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POLITICS AGAINST DECARBONIZATION

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Abstract. This study describes the methodology and results of calculating the increase in global greenhouse gas emissions caused by disruptions in international logistics due to geopolitical restrictions introduced by Western countries against Russia since 2022. The Western sanctions policy regarding, first of all, trade in Russian hydrocarbons has caused the breakdown of trade routes, which until recently could be characterized as “conditionally optimal.” That is, hydrocarbon supplies were carried out along the shortest routes, which ensured minimal fuel combustion during transportation and minimal greenhouse gas emissions, respectively. Now, a forced reorientation has led to an increase in commodity transport work, which requires more fuel combustion and, accordingly, provides an increase in emissions. Closed airspace also has an additional negative effect on rising emissions, as most flights from Europe to Asia and back from 2022 will overfly Russia, which on average adds an extra 2 hours to the flight, requires more fuel to be burned, and therefore leads to increase in greenhouse gas emissions. And considering that flights have only just begun to recover after the 2020 crisis, the impact of the closure of airspace over Russia on greenhouse gas emissions will only grow in the future. The study’s calculations show that reorienting trade in oil and natural gas and extending air routes alone would increase emissions by 261–290 Mt CO₂-eq. This is comparable to the UK’s annual emissions. If we take into account all the distortions in global trade, emissions growth could be even 40–60% higher. Thus, it can be argued that existing trade restrictions brought a significant negative impact on the implementation of global low-carbon development agenda.

Keywords: greenhouse gases emissions, logistics, transport, energy resources, air transportation, reorientation of supplies, CO₂-eq.

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ПОЛИТИКА ПРОТИВ ДЕКАРБОНИЗАЦИИ

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Аннотация. Представлены методология и результаты расчетного анализа роста глобальных выбросов парниковых газов, вызванных нарушениями в международной торговой логистике из-за вводимых с 2022 г. геополитических ограничений на связи между Россией и странами Запада. Только переориентация торговли нефтью и природным газом, а также удлинение летных маршрутов приводят к росту выбросов на 261–290 млн т CO_2 экв., что сопоставимо с годовыми выбросами Великобритании. При учете всех искажений в глобальной торговле рост выбросов может оказаться еще на 40–60% выше. Таким образом, можно утверждать, что существующие торговые ограничения оказывают существенное негативное воздействие на реализацию задач глобального низкоуглеродного развития.

Ключевые слова: выбросы парниковых газов, логистика, транспорт, энергоресурсы, авиаперевозки, переориентация поставок, CO_2 экв.

INTRODUCTION

Global concern over the increase in greenhouse gas (GHG) emissions resulting from human activities is driving the search for ways to reduce them. In recent years, the low-carbon agenda has gained significant momentum on a global level. Efforts to minimize emissions have primarily focused on altering the structure of energy consumption and enhancing technological efficiency throughout the production, transformation, and supply chains. However, an important factor often overlooked by experts is logistics, which contributes significantly to emissions. This becomes evident when comparing an ideal market with the shortest supply routes to the increased emissions associated with more complex transportation chains.

Disruption of optimal supply routes can occur for various reasons. This study examines the impact of geopolitical decisions on the rise of global emissions, using the example of sanctions and political restrictions affecting Russia's interactions with the US, the EU, and the UK. In particular, we review the increase in emissions caused by:

- The reorientation of Russian gas, oil, and oil product supplies from the European market to alternative markets, as well as Europe's compensation for these supplies from other regions;
- Changes in air transportation routes due to the necessity of bypassing Russian airspace.

CALCULATION METHODOLOGY

Estimation of emission changes using the example of Russian gas supply reorientation. The change in emissions resulting from Europe's

renunciation of Russian natural gas (ΔE_{gas} , Mt CO_2 -eq.) is calculated as follows:

$$\Delta E_{\text{gas}} = \Delta E_{\text{rPG}} + \Delta E_{\text{rLNG}} + \Delta E_{\text{oLNG}},$$

where ΔE_{rPG} = change in emissions from Russian pipeline gas (PG) supplies; ΔE_{rLNG} = change in emissions from Russian LNG supplies; ΔE_{oLNG} = change in emissions from other LNG supplies.

