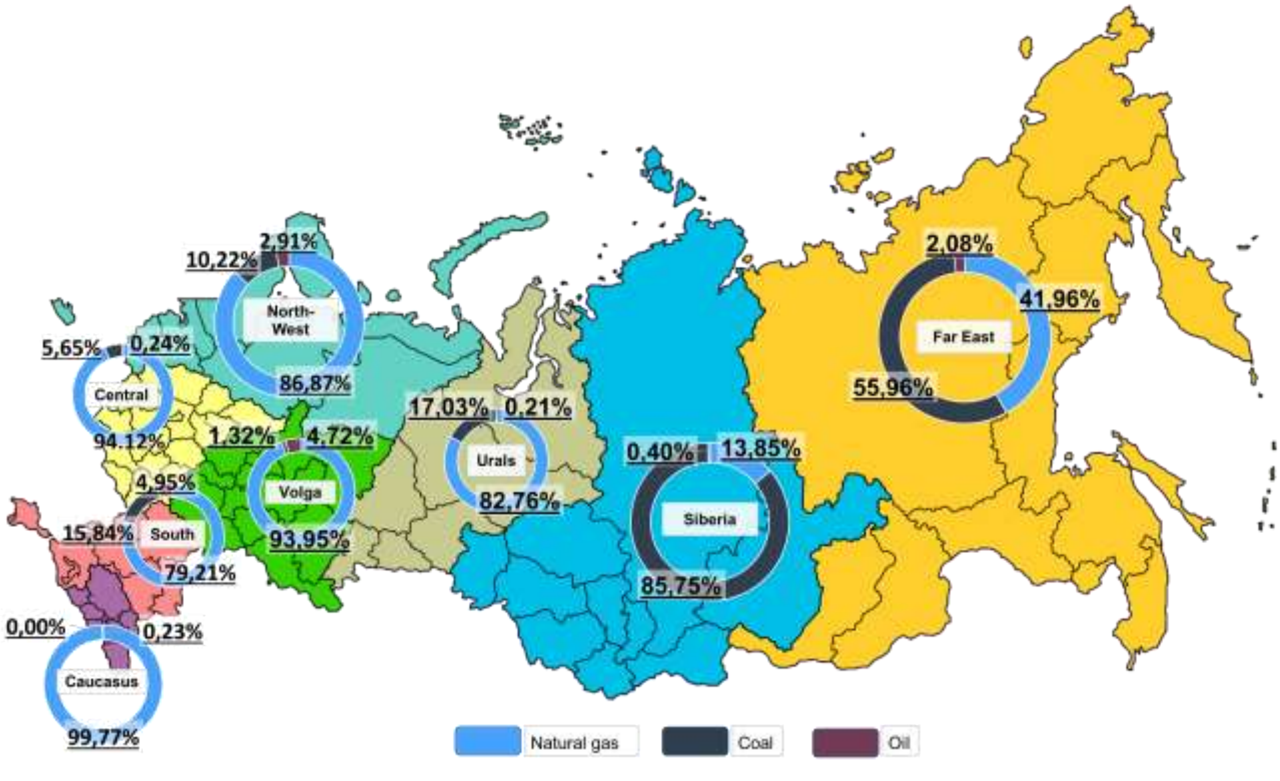

Рис. 6. Топливно-энергетические балансы российских регионов по 3 источникам энергии на начало 2019 года, %

Источник: подготовлено на основании данных Росстата (ЕМИСС).

Сложность прогнозирования сценариев дальнейшего развития российской угольной промышленности также обусловлена тем, что все её предприятия сосредоточены в частных руках. Если газовый, нефтяной и атомный рынки России представлены крупными государственными компаниями ПАО «Газпром», ПАО «Роснефть» и ГК «Росатом», то угольных компаний достаточно много, все они предоставлены сами себе и очень чувствительны к конъюнктуре и изменениям в регулировании.

Говоря о технологиях чистого угля, на первый взгляд перспективными кажутся электрические станции, работающие на ультрасверхкритических параметрах пара, что позволяет станциям снижать потребление угля с 800 грамм до 380 грамм за 1 кВт·ч. Результатом подобной экономии также становится сокращение выбросов и зольных отходов, что значительно повышает экологические показатели угольной генерации. Использование современных электронных фильтров может дополнительно снизить негативное влияние от сжигания угля на ТЭС, приводя к сокращениям выбросов парниковых газов вплоть до уровня ТЭЦ, работающих на природном газе. На сегодняшний день описанные технологии широко распространены в Китае и Японии. В России данная технология не получила должного распространения по причине её высокой стоимости.

Таким образом, декарбонизация мировой экономики формирует условия траектории дальнейшего развития российской угольной отрасли. В частности, если Европа продолжает снижать объемы закупки угля, то с российской стороны образуется избыток предложения данного вида топлива для стран АТР. Это, в свою очередь, в долгосрочной перспективе может привести к падению цен на российский уголь. Существует риск того, что в конечном итоге уголь будет продаваться по себестоимости, а вся прибыль будет съедаться тарифами железнодорожного оператора.

По мере сокращения спроса на уголь добывающие предприятия могут начать сталкиваться с риском их закрытия, а нагрузка на инфраструктуру ляжет целиком на плечи государства. В складывающихся условиях представителям угольного бизнеса и российскому правительству необходимо активизировать работу, направленную на поддержку отрасли, внедрение новых технологий и создание возможностей для перенаправления экспортных потоков угля с западного направления на восточное. Причем включаться в работу нужно незамедлительно. Пока что поддержка отрасли со стороны государства незаметна, а частные производители свои будущие планы выстраивают исключительно с опорой на физический экспорт добываемого угля.

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Sector Coupling – a view from a German TSO

The Transmission System Operator 50Hertz

50Hertz is one of the four transmission system operators (TSO) in Germany. The German control area is shown in the Figure 1. All the TSOs in Germany are responsible for the extra high voltage grid (220 kV and 380 kV). 50Hertz is responsible for transmission grid in northern and eastern part of the country (Berlin, Brandenburg, Hamburg, Mecklenburg-Western Pomerania, Saxony, Saxony-Anhalt und Thuringia) and provides about 18 million people with electricity [4].

Figure 1. 50Hertz as part of the German Electricity System [4]

The grid length of 50Hertz is about 10, 200 kilometres, which is equal to the distance from Berlin to Rio de Janeiro. The company has more than one thousand employees and its maximum load is around 16 GW, which is around 20 % of the whole German load. The main tasks of the company are to provide the efficient maintenance of lines, cables and substations, to ensure the stability of the grid, to promote the integration of renewable energies (RE) and to participate in German and European electricity market, creating the grid of the future. The company is especially interested in researching and creating of innovative ideas and their implementation in the operational work of the company, combining new technologies and intelligent applications, in order to meet the requirements of a rapidly changing energy system *[4]*.

50Hertz connects large-scale generators (including large offshore wind parks) and large consumers to the grid. Wind energy is the most important renewable energy in Germany. Around 36 percent of the whole installed wind power of the country is fed into 50Hertz's grid, which is around 18,346 MW onshore and 1,068 MW offshore, mostly in northern Germany. 21 MW of wind power are expected by the year 2020. At the same time, the biggest consumption centres in Germany are located in South of the country. Due to the increasing distance between consumption of energy in the south and the production of renewable energy in the north of the country, it became the biggest challenge to keep the balance of the system, to cover the electricity volumes of the decommissioned nuclear and coal power plants. Currently there are a number of transmission grid projects at the company, with an aim to increase the transmission capacities and also to connect Germany better with the electricity grids of neighbouring countries *[4]*.

The electricity generation from RE-sources, namely wind and solar radiation, has a very stochastic character, which means, it has very strong fluctuations due to the weather, so that it rarely corresponds to the current electricity demand. Often wind turbines are located in sparsely populated areas with correspondingly low electricity demand. In the traditional electricity market, electricity was supplied at the lowest price at the moment and was generated followed the electricity consumption. Nuclear, coal and lignite-fired power plants supplied the base load and gas power plants were switched on for pick loads. In the energy system of the Energiewende renewable energies can increasingly take over more than half of the total electricity generation for single hours or even days. However, this electricity must be consumed exactly when it is generated - if not, they must be switched off *[5]*.

According to the Renewable Energy Sources Act (EEG), the system operators are obliged to feed in all at the moment available renewable electricity in their grid. Germany plays a leading role in the integration of renewable energy sources and distributed electricity generation. In order to feed in all electricity from RE sources and to maintain the balance between generation and demand, the task of TSO in Germany is to compensate the electricity fluctuations in the grid. This balancing is a particularly demanding task not only in network area of 50Hertz, but in the whole country. In the worst case, an unbalanced system can lead to complete power failure. Together with grid expansion, this requires the inevitable intervention measures, so-called redispatch *[4]*.

Redispatch is a requirement of TSO to adapt the active power feed-in of power plants with the aim to avoid network bottlenecks, by lowering the active power feed-in of one or more power plants while increasing the active power feed-in of one or more other power plants.

This measurement costs millions of euros annually, which have to be paid by the end customer. One of the most important goals of the grid expansion and forecasting projects of 50Hertz is to reduce the redispatch costs and as a result electricity prices for the end customers. In order to meet the demanding environmental goals and to create a safe, economical and environmentally friendly energy policy, modernization of today's energy system is necessary.

Sector Coupling Prospects for Germany

Modernization of today's energy system should not only be based on the electrical sector, but also on heating, cooling and transportation sectors *[4]*. In addition, the climate protection goals cannot be achieved without effective decarbonisation of the above-mentioned sectors. The goal is to be able to use the generated RE at the right time and at a suitable location without losing it. A successful energy transition and decarbonisation across all sectors requires an integrated approach for all sectors. In this way, the energetic potential and flexibility of one sector can be used in another one and vice versa. This ensures more flexible energy usage in industry, household, trade / trade / services and transport under the premises of economy, sustainability and security of supply *[4]*. To achieve this, the networking of the energy sector and industry sectors is needed, so called sector coupling.

At the same time, the most important aspect stays an integrated system-friendly behaviour, without additional stress for the electricity grid. From a grid perspective, sector coupling (at least in the medium term) is not an alternative to the necessary network expansion. The driver of sector coupling is a decarbonisation of other sectors, not the “healing" of network bottlenecks. The German federal government emphasize the role of sector coupling for the energy transition in connection with storage technologies. The heating and transport sectors have significantly lower share of RE then electricity sector. By coupling of all of these sectors, the share of RE in all sectors can be increased, so as CO2 emissions in heating networks and transport can be reduced *[4]*. Sector coupling focuses on different consumption profiles, for example household, trade, industry or services. Particularly the household and traffic sectors have so far barely contributed to GHG reduction. Sector coupling could remedy this (see Figure 2). So far, 29 % of the targeted 40 % reduction of greenhouse gases by 2020 has been achieved *[6]*.

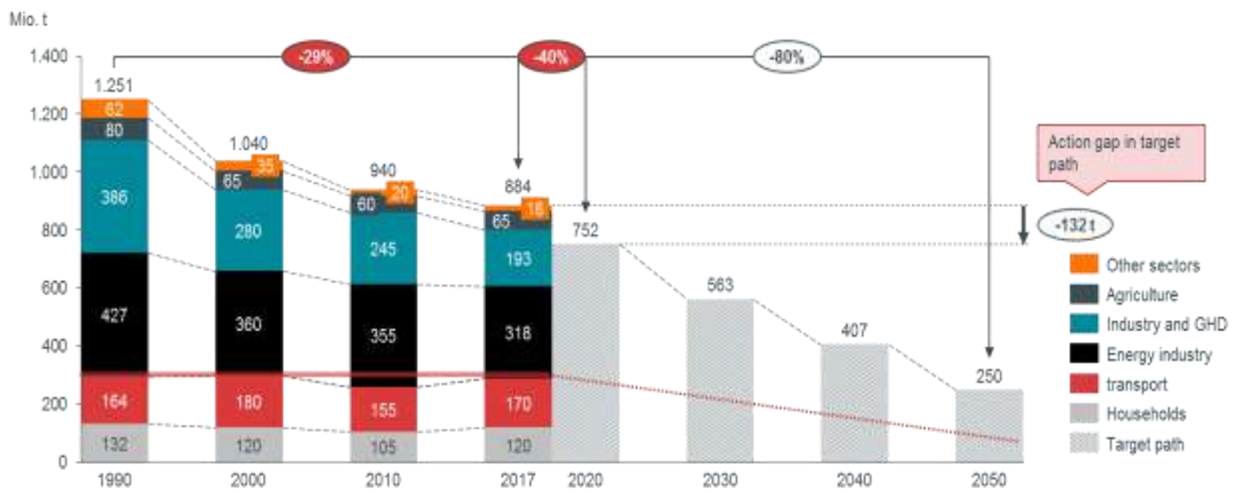

Figure 2. Greenhouse gas emissions (CO2 and others) in CO2 equivalents

With this concept, the existing energy surpluses from PV and wind turbines can be efficiently used by electrifying all energy usages by using Power-to-X technologies. Storage, transport and usage of RE will be possible with following innovative concepts: Power-to-Mobility (PtM), Power-to-Gas (PtG) or Power-to-Heat (PtH) *[4]*.

Power-to-Heat (PtH)

A PtH transfer is a process of converting renewable electricity into heat. This can be possible using combined heat and power (CHP) systems and heat pumps.

The heat demand in Germany is more than twice as high as the electricity demand. The 75 % of heat demand is covered by fossil fuels and causes around 275 million t CO2 per year. That is why the decarbonisation of this sector is extremely needed [4].

Power-to-Gas (PtG)

The PtG process connects the electricity sector to the gas sector by converting the excess electricity into a network-compatible energy gas such as hydrogen or methane. An optional methanation is used as the central connecting element between the electricity and gas sectors. An elementary advantage of this concept is possible long-term storage. Hydrogen can be divided in two different forms, namely blue hydrogen and green hydrogen *[7]*. The difference is depicted in Figure 3.