The ΔE_{rPG} indicator (Mt CO_2 -eq.) is calculated as follows:

$$\Delta E_{\text{rPG}} = E_{\text{schafter}} - E_{\text{schbefore}},$$

where E_{schafter} = emissions from exports of PG, issued after reorientation of supplies; $E_{\text{schbefore}}$ = the same before reorientation of supplies.

Total emissions at exporting PG from Russia (E_{sch} , Mt CO_2 -eq.) are calculated as follows:

$$E_{\text{sch}} = E_{\text{ex, pr, f}} + E_{\text{ex, pr, fl}} + E_{\text{tr, f}} + E_{\text{tr, fl}},$$

where $E_{\text{ex, pr, f}}$ = fugitive emissions from gas extraction and primary gas processing; $E_{\text{ex, pr, fl}}$ = emissions from stationary flaring during gas extraction and primary processing; $E_{\text{tr, f}}$ = fugitive emission during transportation; $E_{\text{tr, fl}}$ = emissions from stationary flaring during transportation.

Emissions from the supply chain (due to flaring and leaks) during natural gas production, processing, and transportation are calculated using a general formula developed by the IPCC, which is also used in compiling the National Inventory of Anthropogenic Emissions, including Russia's inventory [source 1]:

$$E_{\text{ex, pr, l}} = \sum_{j=1}^3 V_d \cdot K_{\text{fj}} \cdot K_{\text{GWPj}},$$

where j = emitted gas (emissions are accounted for CO_2 ($j = 1$), CH_4 ($j = 2$), N_2O ($j = 3$)); V_d =

volume of production, processing, and transportation (depending on the element of the supply chain for which the calculation is made); K_{fj} = national emission factors for fugitive /flaring emissions from natural gas extraction and primary processing operations and pipeline transportation of natural gas; K_{GWPj} = emitted gas emission conversion factor (CO_2 and CH_4) in tons CO_2 -eq. by 100-year GWP (global warming potential) [source 2].

The K_{fj} combustion and fugitive emission factors are recommended for use by the National Inventory of Anthropogenic Emissions, and the conversion factors to CO_2 -eq. are in line with IPCC recommendations [source 3, pp. 2.16-2.17].

The production metrics include:

- The extraction volume required to ensure pipeline export supplies (the volume of exports of PG to Europe for the period under study), including the required gas consumption to cover in-house needs of production and pipeline transportation operations (calculated on the basis of specific gas discharge for in-house needs in the Gas Production sector as reported by PJSC Gazprom¹) [source 4];

- Gas consumption for in-house needs in the Gas Transportation sector as reported by PJSC Gazprom [source 4];

- pipeline consignment operation, calculated based on the volume of pumping transfer (170 billion m^3 is assumed in the calculations, which corresponds to the average volume of PJSC Gazprom's PG sales in Europe, excluding Turkey, for the period of 2016–2020) [source 5, p. 86]) and average transportation distance for supplies to the European sales market (assumed at 3149 km level based on the FAS RF order in effect at the time of publication preparation) [source 6].

The following formula was used to calculate the change in emissions from LNG:

$$\Delta E_{rLNG} = E_{LNGafter} - E_{LNGbefore},$$

where $E_{LNGafter}$ = the amount of LNG export emissions emitted after reorientation of supplies;

¹ Specific gas discharge is taken as the “Energy intensity of extraction” indicator published in PJSC Gazprom's Sustainability Report, which includes gas and other energy consumption for in-house needs in extraction.

$E_{LNGbefore}$ = same before reorientation of supplies, Mt CO_2 -eq.

Calculation of cumulative emissions from LNG exports before and after reorientation (E_{LNG} , Mt CO_2 -eq.) is done according to a unified algorithm:

$$E_{LNG} = E_{ex, pr} + E_{(LNG)} + E_{(PG)} + E_{LNGtransp} + E_{regasification},$$

where $E_{ex, pr}$ = emissions from gas extraction and primary processing for LNG production; $E_{(LNG)}$ = GHG emission from the liquefaction plant operation; $E_{(PG)}$ = emission from gas transportation over gas pipelines to the LNG plant; $E_{LNGtransp}$ = emissions from transportation of the entire volume of LNG (produced at the plant in a year) by tankers to European ports; $E_{regasification}$ = emissions from LNG regasification (assumed to be equal to 0.03 ton CO_2 -eq. per ton of LNG) [source 7].