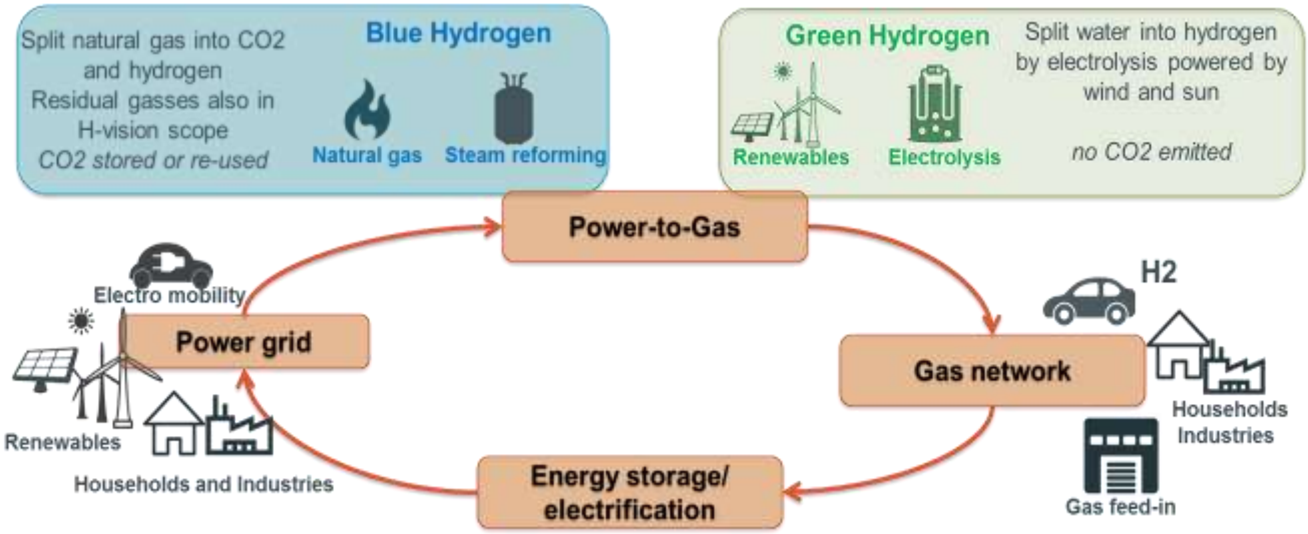

Figure 3. Sector coupling: Power to gas

Considering a cost reduction of electrolyzer technology (conversion of electricity into hydrogen), the usage of electricity surplus in Germany can make a valuable contribution to the decarbonization of the overall energy system. In order to promote the development of PtG technology, the Federal Ministry of Economics had launched the idea competition "Reallabors der Energiewende". 50 Hertz active participates as a part of HYPOS consortium [4] (see the chapter “Real laboratories for the energy transition”.

Power-to-Mobility (PtM)

This concept means the use of the surplus “green” electricity for charging electric vehicles. In addition, the electric cars in the grid can theoretically be used as energy storage due to the bidirectional connection. In addition, the so-called natural gas vehicles can be “fueled” with the fuel generated from power-to-gas technology (s. Figure 3).

According to new agreement of the European Parliament, the CO2 emissions of new cars must be 37.5 percent (cars) or 31 percent (commercial vehicles) below the already agreed emission limits in 2021. The electrification of the transport sector can make an important contribution here [4].

Even when assumptions are high for the prevalence of electric vehicles, the effect of sector coupling on electricity consumption remains low. As you can see on the graph the Power to Heat applications have larger effects on energy consumption than electric mobility [6].

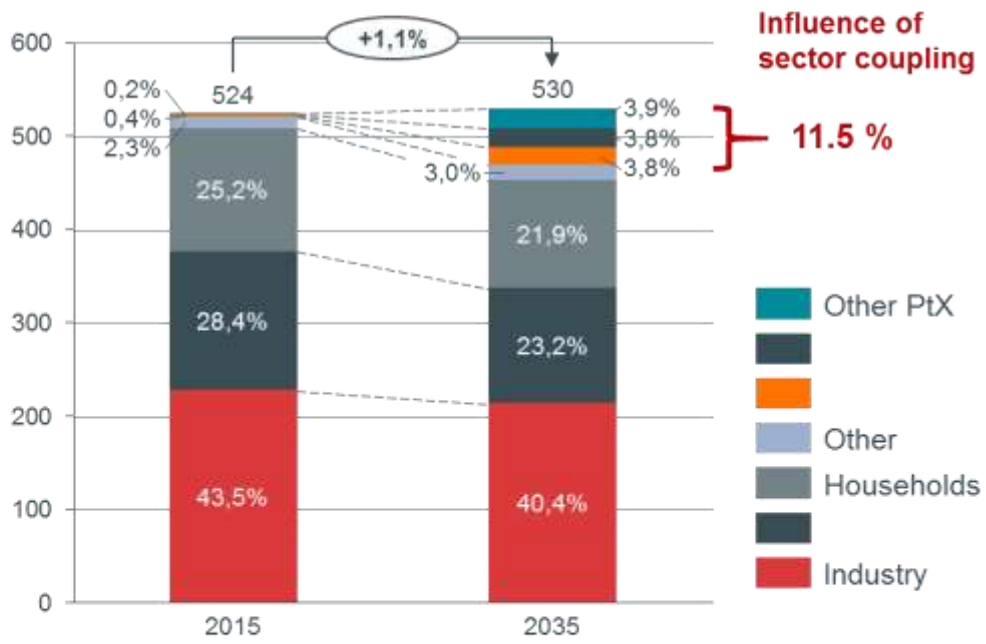

Figure 4. Net electricity consumption in Germany

Regarding some simulations peak loads caused by electric mobility are hardly significant compared with the total load, under following assumptions [8]:

- Load profile for electric mobility contains 20 % of flexible and 80 % of regular charging behaviour;
- Peakload due to electric mobility (7 GW) and across all sectors (84 GW) on a weekday in the coldest winter week;
- Increase of peakload can be limited by flexibility in the system.

However, the impact of the sector coupling on the power consumption is low - effect on (residual) load peaks and load flows still needs investigation. The need for power-to-gas in Germany is still disputed. There are many controversial opinions, here are some of them:

– Power-to-gas is not necessary or economically viable for an 80% reduction in German greenhouse gas emissions. (Long-term scenarios BMWi 2017)

– "The -95% targets cannot be achieved without PtX. A large part of the PtX is imported from abroad. " (Dena Lead Study 2018)

– „Even in the long term, importing synthetic methane is associated with lower costs than generating synthetic methane based on offshore wind energy in the North and Baltic Seas„ (Agora Energiewende 2018: The Future Cost of Electricity-Based Synthetic Fuels)

– "Scenarios with a broad mix of technologies [cause] significantly lower costs by 2050 ... and [are] more robust in terms of implementation challenges such as acceptance ..." (dena Lead Study 2018)

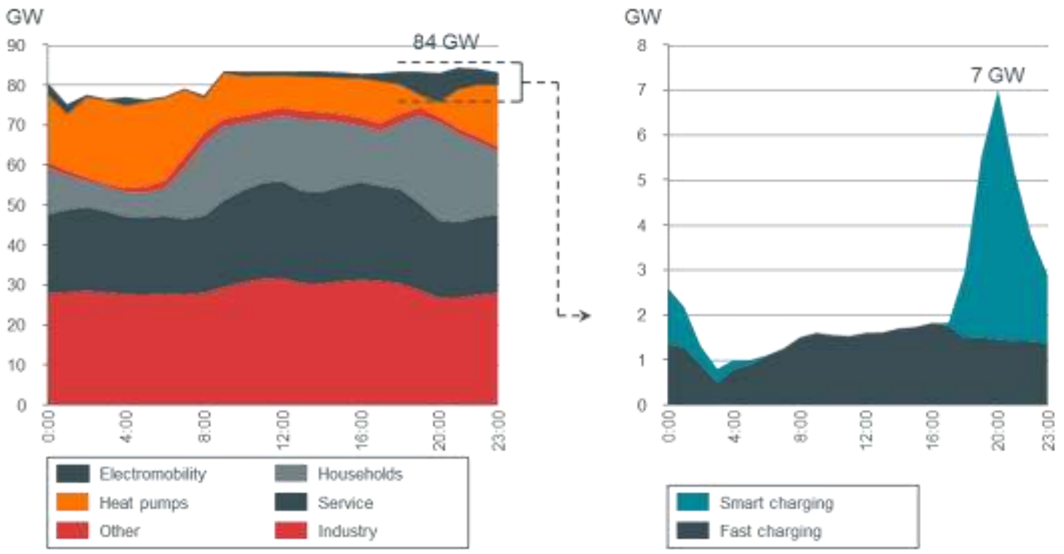

Figure 5. Predicted load curve per sector. Based on the GDP 2035B using the example of 07/02/2035, 10 million electric cars

Moreover, it is important to note, that direct electrification is the most efficient way to use renewable electricity in transport and that the production of SynGas is cheaper abroad. An alternative could be to import the synthetic fuels via existing infrastructure. That can be seen on example in the Figure 6.

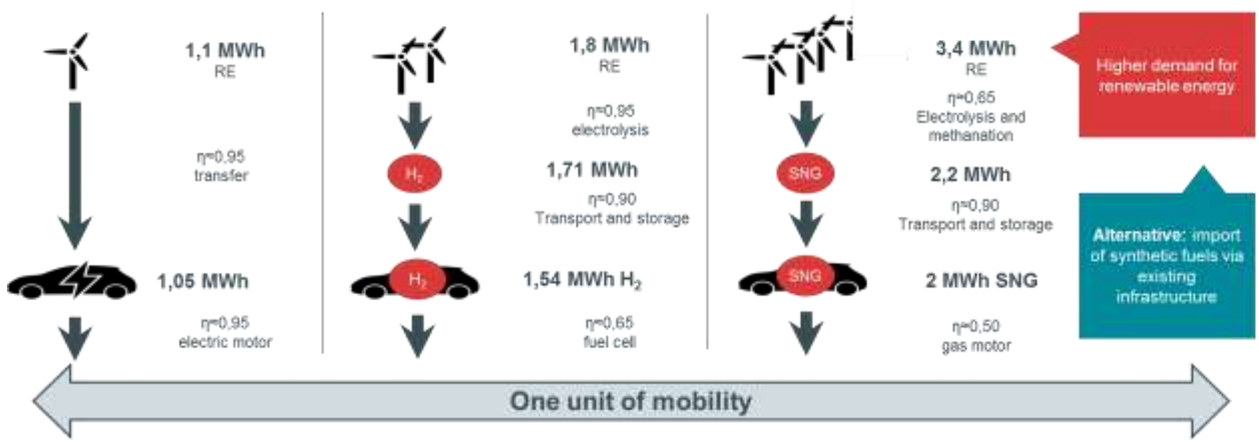

Figure 6. Direct electrification allows the use of RE in the country

Nevertheless, according to extrapolation by German TSOs (2018), NEP (2019) Szenario 2030B, in order to achieve the ambitious goals of energy policy, namely complete decarbonisation of heat and transport sectors, significant amount of RE will be required (around 500 TWh) (see Figure 7) [9].

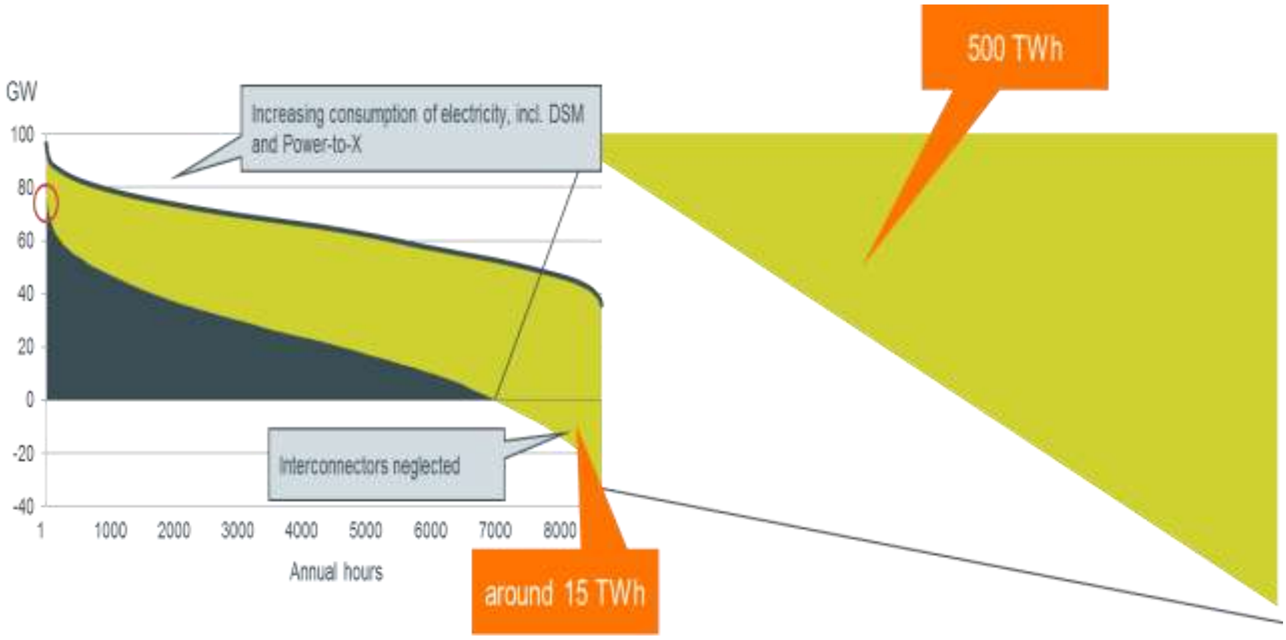

Figure 7. Projection Residual load 2030 and needed Load for covering other sectors

Today Germany is at the very beginning of the way of sector coupling. There are still many opened questions and unsolved problems. Here are some of them:

– What obstacles exist in terms of technical feasibility?