Emissions from gas extraction and primary processing are calculated as follows:

$$E_{ex, pr} = V_{LNG} \cdot \frac{E_{exUS}}{V_{exUS}},$$

where V_{LNG} = the amount of gas extraction required for LNG production, gas consumption for gas pipeline delivery operations to the LNG plant, and gas consumption for the LNG plant's in-house needs [source 1]; V_{exUS} = total natural gas extraction in the LNG supplying country for the representative period; E_{exUS} = total GHG emissions from gas extraction in the LNG supplying country for the representative year, Mt CO_2 -eq.

This value is calculated as follows:

$$E_{exUS} = \sum_{j=1}^3 E_j \cdot K_{GWPj},$$

where E_j = total GHG emissions from gas extraction and primary processing for a representative year according to the National Inventory of the respective country (includes emissions from fugitive and flaring) [source 8].

GHG emission from LNG plant operation $E_{(LNG)}$ is calculated according to the formula:

$$E_{(LNG)} = E_{fl} + E_f,$$

where E_{fl} = gas flaring emission for in-house needs of the LNG plant; E_f = fugitive emissions from LNG production, Mt CO_2 -eq.

The E_{fl} indicator is calculated according to the formula:

$$E_{fl} = \sum_{j=1}^3 V_{fl, in-h} \cdot K_k \cdot K_{fl, IPCCj} \cdot K_{GWPj},$$

where $V_{fl, in-h}$ = the volume of natural gas used for the LNG plant's in-house needs (assumed to be equal to 8% of the plant's production volume [1, 2]); $K_k = 37,681$ or the conversion factor for billion m^3 to TJ; $K_{fl, IPCCj}$ = IPCC factors for flaring emissions.

Fugitive emissions during LNG production E_f , Mt CO_2 -eq. are calculated by the formula:

$$E_f = \sum_{j=1}^3 K_{(LNG)ff} \cdot V_{LNG} \cdot K_{GWPj},$$

where $K_{(LNG)ff}$ = fugitive emission factor for LNG production [source 9], mln tons/billion m^3 ; V_{LNG} = LNG production volume, billion m^3 .

Emissions from gas pipelines into the LNG terminal $E_{(PG)}$, Mt CO_2 -eq., are calculated by the formula:

$$E_{(PG)} = E_{int} \cdot V_{(PG)},$$

where E_{int} = CO_2 -eq. emissions intensity for transportation of 1 billion m^3 (given in the operator's reports) [sources 10, 11]; $V_{(PG)}$ — gas pipeline pumping volume, billion m^3 .

Emissions from LNG tanker transportation to Europe (LNG as marine fuel), Mt CO_2 -eq., are calculated by the formula:

$$E_{LNGtransp} = E_{(t_LNG)} + E_{(t_DF)},$$

where $E_{(t_LNG)}$ = emissions from tanker transportation of the LNG volume produced at the plant per year when LNG is used as fuel for the LNG tanker; $E_{(t_DF)}$ = emission from tanker transportation of the LNG volume produced per year when diesel fuel (DF) is used for the tanker.

The emission $E_{(t_LNG)}$ is calculated by the formula:

$$E_{(t_LNG)} = \sum_{j=1}^3 V_{tankerLNG} \cdot K_{flLNGj} \cdot K_{GWPj},$$

where $V_{tankerLNG}$ = volume of LNG consumed by the tanker for the round trip; K_{flLNGj} = factors of emissions from fuel flaring, IPCC factors [source 3].

The volume of marine fuel consumption $V_{tankerLNG}$:

$$V_{tankerLNG} = V_{dt} \cdot Q_d \cdot 2 \cdot Q_y,$$

where V_{dt} = fuel consumption of a tanker per day (reference value, which is given in the specifications of the vessel); Q_d = the number of days in transit, calculated in the *Signal Ocean Platform* depending on the selected departure and arrival points [source 12]; Q_y = the number of trips per year, or LNG plant production volume/vessel capacity.

The calculation of emissions from tanker combustion of diesel fuel:

$$E_{(t_DF)} = \sum_{j=1}^3 V_{tankerDF} \cdot K_{combDFj} \cdot Q_y \cdot K_{GWPj},$$

where $V_{tankerDF}$ = the volume of DF consumption by the tanker for the round trip calculated just as for LNG; $K_{combDFj}$ = factors of emissions from DF combustion.