– In order to have the technology "ready to go" from 2030, real laboratories can provide valuable insights for power to gas

– Which business models will prevail?

– What does the distribution of roles look like in an economically regulatory useful framework?
However, in order to have the technology "ready to go" from 2030, real laboratories can provide valuable insights for power to gas and can help to solve some outstanding issues.

Laboratories of Energiewende

Real laboratories represent a test rooms with a real conditions to gain experience with rooms for innovation and regulation. Real laboratories require legal flexibility instruments, for example in the form of experimental clauses. Real Laboratory was a part of the 7th Energy Research Program "Innovations for the Energiewende", which includes 6 billion Euro. There were 90 applications in the first round (from 11.02.2019 to 05.04.2019), from which 20 winners were announced, funded in the following areas: large-scale energy storage in the electricity sector, energy-optimized quarters, sector coupling and hydrogen technologies. Targets and scopes were: to develop the hydrogen technologies in country, to promote them for max. 5 years, including planning and installation phase as well as a 1 to 3-year test operation / monitoring phase, 100 million Euro per year for four years between 2019 and 2022, and additionally 200 million Euro for real laboratories in structural change regions. At the latest in three years, there will be another call for tenders for new projects. Exploring innovations and new solutions to deal with fast changing energy sector is one of the core tasks at the 50Hertz company. As a result, eleven real laboratories of Energiewende were founded in the 50Hertz control zone and 50Hertz has agreed to participate in two real laboratories, and two more are in narrower choice (see Figure 8 and Figure 9).

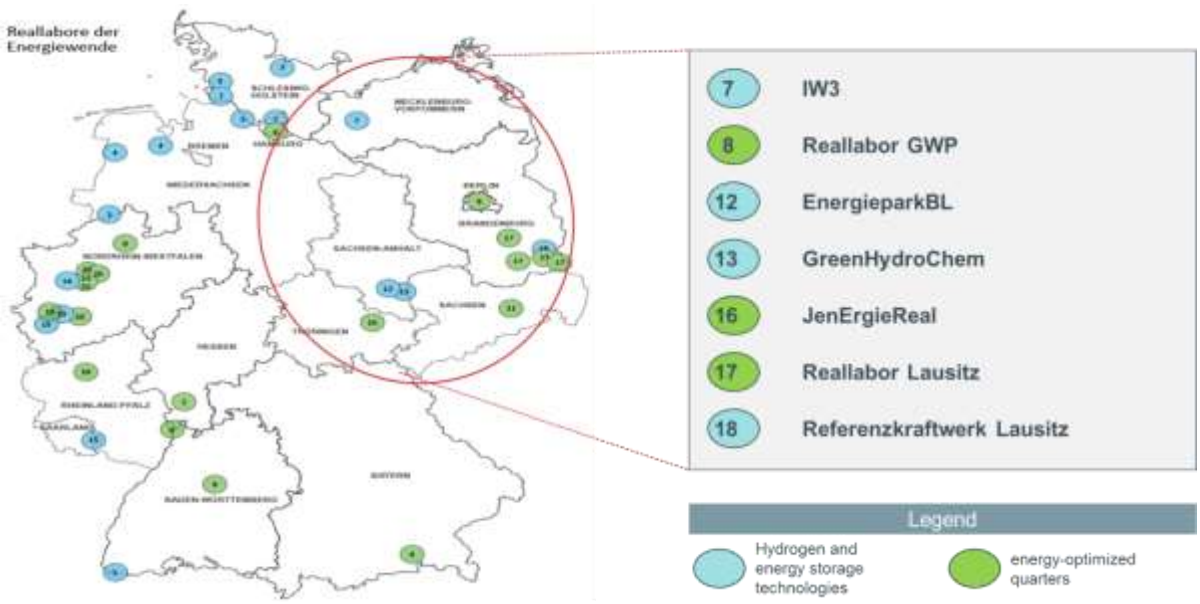

Figure 8. Real laboratories of the energy transition in the 50Hertz control zone

Figure 9. Participation in real laboratories of 50 hertz

Conclusion

It can be noted, there are still many unsolved problems and questions, as well as the pros and cons of sector coupling in Germany. Right now Germany is at the very beginning of this way and there is a lot of work ahead. PtX / G technologies are on the long way to competitiveness. A combination of these systems can lead to a number of advantages, namely increased integration of renewables to the grid through the use of flexibility options from neighbouring energy substitution or energy storage systems; additional market interaction (a reaction to volatile electricity market prices, e.g. system-oriented energy storage through battery storage (BS), reaction of CHP systems with heat buffer, etc.). For this purpose, existing gas and heating network infrastructures can be used, which can also implement a storage function. Such systems can also be involved in energy services. Considering this topic and weighing a lot of pros and cons, it is important to note, that the driver is the decarbonization of the sectors industry, mobility and heat - not the “healing" of network problems. An overall economic benefit of sector coupling becomes visible only in a long-term perspective (after 2035). In order to advance the market maturity of PtX / G and to have the technology fully developed after 2035, real laboratories are already useful and necessary.

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Molecules vs Electrons, where are we headed?

Introduction

Deep and intensive decarbonisation of the energy system is needed to meet the goals set out in the Paris agreement and move towards a circular and carbon free world. Since access to clean, reliable and affordable energy is one of the main drivers for human development it is key to make this shift as efficiently and cost effective as possible in order not to lose societal support and avoid significant economic drawbacks.

Current energy systems can be divided in two key forms; electricity and molecules (liquids and gasses). In most systems around the world electricity is only a small component and fossil liquid and gaseous fuels make up the largest part of the total energy system. Current technologies to decarbonize the energy system favour electricity generation and therefore the trend is towards further electrification of sectors like transport, households and industry.

Current trend and challenge

However, is this feasible? When we look at the current system we can see that, within the EU (EC 2018), only 20% of the total primary energy used is electricity. The rest is molecules in the form of gasses and liquids for transport, industry and power generation. The EU has currently spend

1000 billion euro over the past 10 years to make 50% of the electricity production carbon neutral. This is a very high number but when put into perspective of the EU economy (0,5%) this is doable. However, it does raise the question how much fully decarbonizing the molecules is going to cost.

An additional complexity for the decarbonisation of the energy system is that the historical starting point of a low complexity central generation system will most likely be replaced with a complex multiple generation system whereby the consumer is not only recipient but also plays a part in the smart exchange and generation of energy. This system change is a key aspect of the energy transition and plays a part in determining the most optimal way forward in relation to electrons (electrification) and molecules (gas and liquid).

Which way forward

Interestingly, future scenario's do not necessarily agree on what type of system is most optimal and cost effective. Here we have looked at two scenario's relating to extensive use of molecules 'optimal renewable gas future' (Navigant, 2019) and extensive electrification or 'High E breakthrough' (Element Energy, 2019). Both scenario's focus on a fully carbon neutral energy system in 2050 but arrive there by two different routes. They also both claim to be more cost effective compared to the other.

The optimal gas scenario uses the rationale of fully utilizing the existing gas infrastructure and connectivity to consumers and industry. It further states that certain industries like steel, manufacturing, chemical and heavy mobility will have a hard time electrifying and against proportionally high costs. Molecules are also use for storage and peak shaving of renewable energy generation. Furthermore, the use of biomass for gasification and hydrogen (blue and green) is foreseen as replacing fossil natural gas. Resulting in a future where 40% is electric and 60% molecules. Compared to fully switching to electricity this will save between 100 -217 billion euro annually for the EU.

The high E breakthrough scenario in comparison comes from a different perspective. Here it is assumed that 90% of the primary energy use is electric. Hydrogen plays a part but on location and generated from electrolysers, essentially meaning that the industry that uses hydrogen is 'electrified'. Furthermore, they assume that Europe is largely interconnected and technologies have been developed and applied to make this interconnectivity possible. It is thereby possible to focus optimally implement technologies for generation (for example wind on north sea) and storage (for example hydro power in the alps) and tie these together. Although massive investments in new electricity infrastructure is required, the gas infrastructure maintenance and replacement costs are redundant and saved. Overall, this can result in an actual saving of 90 billion euro's per year. Purely by subtracting the costs of maintaining the gas and oil infrastructure from the foreseen extra investments.

Conclusion and discussion

Interesting to see that both scenario's use the other weakness as a strength. For optimal gas the fact that the infrastructure can be utilized for renewable gas is see as an advantage, whereby less investment in electricity is required. For the high E scenario the opposite is claimed and the costs of maintaining the gas infrastructure alongside a large and heavy electricity infrastructure is seen as a waste where discarding the gas infrastructure results in an overall saving.

Whatever, scenario is through we should keep in mind that technical solutions are not the only thing we need to consider. Going from 80% molecules to 10% requires a complete shift in system and mind-set. This might be possible technically and even economically but will disrupt the current economic system and create unforeseen resistance to the overall aim of complete decarbonisation. The EU has actually recognized this as well and in the most recent predictions, 1.5TECH and 1.5LIFE (EC, 2018), a large share of molecules is foreseen (up to 50%). Given the current system and challenges that lies ahead that seems a sensible middle, which still requires extensive electrification and generation of renewable molecules and electricity. We should take care not to disrupt the current economic and societal model too much too quick. A future where 50%/50% electricity and molecules is foreseen will have a big effect on our current energy system but also leave room for traditional industries and energy companies to shift within a known business model. Thereby, tempering the changing to a certain extend and making sure that public opinion remains behind the energy transition.

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Renewable Energy in Ukraine

Executive summary
RES capacities in Ukraine have increased dynamically in the last years. This report argues that Ukraine would benefit from continuing this development.

Although Ukraine has committed itself to a range of international climate obligations it is still not very ambitious compared to other countries. As Ukraine has signed the Paris Agreement it would be appropriate for Ukraine to raise its ambitions to contribute to keep global temperature rise well below two degrees. A rise in RES is an integral part of such a decarbonization path.

Further RES expansion yields several advantages for the Ukrainian energy system. New capacities are needed to replace the ageing power plant fleet and to sustain energy security, especially as electricity generation from coal is losing its competitiveness. Moreover, the diversification of energy sources may reduce market power of major energy suppliers and dependence on energy imports and international resource markets.

Ukraine has already achieved a substantial rise in RES capacities, mainly due to the introduction of generous feed-in-tariffs for RES. In 2020, a RES-auction-scheme will be introduced.

Higher RES penetration poses challenges to the Ukrainian energy system, foremost due to the variability of RES. We propose to address these challenges by different instruments. First, the mix of RES technologies as well as the location of facilities can be optimized to smooth variability. Second, variability can be addressed by regulatory measures such as incentivizing curtailment of excess RES and demand response or improving RES-forecasts. Third, variability can be addressed by increasing the flexibility of the electricity system by building storage, transmission lines or flexible power plants. Finally, the cost of RES can be reduced by transitioning towards a well-designed, competitive auctioning mechanism.

In this report we argue that increasing the share of RES is an opportunity for developing a cost-efficient and clean energy system in Ukraine. To reap this potential, the country must raise its renewables target and implement complementary measures to ensure smooth system integration.

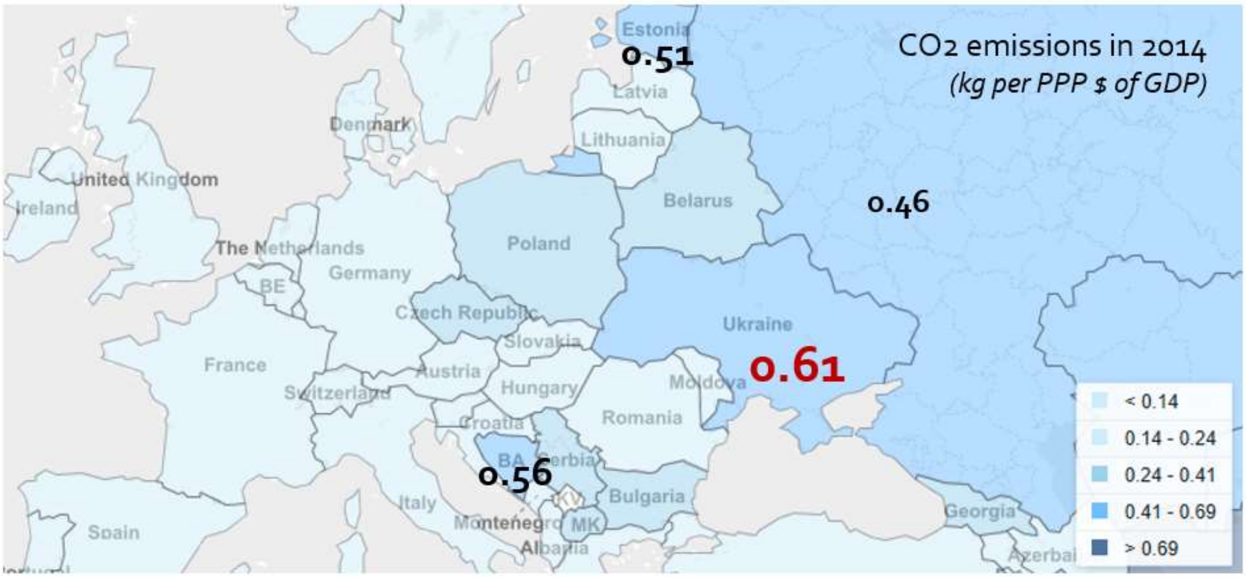
1. Motivation

Ukraine was one of the first countries that ratified the Paris Agreement. It, however, still lags behind all European countries in terms of emission intensity. According to Figure 1, Ukraine in 2014 emitted 0.61 kg CO2 per PPP $ of GDP. As the energy sector[32] is the most emission-intensive sector in the

[32] In Ukraine's greenhouse gas inventory 1990-2017 (draft) the energy sector comprises transport, energy industries, fugitive emissions, energy in manufacturing industries and other energy sectors.

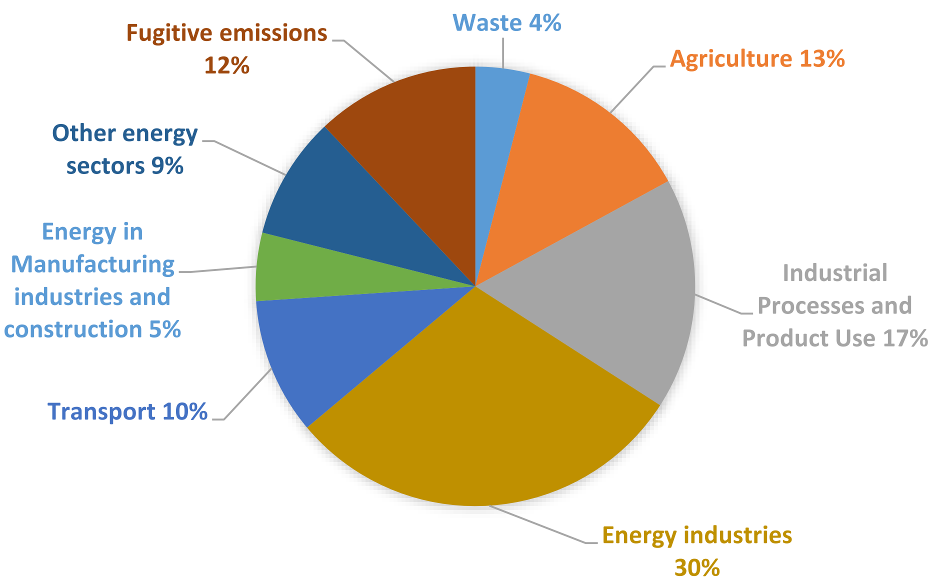
Ukrainian economy (see Figure 2), raising the RES share in electricity generation is crucial for reducing emissions.[33]

Figure 1. CO2 emission intensities in 2014



Source: Worldbank

Figure 2. Ukraine's GHG emissions by sector in 2017



Source: Ukraine's greenhouse gas inventory 1990-2017 (draft), Ministry of Ecology and Natural Resources of Ukraine

[33] Already six Ukrainian cities committed themselves to raise their RES share up to 100% by 2050, following the global climate initiative 350.org. Their ambition is leading the way for the whole country. https://gofossilfree.org/a-huge-win-in-ukraine/

In 2020 Ukraine has to submit a number of new or revised energy and climate policy strategies and plans. First of all, the Energy Strategy 2035 has to be revised and a respective action plan needs to be set out, as the former action plan is only valid until 2020. Additionally, the National Renewable Energy Action Plan and the National Energy Efficiency Action Plan need to be defined in the near future as well. Therefore, this year Ukraine has the chance to redefine its overall energy and climate strategy and to align it with the Paris Agreement.

In this paper, we present arguments for the integration of more RES capacities in Ukraine. We show the current state of RES in UA as well as the policy mechanisms currently in place to promote the building of new capacities. Additionally, the potential of further RES expansion in Ukraine will be highlighted. We then come to the challenges a higher RES share in the energy system raises and propose instruments to address them. We conclude with an outlook.

2. Arguments for RES expansion

In the following chapter, we discuss how Ukraine can benefit from the integration of more RES.

2.1 European Integration

The fight against climate change is a main political project of the European Union. The new European Commission that entered office in 2019 made the "European Green Deal" (please note that it is "European" not "EU") its flagship project. Ukraine showing stronger engagement in the reduction of greenhouse gas emissions and expanding RES will hence demonstrate Ukraine's commitment to pursue a path of European integration.

On the other hand, abstaining from substantial decarbonization efforts might become a very expensive strategy for Ukraine as the EU actively discusses to introduce a tax on imports of carbon-intensive products. Depending on the implementation this could close the EU market for many Ukrainian goods exports.

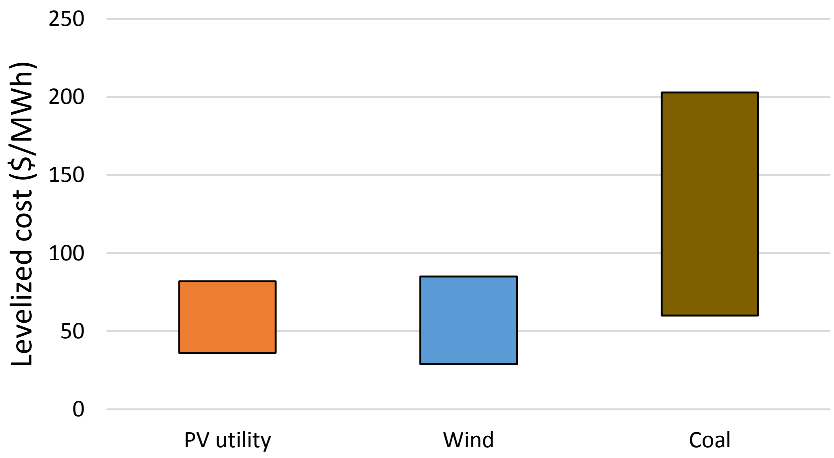
2.2 Coal exit

Ukraine will have to reduce the share of coal in its energy mix for environmental and economic reasons. The economic situation of the coal industry in the country is dire. State owned coal mines are requiring approximately 9 UAH billion of yearly subsidies (average for 2015–2017), caused i.e. in 2014 about 2000 injured miners and 99 deaths and are characterized by obsolete equipment[34]. In terms of levelized cost, wind (29–56$/MWh) is already cheaper than coal (60–143$/MWh)[35]. So, new RES facilities are already cheaper than building a new coal-fired power plant.

[34] https://lowcarbonukraine.com/wp-content/uploads/2019/06/2019-06-11_PB13_Structural-Change-in-Coal-Regions_en_short.pdf

[35] https://www.lazard.com/media/450784/lazards-levelized-cost-of-energy-version-120-vfinal.pdf

Figure 3. levelized cost of electricity generation of wind, solar and coal plants



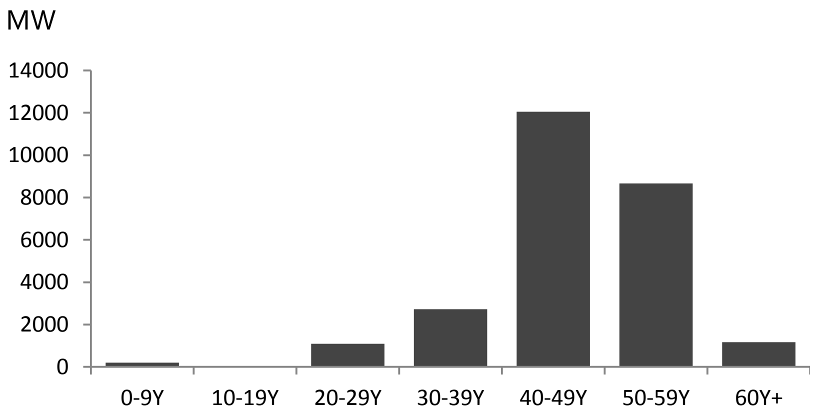
Source: Lazard (2019)

2.3 Replacement need

Most of the power plant fleet in Ukraine is old and inefficient. This implies high emissions and primary energy consumption and puts energy security in Ukraine at risk.

The average age of coal generation capacities is 47 years, compared to the average age of coal power plants in Germany, which is 27 for hard coal and 30 for lignite. 85% of installed TPP and CHP capacities in Ukraine are older than 40 years. Thus, a significant share of plants has reached the real lifetime of coal-fired power plants of 40-45 years[36]. While the lifetime of power plants can be exceeded, aging capacities increase the costs of maintenance and the need for repair. Furthermore, ageing power plants increase the risk of unexpected shutdowns, which in turn increase the risk of lack of power.

Figure 4. Structure of TPP's and CHP's capacity by age



Source: National Plan for emission reduction; Energy conversion efficiency of 40% is assumed.

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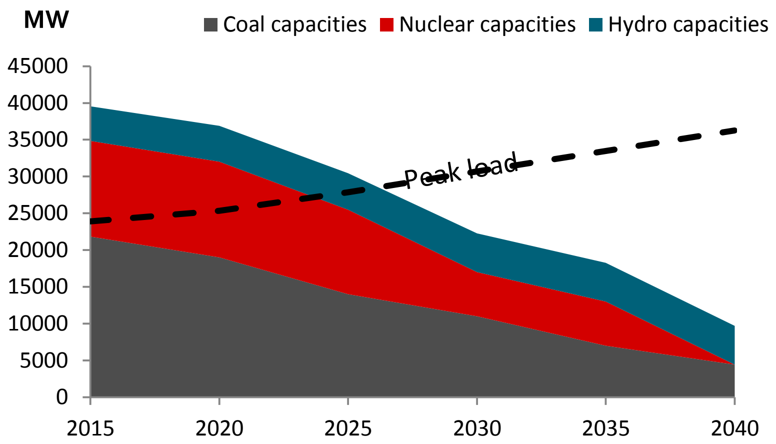
[36] Markewitz, P., Robinius, M. and Stolten, D. (2018) 'The Future of Fossil Fired Power Plants in Germany – A Lifetime Analysise', *Energies*, 11.

The ageing power plant fleet is not a short-term issue. The current amount of installed capacities of nuclear power plants (NPP), thermal power plants (TPP) and big hydro in Ukraine provides an appropriate power supply to cover peak demand. From mid of the next decade on, an increasing demand as well as a decrease of available power capacities will require replacement capacities.

Figure 5. Forecasted nameplate capacity for Ukraine



Source: Own calculations

2.4 Investment attraction

As a large part of the country’s power system needs to be overhauled within the next two decades, large-scale investments are needed. Investments into RES – that are more granular – are often financed by foreign investors. Furthermore, investments in RES currently face very attractive conditions because international financial institutions offer preferential interest rates for them at the moment. Thereby, Ukraine can benefit from knowledge transfer through FDI**.**

2.5 Diversification of energy sources

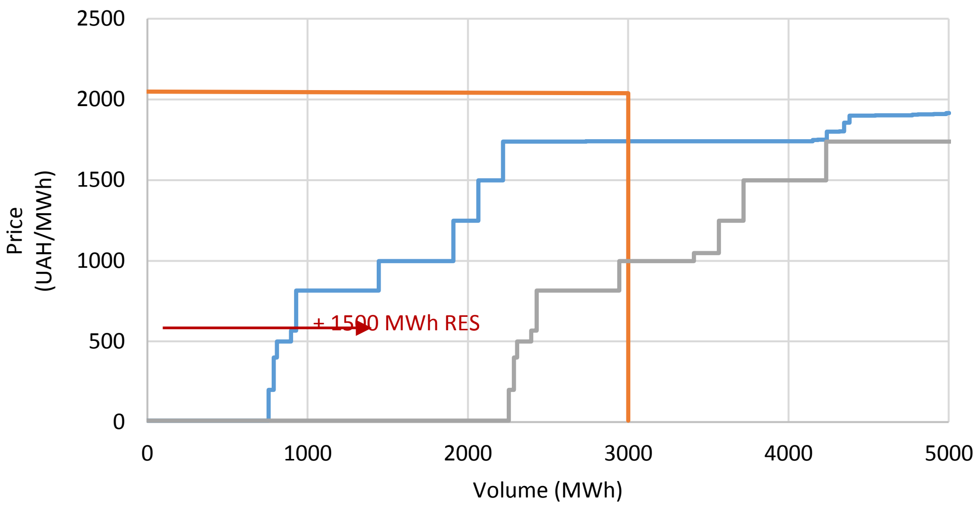
Further expansion of renewable energy capacities implies a diversification of energy sources in the Ukrainian system. Accordingly, dependence on single energy producers may decrease. This is especially favorable because the Ukrainian energy market is highly concentrated. The largest part of existing capacities is controlled by DTEK and state-owned generators (Energoatom, Ukrhydroenergo and Centrenergo). Hence, RES expansion could increase liquidity and competition in Ukraine’s electricity market.

Diversification does not only reduce dependences on internal suppliers but also from energy imports. According to our calculations, 7 GW wind and solar in the Ukrainian energy system would enable a reduction of coal imports by 30% (7 million tons). Moreover, RES expansion may reduce political dependencies arising from these transfers.

2.6 Price effect on electricity

Integration of a higher RES share in the market tends to decrease the wholesale price of electricity because marginal costs of RES are zero. This is called the merit order effect. The enhanced level of competition through energy source diversification may enhance this effect.

Figure 6. Electricity demand and supply



Source: Own calculations based on data from Ukrenergo

Moreover, a higher RES share may lead to more stable long-term prices because it reduces the dependence on price fluctuations on international energy resource markets.

2.7 Decentral RES

RES expansion may contribute to a decentralization of the energy sector. Small facilities can be managed on communal level and therewith, citizens may directly be involved in the transition of the energy system. Decentralization is beneficial for the Ukrainian energy system because it relieves grid constraints as the need for electricity transport gets smaller. Moreover, it improves energy security especially in remote areas.

3. Status Quo

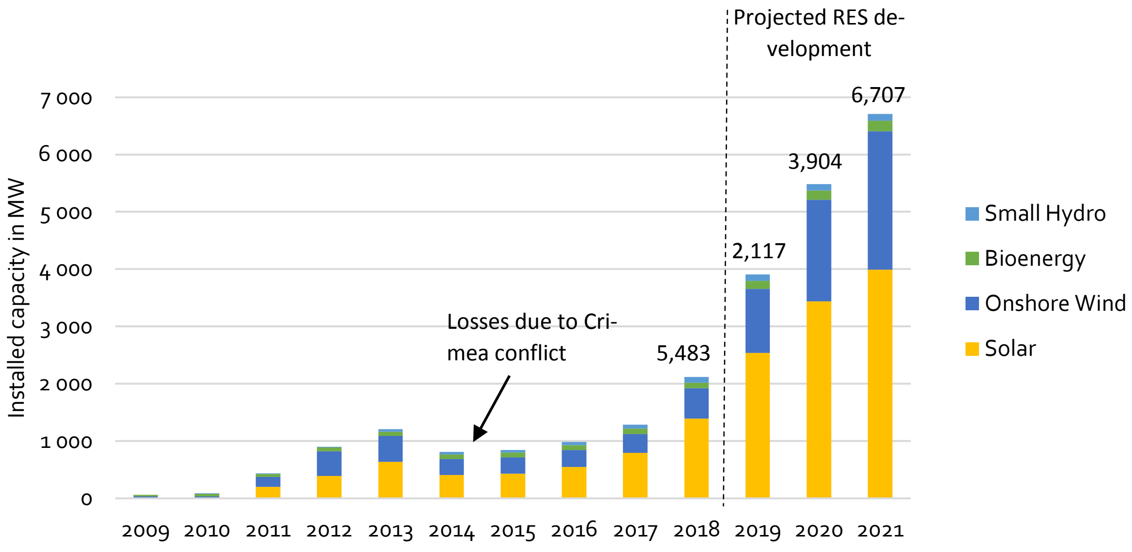
This chapter regards the current state, recent developments of RES capacities in Ukraine and political mechanisms currently in place to promote their expansion. Additionally, Ukraine's potential of further RES expansion is examined.

3.1 Status Quo

Due to the green tariff scheme, falling technology cost, improvements in the overall business environment, and the significant technical and economic potential, the installation of renewable energy sources accelerated recently in Ukraine. From end 2016 to end of the second quarter of 2018, wind capacities grew by about 18% and solar capacities by about 78 %. For the period 2019-2021 around 4.6 GW of new RES projects are expected. By 2021 RES is likely to cover around 7% of Ukraine's electricity generation.

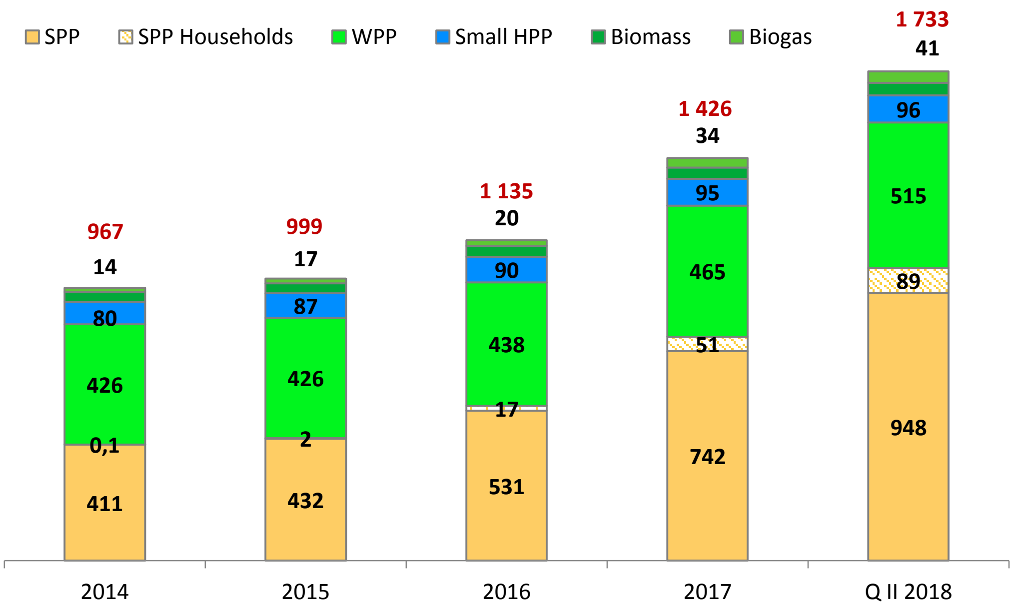
RES expansion is going to be promoted further. This year, the RES law was adjusted. Accordingly, the RES law this year RES auctions will be introduced in April 2020. It replaces the feed-in-tariffs that are payed to facilities becoming operational only until this year. Also, the new government has committed itself to foster RES capacities.

Figure 7. RES development until 2018 and projection until 2021 in MW



Source: Estimation based on varying sources

Figure 8. Installed capacity of renewable energy objects under the Green tariff

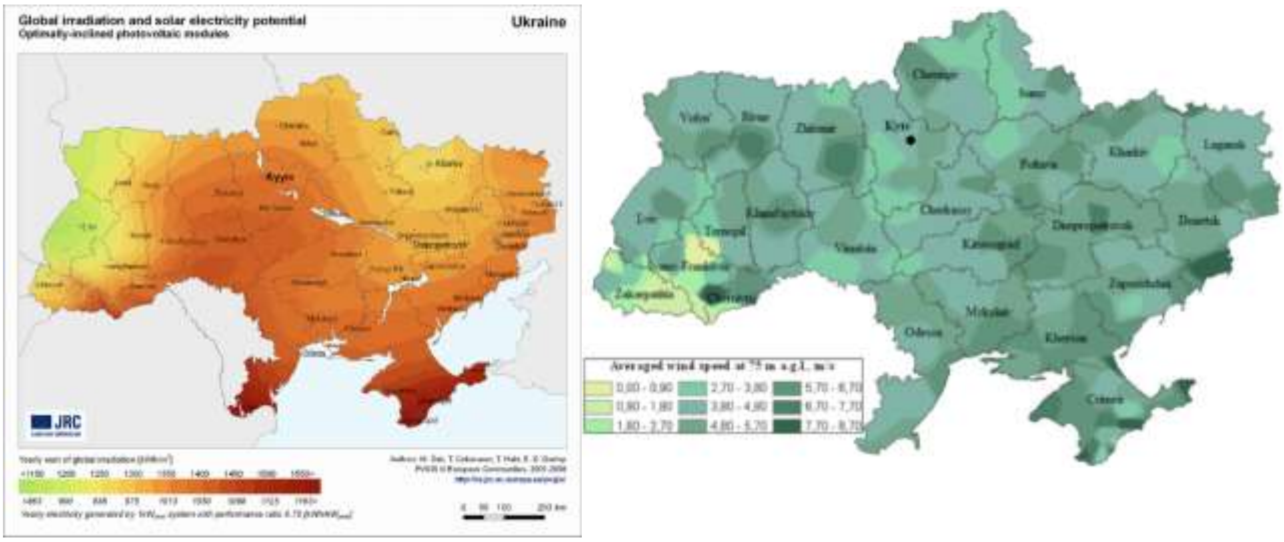


Source: SAEE (2018)

3.2 Potential

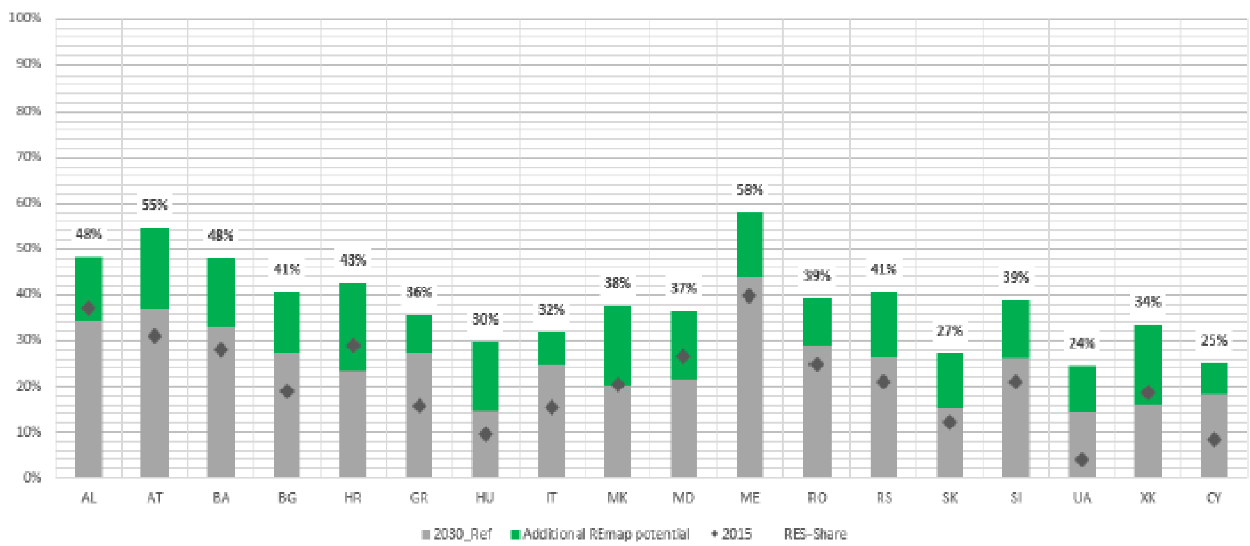
With a surface of approx. 603,000 km² and spanning five different climate zones, Ukraine has great potential for the construction of new wind and solar facilities and the weather conditions in many regions may enable the generation of high energy yields. The maps below show that especially the southern areas of Ukraine yield high irradiation levels and thus are particularly suitable for the solar energy generation. With regard to wind, especially higher elevated are those with higher wind speeds and therefore offer the best conditions for the construction of wind turbines.

Figure 9. Solar and wind electricity potential in Ukraine



Source: European Commission; Makarovskiy, Y. and Zinych, V. (2013) 'Wind energy potential assessment of Ukraine'

Figure 10. Share of renewable energy in gross final energy consumption by CESEC member, in %



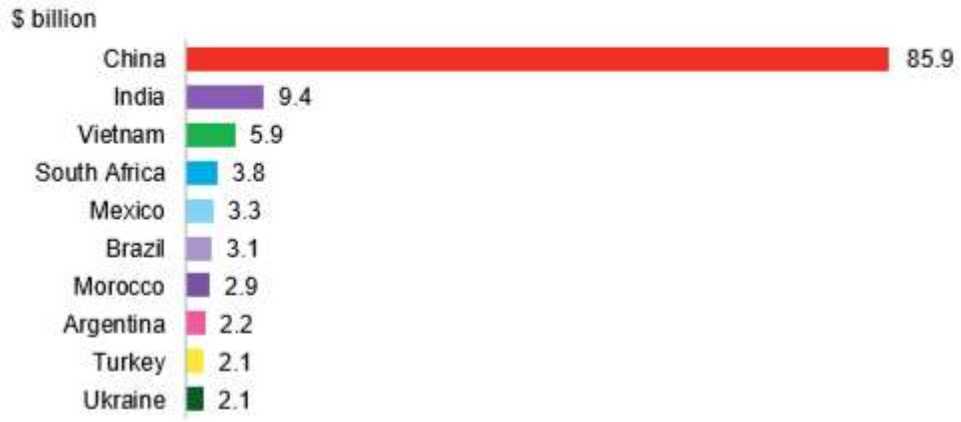
Source: Renewable Energy Prospects for CESEC, IRENA (2019)

The investment environment for RES in Ukraine is considered attractive. This was just recently highlighted by the Climatescope 2019 annual report published by the Bloomberg New Energy Finance research agency. In 2018, it ranked among the top 10 developing nations in terms of clean energy investment inflows, which can be seen in figure 11. The report states that particularly current energy sector reforms as well as the tax rates and feed-in tariffs are the major reasons for this.[37] Moreover,

[37] https://kosatka.media/en/category/vozobnovlyaemaya-energia/news/ukraina-na-8-meste-sredi-razvivayushchihsya-stran-po-privlekatelnosti-investiciy-v-vie#.Xd6MYO5CDRQ.twitter

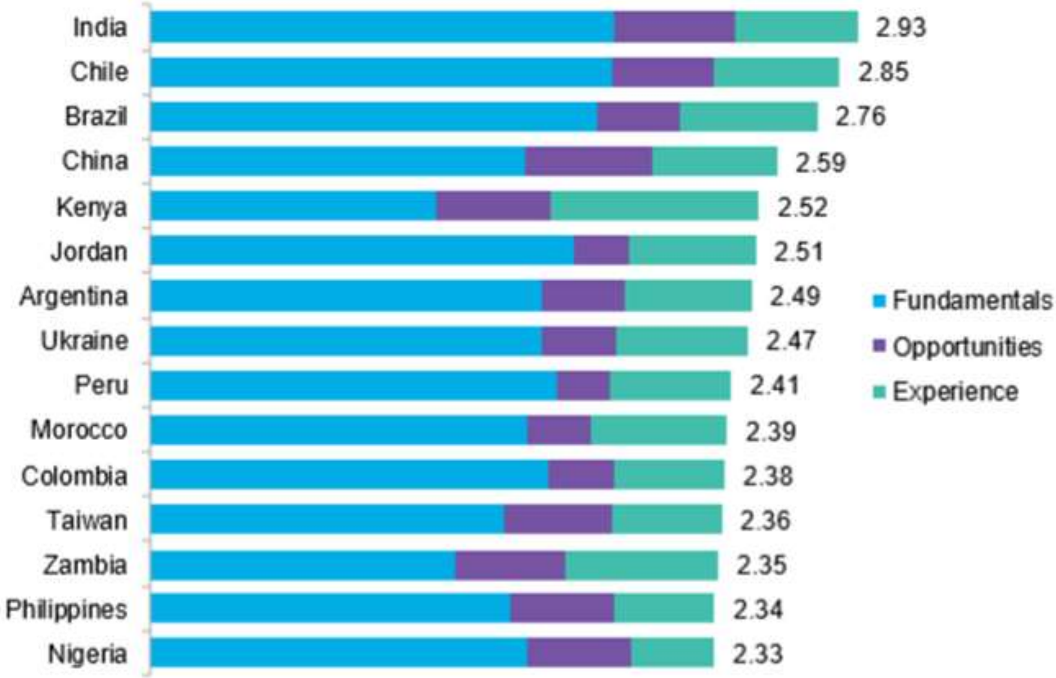
in the Climatescope score that assesses investment attractiveness of 104 emerging markets, Ukraine has attained the 8th rank, see figure 12. In 2018 it achieved only the 63rd rank.

Figure 11. The top 10 developing nations for clean energy asset finance, 2018



Source: Climatescope 2019, Bloomberg New Energy Finance

Figure 12. Climatescope score of top 15 countries



Source: Climatescope 2019, Bloomberg New Energy Finance

Although renewables were expanded dynamically, Ukraine is still not yet exploiting its high potential. A recently published study by IRENA (2019) pointed out that Ukraine is staying far below the capacities it would be able to build up. It states Ukraine has the cost-effective potential to increase its RES share in gross final energy consumption up to 24% in 2030. This share is considerably higher than what was projected for the same year.

4. Challenges

Increasing penetration of variable RES – mainly wind and solar – brings about new challenges for the development and operation of the electricity system. In the following, we present the different problems that are likely to occur.

4.1 Volatility

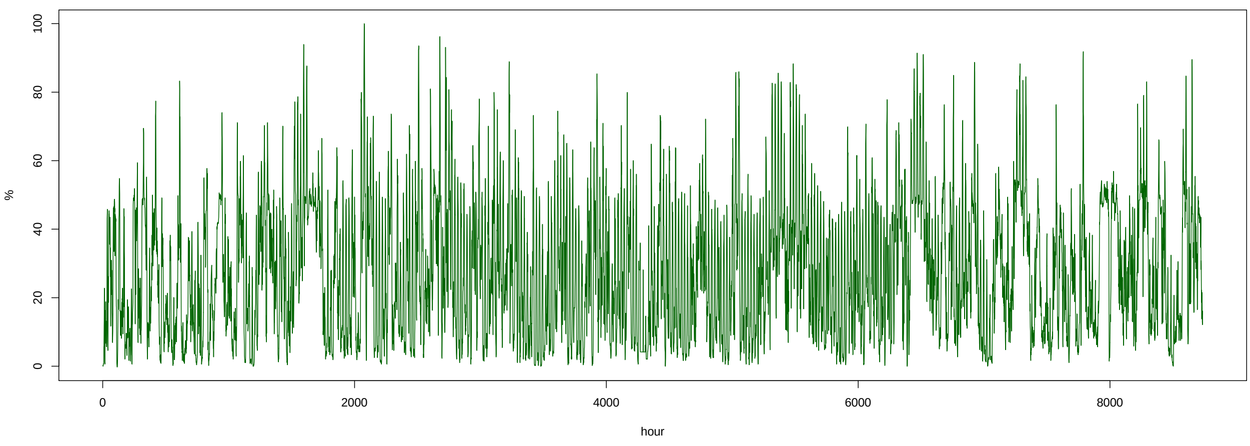
Mainly wind and solar power raise the volatility of the energy system. Unlike conventional power plants, wind and solar power yields rely on fluctuating weather conditions and are thus not perfectly predictable. A higher RES share introduces more volatility of energy supply into the system and consequently increases balancing needs and grid constraints. It hence requires a higher degree of flexibility than a conventional power system.

The ability of conventional power plants to react to RES fluctuations is limited through technological and economic constraints. But in the short term, the existing power plant park should be sufficient to balance fluctuations from renewables. However, higher RES shares accompanied with the aging stock of conventional power capacities as well as a potential increase of power demand will create pressure for action in the medium- and long-term.

There are three potential kinds of market imbalances arising from a higher RES share:

- Excessive fluctuations that cannot be balanced sufficiently quickly
- Excessive power supply, such situations become more likely when renewable capacities are installed on a large scale. This happens e.g. when the wind is blowing and the sun is shining but nuclear plants need to be kept running while demand is low. This poses a problem, as putting more energy into the system than is consumed will damage the system.
- Excessive power demand, typically, such situations result if on the one hand power generation by renewables is low and on the other hand demand of households and industry is high. This situation might arise when more and more conventional plants are replaced by renewable power capacities.

Figure 13. RES hour-to-hour load differences 2017, in %



Source: Own calculations

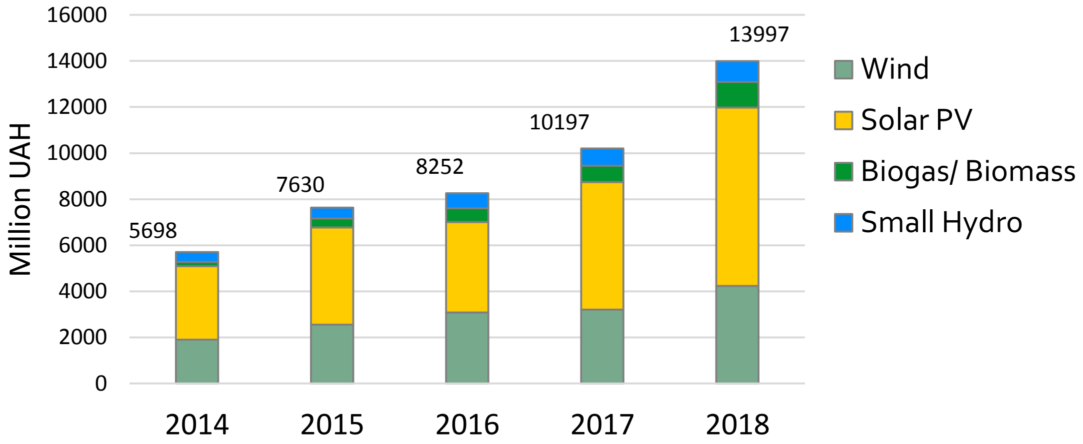
4.2 Network constraints

Without regulation, investors tend to choose the locations with the highest expected energy yields. This leads to a geographical concentration and hence short-term risks for the Ukrainian electricity system. High utilization of grids in respective regions may therefor cause bottlenecks and increase balancing needs due to the regional correlation of energy yields.

4.3 RES development comes at high cost

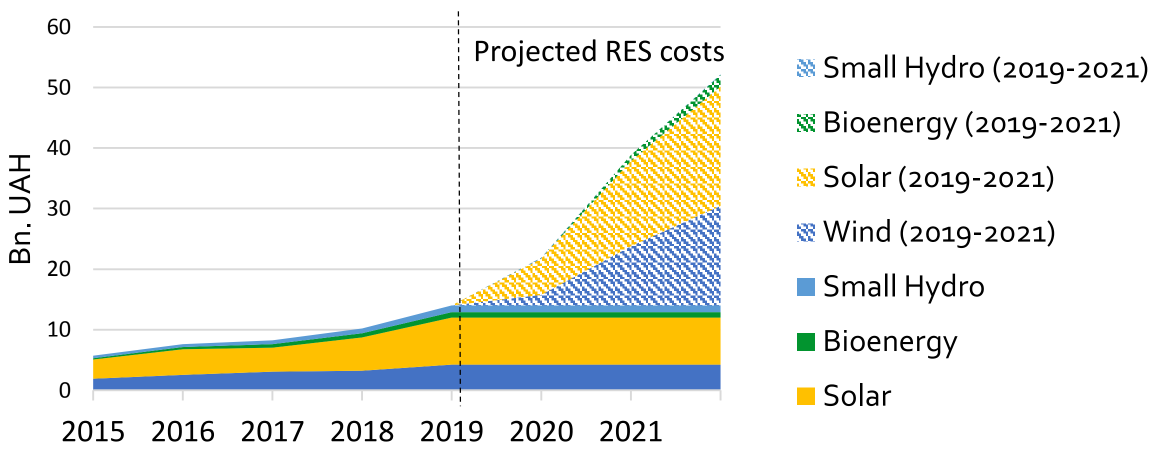
Undoubtedly, the feed-in-tariff has been one major reason for the dynamic RES expansion in recent years. This positive development comes at excessive costs as the Green Tariff is clearly above the generation cost of RES. In 2017, the green tariff represented 7-8% of the wholesale electricity price. Due to the significant increase of wind and solar capacities in 2018 and 2019, feed-in-tariff-expenditures rose significantly too. As the Green Tariff is guaranteed until 2030, costs will continue to occur on an annual basis until then.

Figure 14. Annual costs of the Green Tariff in million UAH



Source: SE Energorynok, NBU, DiXi Group

Figure 15. Projected RES costs until 2021



Source: Own calculations

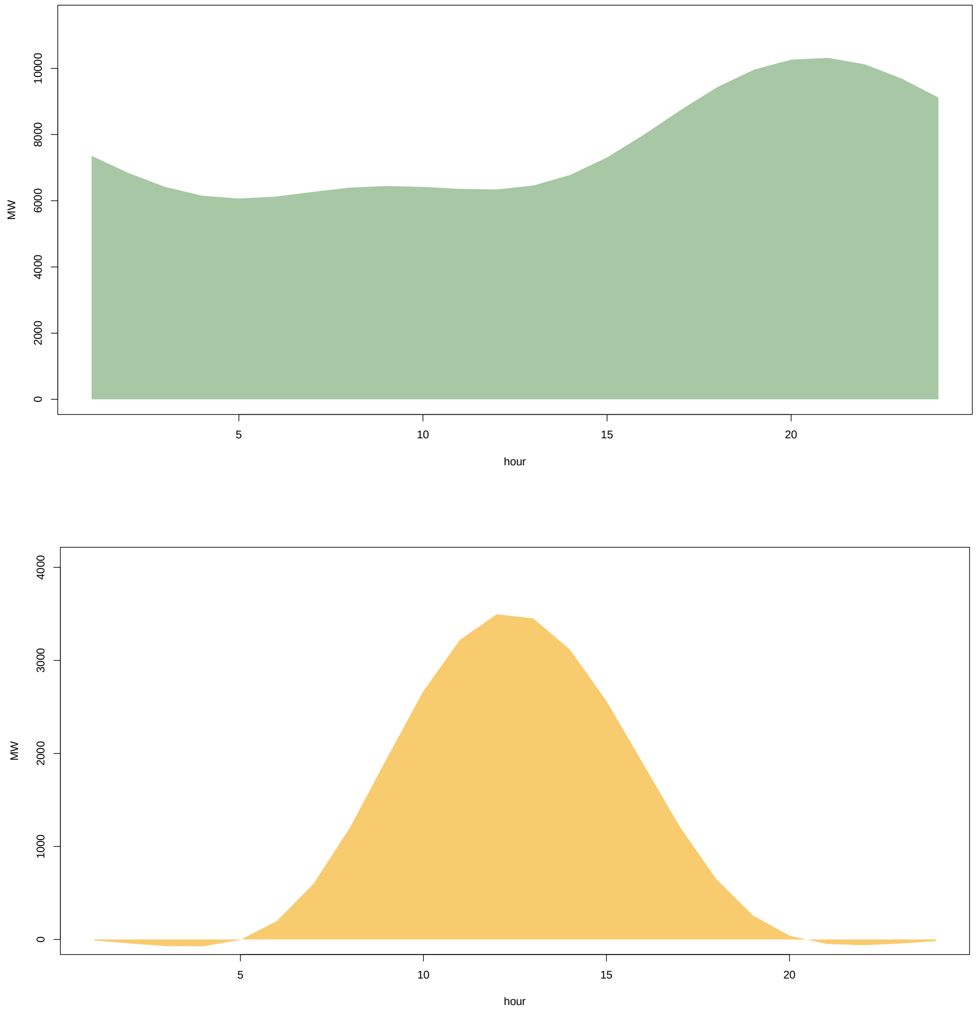
5. Main instruments to address these challenges

In this chapter we propose different instruments how the aforementioned challenges a further expansion in RES may raise can be addressed.

5.1 Optimal mix of renewable technologies

Different types of RES are – to some extent – able to balance each other's fluctuations in power generation. Wind and solar generation are largely independent from one another. They daily load profiles typically differ, so that wind and solar capacities can complement each other. A well-chosen mix of both generation technologies reduces generation cost, balancing needs of the system and the risk of power unavailability.

Figure 16. Average day profile of wind and solar power generation



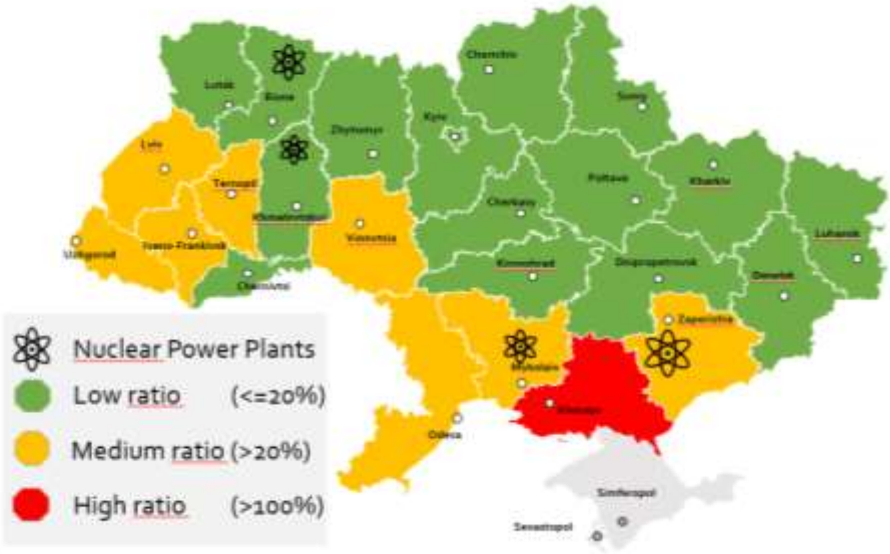
Source: Own calculations

5.2 Optimal location selection

Power generation of variable RES depends on the current solar radiation and wind speed at the specific location. Ukraine has a considerable amount of heterogeneous locations for the development of renewable energy capacities. A geographical dispersion of the wind and solar installations across the country allows to balance the fluctuations of RES generation to a certain extent. This phenomenon is called “geographic averaging”. An optimal location selection for wind and solar generation capacities increases the RES output, stabilizes the grid and reduces the need for other balancing options.

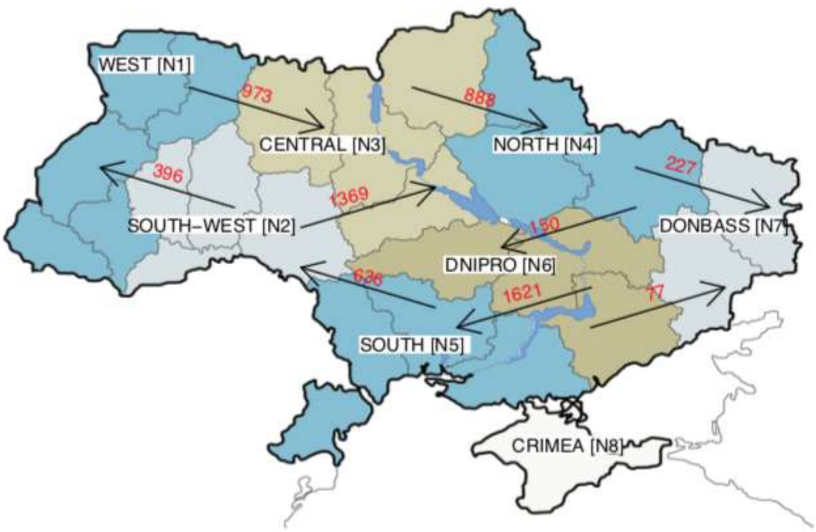
Therefore, authorities responsible for licensing new wind and solar power capacities should consider to provide specific incentives for a wider distribution of installations across the country, as otherwise investors might just concentrate all plants in the most sunny/windy regions. Therefore, we propose a “regional curtailment charge” that reduces the RES-tariff for new installations in most constraint areas.

Figure 17. Max. demand coverage by variable RES, in %



Source: Own calculations

Figure 18. Modelling of Regional net transmission (GW)



Source: Own calculations

5.3 Flexibility

The integration of higher RES shares requires a higher level of flexibility in the Ukrainian energy system to ensure that demand is always met by supply, even if the wind does not blow and the sun does not shine.

Preferred instruments are energy storage, fast-starting gas turbines to cover demand peaks, temporarily cutting off certain consumers (i.e. demand-side response) and RES curtailment. From an international perspective, integration into the ENTSO-E system would give Ukraine balancing options through import and export in situations of excess demand and supply.

We regard curtailment as an appropriate instrument for the current situation of the Ukrainian energy market where higher shares of RES are about to be integrated and a phase-out of inefficient conventional plants is pending. Curtailment is a reduction of power generation below the possible level that a power system can generate under given conditions. Typically, curtailment needs are associated with situations of excess power supply, i.e. when RES generation is high and power demand low and it is not possible to reduce loads of conventional sources or power storage by pump accumulation.

In the short run, curtailment helps to mitigate the green-coal paradox – a situation where increasing RES shares have to be balanced by old coal plants with high minimal loads, leading to higher system emissions. Precautionary curtailment in very windy and sunny hours significantly reduces system emissions because it allows to keep nuclear units running instead of old coal plants.

Even under the assumption that neither structure nor variability flexibility of existing power plants (except RES) change, analysis by the Berlin Economics project Low Carbon Ukraine shows that curtailment losses of RES for avoiding excess power would not exceed 10 % in the given scenarios. Curtailment losses remain in a tolerable range up to a capacity of 15 GW of RES and could be further reduced by adaptation power generation of NPP, TPP and big hydro.

RES curtailment should be regulated in a fair and transparent way to ensure that incentives to invest into RES in Ukraine are not deterred. This includes a non-discriminatory compensation scheme that allows RES producers to get back part of their lost profit due to curtailment.

5.4 RES auctions

A more cost-efficient instrument promoting RES expansion than feed-in-tariffs are auctions of RES capacities. According to the draft law No. 8449 an auctioning system for RES will be introduced in April 2020. The establishment of a RES auction scheme is in line with the global trend towards increased competitiveness of RES support schemes.

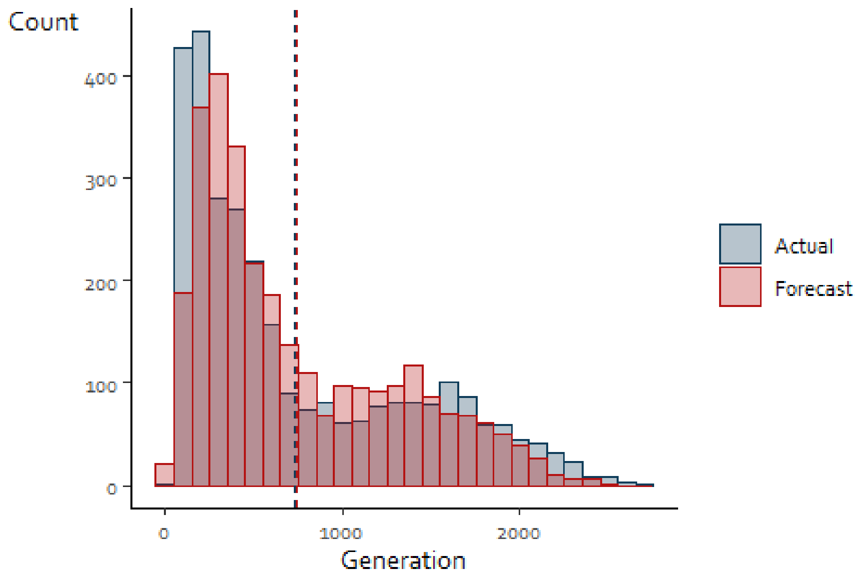
If the scheme is designed properly, it can reduce the costs of RES support. A well-designed scheme should ensure sufficient liquidity, competition and transparency at auctions. To avoid network restrictions, it should incentivize a more distributed location selection, as well.

5.5. Improving forecasts

That wind and solar generation cannot be perfectly predicted implies either risks to energy security and the grid system or the need for costly reserves. Improving forecasts in Ukraine can save a lot of investments. This was feasible for Germany, too, where the average forecast error (50Hz zone) decreased between 2005 and 2018 from 27% to below 2% while RES increased by 200%.

The figure below shows the overestimation obtained in the Low Carbon Ukraine electricity system model.

Figure 19. Overestimation of RES Generation



Source: Own calculations

6. Outlook

There is still a long way to go for Ukraine to catch up to the climate ambition and performance of the EU. But, being a forerunner in the region, Ukraine has already demonstrated its capability to dynamically increase RES capacities. As RES auctions are soon to be implemented and Ukraine is substantially supported by the EU[38], the preconditions are met for Ukraine to further accelerate this development.

However, Ukraine needs a sufficient strategic basis to take advantage of its large RES potential, now as the legal fundament is in place (RES law, electricity market law). To ensure a smooth phase-in of renewables several technical and administrative measures are required, such as auction rules and amounts, network development, development of flexibility, network operation rules and market operation rules. A comprehensive plan to ensure that all elements are put in place would be helpful. The prize would be much faster and cheaper RES deployment to the benefit of Ukraine.

[38] https://ec.europa.eu/neighbourhood-enlargement/neighbourhood/countries/ukraine_en

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The Potential Impact of an Interruption in Gas Transit via Ukraine in January 2020

This paper is a summary of the following article, which was published by the Oxford Institute for Energy Studies in November 2019 at www.oxfordenergy.org:
Simon Pirani, Tatiana Mitrova, and Jack Sharples, 2019. *Russia-Ukraine Gas Transit Talks: Risks for All Sides*. Oxford Institute for Energy Studies.
The presentation delivered at the Energetika conference was based on that published paper.

Introduction

For several months, gas market analysts have been following the negotiations between Gazprom and Naftogaz, as the two sides approach the expiry of their bilateral contract, which governs the transit of Russian gas across Ukraine to Europe. The expiry of the previous contract on the 31st of December 2008 was followed by a suspension of gas transit that lasted several weeks, and Gazprom's customers are concerned that history could repeat itself when the current transit contract expires on the 31st of December 2019. This research examines the potential impact of such a suspension on those countries that currently receive Russian gas via Ukraine, the extent to which their daily gas needs could be met through storage withdrawals, and how long those storage stocks might last if the suspension of Ukrainian gas transit were to continue throughout Q1-2020.

The importance of gas transit via Ukraine

In the immediate aftermath of the disintegration of the Soviet Union, transit via Ukraine accounted for approximately 95% of all Russian gas deliveries to the European market. Since then, several new pipeline routes have been launched, reducing Gazprom's dependency on transit via Ukraine. Such pipelines include the Blue Stream pipeline under the Black Sea from Russia to Turkey (2003), the Yamal-Europe pipeline from Russia to Germany via Belarus and Poland (2006), and the Nord Stream pipeline from Russia to Germany under the Baltic Sea (2011-12).

Yet Ukraine remains an important transit route for the delivery of Russian gas to the European market. According to the International Energy agency (IEA), physical deliveries of Russian gas to the European market (including direct deliveries to Finland, the Baltic states, and Turkey) totalled 192.2 billion cubic metres (bcm). Of that volume, 79.5 bcm (41%) was delivered via Ukraine. Russian Gas delivered via Ukraine is supplied to Poland, Slovakia, Hungary, and Romania. From Slovakia, it is delivered onwards to Austria, Italy, Slovenia, and Croatia. From Hungary, it is delivered onwards to Serbia and Bosnia-Herzegovina. From Romania, it is delivered onwards to Bulgaria, Northern Macedonia, Greece, and Turkey.

The delivery of Russian gas to Europe via Ukraine is governed by a 10-year transit contract that was signed in January 2009, as part of the resolution of the Russia-Ukraine gas dispute. That dispute of Russian gas supplies to Ukraine and the transit of Russian gas via Ukraine came to a head when the previous contracts expired on the 31st of December 2008 and no new contracts were agreed before the old contract expired. After several weeks in which no Russian gas was delivered to Ukraine, and the transit of Russian gas to Europe via Ukraine was also interrupted, new supply and transit contracts were signed.

In the years since those contracts were signed, it became clear that the Ukrainian counterparty – state-owned Naftogaz – did not require the volumes it was obliged to import under the supply contract. On the other hand, the Russian counterparty – Gazprom – also did not require the transit volumes it was committed to ship under the transit contract. There was also disagreement between the two parties over the pricing formula in the gas supply contract, and the price at which Naftogaz was contractually-obliged to buy gas from Gazprom. The result of this discord was a long-running commercial arbitration case that was concluded in two parts (one each for the transit and supply contracts) in December 2018 and February 2019. Once the mutual claims were combined, the net result was that Gazprom was required to compensate Naftogaz with $2.56bn. Gazprom appealed the ruling, and no resolution has yet been reached.

Regarding the gas supply contract, Naftogaz ceased purchasing gas directly from Gazprom in November 2015. As part of the conclusion of the arbitration case, the direct sale of gas by Gazprom to Naftogaz was meant to resume. However, this has not happened. The supply contract will expire on the 31st of December 2019.

The transit contract is also due to expire on the 31st of December 2019. The two sides have held negotiations in recent months, mediated by the EU Commissioner for Energy Union, Maroš Šefčovič. However, Naftogaz and Gazprom appear to remain far apart in their negotiating positions. Naftogaz (with the support of the European Commission) is pushing for a new 10-year gas transit contract, with substantial transit volumes (reports suggest 40-60 bcm per year) and higher transit tariffs to compensate for the drop in overall transit volumes. Given that the Nord Stream 2 and Turkish Stream pipelines are almost complete, Gazprom is unwilling to commit to such large transit volumes for such a long period. Instead, Gazprom is pushing for a shorter transit contract with smaller volumetric commitments. Indeed, in November 2019, Gazprom submitted a proposal to extend the existing contract by one year, or sign a new one-year transit contract.

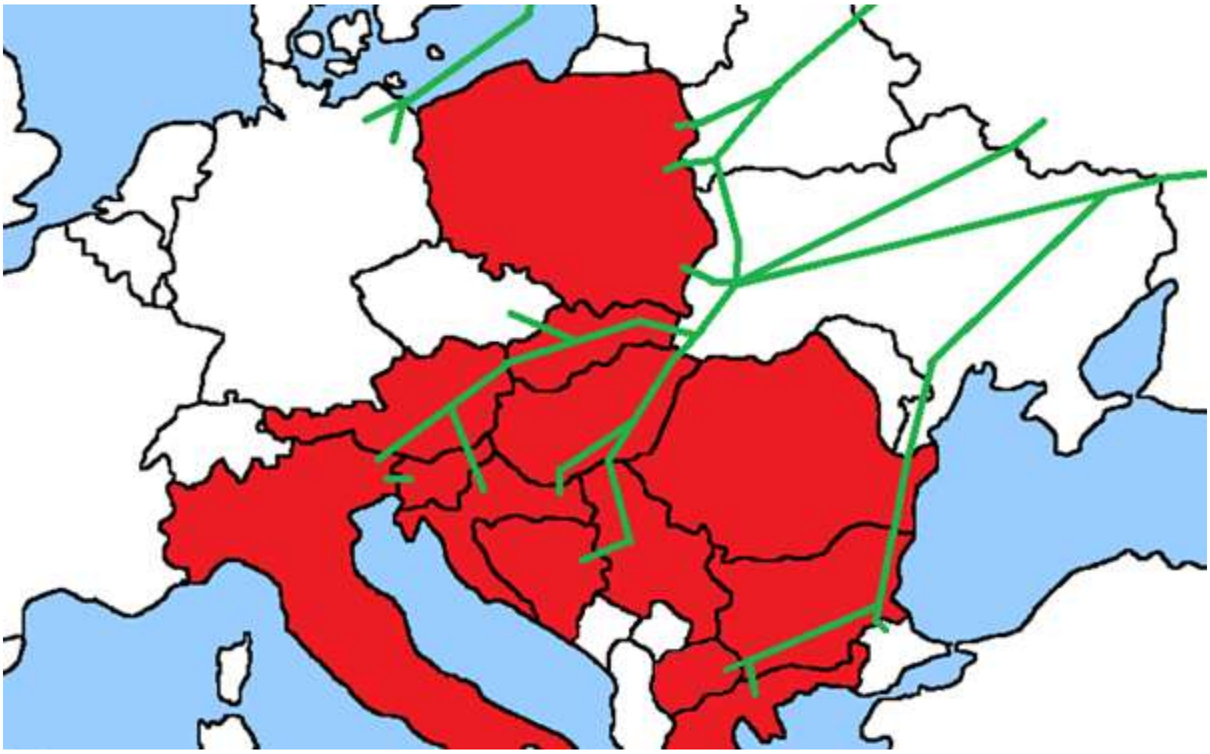
Not only are the two sides far apart in terms of transit volumes and transit tariffs, the most recent Gazprom proposal suggests that the new transit agreement be part of a ‘package deal’ that also includes the laying aside of all outstanding legal claims, including the $2.56bn arbitration award. This is something Naftogaz would find almost impossible to accept.

With the expiry of the existing transit contract fast approaching, many observers are concerned that no new transit arrangement will be in place on the 1st of January 2020 and that, as a consequence, the transit of Russian gas to Europe via Ukraine will cease. In 2009, that suspension of gas transit via Ukraine latest several weeks. In the present case, the potential length of such a suspension in gas transit cannot be predicted.

The potential impact of a suspension of gas transit via Ukraine

The research summarised in this paper was published in November 2019 by the Oxford Institute for Energy Studies, and subsequently presented at the Energetika conference in the same month. The research analysed the potential impact of a suspension of gas transit via Ukraine in January 2020, focusing on 12 countries that import Russian gas via Ukraine (Poland, Slovakia, Austria, Italy, Slovenia, Croatia, Hungary, Serbia, Romania, Bulgaria, North Macedonia, and Greece). Turkey was excluded for two reasons: Lack of daily gas flow data and because it is expected that the launch of the first line of the Turkish Stream pipeline means that Turkey would not receive any Russian gas via Ukraine, regardless of whether there is a suspension of transit or not.

Fig. 1. Map of countries that receive Russian gas via Ukraine



Source: Map created by the author

The research examined the amount of gas held in storage by these countries, the maximum daily capacity of those facilities to bring gas out of storage, the regular seasonal storage withdrawals, and their net imports via Ukraine. By subtracting the regular (seasonal) storage withdrawals for each month (January to March in 2017, 2018, and 2019) from the daily storage withdrawal capacity, it is possible to calculate how much ‘spare’ storage withdrawal capacity exists in each country. The daily average net imports of Russian gas received via Ukraine is subtracted from this ‘spare’ storage withdrawal capacity, it is possible to calculate whether existing spare storage withdrawal capacity would be sufficient to compensate for the loss of supplies usually received via Ukraine.

The results presented in the table below demonstrate that while Austria, Hungary, Italy, Poland, Romania (mostly), and Slovakia have sufficient daily storage withdrawal capacity, Bulgaria, Croatia, and Serbia would face a shortfall, while Greece, North Macedonia, and Slovenia have no gas storage at all. However, because Slovenia receives its gas via Italy, and its gas needs are small relative to those of Italy, Slovenia would probably be able to draw on Italian gas storage in the event of a shortfall in pipeline imports. The same would probably hold true for Serbia and Croatia, which receive their Russian gas via Hungary. Hungary has plentiful storage, and Gazprom has coordinated the injection of additional volumes into that Hungarian storage, and it also the main supplier to Serbia and Croatia.

While Greece has the option of additional LNG imports and additional pipeline imports via Turkey, Bulgaria would be reliant on the reversal of the Trans-Balkan Pipeline (TBP). The TBP usually flows from north to south, bringing gas from Ukraine to Turkey via Romania and Bulgaria. With Turkish Stream set to launch before the end of 2019, flows via the TBP are likely to dry up in 2020 regardless of the situation in relation to Ukrainian transit. Therefore, the Bulgarian Transmission System Operator (TSO), Bulgartransgaz (BTG) has made plans to reverse part of the TBP to bring gas northwards from Turkey, with the possibility of onward delivery to Romania. That south-to-north capacity was made available for booking in November 2019, for use from January 2020. On this basis, Bulgaria is likely to receive sufficient flows of gas from Turkey for its own use and to deliver onwards to North Macedonia, to make up for their shortfalls in the event of a suspension of transit via Ukraine.

Therefore, the region as a whole should, by and large, be able to cope with a relatively short-lived suspension of gas transit via Ukraine by drawing on their own storage, and storage in neighbouring countries, if the question concerns daily flows and daily demand, for as long as storage stocks last.

Fig. 2. Daily average 'spare' storage withdrawal capacity minus daily average net imports via Ukraine (mmcm/d)

	Jan-17	**Feb-17**	**Mar-17**	**Jan-18**	**Feb-18**	**Mar-18**	**Jan-19**	**Feb-19**	**Mar-19**
Austria	32.0	39.8	66.1	42.2	30.3	36.7	35.4	55.3	79.1
Bulgaria	-11.7	-9.4	-6.5	-8.4	-9.3	-7.3	-9.8	-8.5	-6.0
Croatia	-5.0	-1.6	1.6	-1.5	-3.2	-0.9	-3.6	-1.4	1.2
Greece	-10.1	-7.8	-3.9	-9.6	-10.1	-9.5	-9.5	-9.1	-6.1
Hungary	22.8	39.2	55.0	40.2	34.5	42.2	30.2	40.4	51.9
Italy	53.0	113.9	201.5	121.3	78.3	136.2	86.0	114.6	162.5
North Macedonia	-1.7	-1.3	-0.4	-1.3	-1.5	-0.8	-1.4	-0.9	-0.4
Poland	20.0	28.0	31.9	24.0	34.2	29.1	28.9	35.7	38.6
Romania	-5.6	6.0	20.4	4.5	4.8	10.3	-1.0	6.6	19.5
Serbia	-9.5	-8.8	-6.5	-8.8	-9.1	-7.8	-9.2	-10.3	-6.8
Slovakia	27.5	34.0	40.7	28.8	28.6	30.6	19.3	26.5	38.2
Slovenia	-9.4	-8.0	-6.3	-4.4	-5.1	-4.6	-4.9	-4.6	-3.9

	Jan-17	Feb-17	Mar-17	Jan-18	Feb-18	Mar-18	Jan-19	Feb-19	Mar-19
Regional total	**102.3**	**224.0**	**393.6**	**227.0**	**172.4**	**254.2**	**160.4**	**244.3**	**367.8**
Italy + Slovenia	43.6	105.9	195.2	117.0	73.1	131.6	81.2	110.0	158.6
Hungary, Serbia, Croatia	8.3	28.8	50.2	30.0	22.2	33.5	17.4	28.7	46.4

Source: Data from Gas Infrastructure Europe and IEA Gas Trade Flows in Europe, calculations by the author[39]

The second part of the research concerned how long storage stocks might last in the event of a suspension in Ukrainian gas transit. The amount of gas that is likely to be held in storage on the 1st of January 2020 was calculated based on actual storage volumes on the 1st of November 2019, and monthly storage withdrawals in November and December in 2016, 2017, and 2018. The November-December storage withdrawals were subtracted from the actual volume for the 1st of November, to provide the 'starting point' of estimated gas storage on the 1st of January.

Starting from this estimated volume of gas in storage at the beginning of January, the amount of gas that might be withdrawn from storage in January, February, and March 2020 was estimated based on average storage withdrawals in these months in 2017, 2018, and 2019, combined with monthly average net imports via Ukraine in these same months. The results for January, February, and March for these three years were gathered together into quarterly results, in order to present results for Q1-2017, Q1-2018, and Q1-2019. Thus, each of these three quarterly results represents an amount of gas that might be withdrawn from storage in Q1-2020, in order to meet both seasonal needs and compensate for the loss of flows usually received via Ukraine. It is useful to conduct these calculations for Q1 across 2017, 2018, and 2019, because these three years represent varying weather patterns and related weather-driven gas demand. While Q1-2017 included a particularly cold January, Q1-2018 included a particularly cold February and March, while Q1-2019 was unusually warm.

The amount of gas that may be left in storage at the end of Q1-2020 based on the demand patterns for Q1 in 2017, 2018, and 2019, are presented in the table below. The results show that, if left to rely on their own storage stocks to meet both seasonal storage demand and compensate for the loss of transit via Ukraine, Bulgaria and Croatia would not only fail to meet their daily needs, but their storage stocks would run dry before the end of Q1. However, as noted above, Bulgaria is likely to receive pipeline supplies via Turkey and Croatia would likely draw on storage in neighbouring Hungary.

If Italy relied only on storage to compensate for the loss of supplies delivered via Ukraine, its stocks would run dry if Q1 was particularly cold, but would be sufficient if Q1 was warm. The other countries analysed would see their stocks last through Q1. However, assuming ongoing storage withdrawals at the same rate as March through into April and May (for example, if April and May were unseasonably cold), the number of days beyond the end of Q1 that stocks would last varies substantially.

[39] IEA, 2019. *Gas Trade Flows in Europe*. https://www.iea.org/gtf/ and GIE, 2019. *Aggregated Gas Storage Inventory (AGSI+)*. https://agsi.gie.eu/#/

Fig. 3. Scenarios for longevity of storage stocks

	Storage on 1 Nov 2019 (mmcm)	Amount left in storage at end of Q1 (mmcm)			No. of days of stocks left at end of Q1 at March withdrawal rate		
		Q1-2017	Q1-2018	Q1-2019	Q1-2017	Q1-2018	Q1-2019
Austria	8,475	1,077	764	3,586	33	12	180
Bulgaria	581	-598	-541	-524	-63	-52	-58
Croatia	514	-343	-286	-288	-79	-42	-60
Greece	-	-	-	-	-	-	-
Hungary	6,362	1,568	1,679	1,639	65	46	60
Italy	18,166	1,001	-339	688	14	-3	6
North Macedonia	-	-	-	-	-	-	-
Poland	3,180	262	550	860	14	25	69
Romania	2,953	346	324	232	40	17	24
Serbia	-	-	-	-	-	-	-
Slovakia	3,862	2,054	1,841	1,998	909	149	418
Slovenia	-	-	-	-	-	-	-
Regional total	**44,094**	**5,367**	**3,990**	**8,190**	**32**	**13**	**42**
Italy + Slovenia	18,166	292	-762	289	4	-6	3
Hungary, Serbia, Croatia	6,876	484	624	568	17	14	18

Source: Data from Gas Infrastructure Europe and IEA Gas Trade Flows in Europe, calculations by the author[40]

<u>Conclusions</u>

The key conclusions here is that, firstly, that even in a cold Q1-2020, storage would be sufficient to meet the regular seasonal demand (i.e. regular withdrawals from storage) and compensate for the loss of supplies received via Ukraine. Secondly, even in a cold winter, those storage stocks would probably be sufficient to last through the entirety of Q1 2020, with the possible exception of Italy in a cold winter. Furthermore, in the event of a suspension of gas transit via Ukraine, it is likely that Italy, Greece, and Poland would increase their imports of LNG, that Austria would increase its net imports from Germany, that Slovakia would increase its net imports from the Czech Republic (which receives

[40] IEA, 2019. *Gas Trade Flows in Europe*. https://www.iea.org/gtf/ and GIE, 2019. *Aggregated Gas Storage Inventory (AGSI+)*. https://agsi.gie.eu/#/

its gas via Germany), and that Italy would increase its imports from France via Switzerland. These LNG imports and cross-border gas flows would be driven by rising spot gas prices in each of the affected national markets, acting as a signal for traders to move gas from well-supplied markets to markets facing shortfalls.

If the existing Gazprom-Naftogaz transit contract expires without a replacement arrangement being put in place, and there is a suspension of Russian gas transit via Ukraine, the unprecedented high levels of European storage stocks mean that the immediate impact is likely to be price-related, rather than a severe physical shortage. Even the countries that were worst affected by the January 2009 Russia-Ukraine gas crisis have better access to storage, connections with neighbouring countries, and access to supplies delivered via non-Ukrainian routes.

The aim here is not to encourage complacency: The suspension of gas transit via Ukraine would provide a stern test to the European gas market, the utilisation of storage facilities, the ability of national markets to provide pricing signals for traders to move gas across borders, and the utilisation of cross-border pipeline infrastructure to make those cross-border trades a reality. The weather will also play a very significant role in determining gas demand and, therefore, the extent of any shortfalls that must be compensated for by storage withdrawals.

Rather, this research demonstrates the extent to which the European market has reacted in advance to the potential for such a transit suspension, with pricing signals and physical infrastructure encouraging market participants to place gas in storage so that the worst effects of a transit suspension can be mitigated. This leads to the conclusion that while the suspension of gas transit via Ukraine in January 2020 would have a substantial impact upon the European market, that market is significantly better prepared than it was before the last such suspension, in January 2009.

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