The emissions from LNG regasification are calculated using the formula:

$$E_{regasification} = K_r \cdot V_{LNG},$$

where K_r = specific emissions during regasification, assumed to be 0.03 Mt CO_2 -eq. per ton of LNG [3, p. 10859].

The estimation of emission changes using the example of Russian crude oil and oil products supplies reorientation. Change in emissions (ΔE_o , Mt CO_2 -eq.) as the result of Russian crude oil and oil products supplies reorientation is calculated as follows:

$$\Delta E_o = E_{o, after} - E_{o, before},$$

where $E_{o, after}$ = the volume of emissions after reorientation of crude oil and oil products supplies to Europe; $E_{o, before}$ = the same before reorientation.

Emissions from transportation of crude oil and oil products by sea are calculated as follows:

$$E_o = \sum_{j=1}^3 E_j \cdot K_{GWPj} / 1000,$$

Table 1. Emissions from combustion of different types of marine fuel, CO_2 -eq. g/g of fuel

Greenhouse gases	Furnace fuel oil	Marine diesel fuel	LNG
CO_2	3.114	3.206	2.750
CH_4	0	0	0.051
NO_x	0.093	0.087	0.008

Source: [source 13].

where E_j = emissions of each type of GHG at fuel combustion, thousand tons (Table 1).

Emissions of each type of GHG from a tanker fuel combustion are calculated as follows:

$$E_o = \sum_{j=1}^3 V_{uj} \cdot V_{\text{tanker}},$$

where V_{uj} = emissions of each type of GHG per unit of fuel consumed by the tanker, g/g of fuel (Table 1); V_{tanker} = total round-trip fuel consumption for transportation of the entire volume of crude oil/oil products from point A to point B, thousand tons.

This indicator for the representative period is calculated by the formula:

$$V_{\text{tanker}} = V_{\text{trip}} \cdot 2 \cdot N/1000,$$

where V_{trip} = fuel consumption by a tanker for one one-way trip, tons/h; N = number of trips for transportation of the crude oil/oil products' total volume.

$$V_{\text{trip}} = V_y \cdot T,$$

where V_y = fuel consumption by tanker, tons/h (reference information); T = point A to point B travel time, calculated in the *Signal Ocean Platform*, h.

Number of trips for transportation of the total volume of crude oil/oil products:

$$N = Q_{o/op}/Q_{\text{tanker}},$$

where $Q_{o/op}$ = the volume of crude oil or oil products transportation, th. tons; Q_{tanker} = tanker capacity, thousand tons.

Estimation of emission changes using the example of geopolitical decisions in aviation. The change in emissions due to the closure of airspace over Russia and the increase in the flight distances ΔE is calculated by the formula:

$$\Delta E = \Delta E_{\text{av}} \cdot Q,$$

where ΔE_m = average change in emissions for all flights as a result of one-way airspace closure; Q = the total annual number of round-trip flights by-passing the Russian Federation.

ΔE_{av} is calculated as follows:

$$\Delta E_{\text{av}} = \left(\sum_{i=1}^N (E_{t/l(\text{after})i} + E_{c(\text{after})i}) - (E_{t/l(\text{before})i} + E_{c(\text{before})i}) \right) / N,$$

where i = flight; N = the total number of one-way flights considered; $E_{t/l(\text{after})i}$ = emission volume for each type of airplane taking a particular flight in the takeoff/landing cycle after the closure of airspace over the Russian Federation² [source 13, pp. 3.70-3.72]; $E_{c(\text{after})i}$ = emission volume for each type of airplane taking a particular flight in cruising mode after the closure of airspace over the Russian Federation; $E_{t/l(\text{before})i}$ = emission volume for each type of airplane taking a particular flight in the take-off/landing cycle before the closure of airspace over the Russian Federation; $E_{c(\text{before})i}$ = emission volume for each type of airplane taking a particular flight in cruising mode before the closure of airspace over the Russian Federation. The number of takeoff/landing cycles is determined based on the flight data provided by the airlines (direct flight, connecting/refueling flight).

The value of $E_{t/l(\text{before})}$ is calculated by the formula:

$$E_{t/l(\text{before})} = \sum_{j=1}^3 E_{t/l(\text{before})j} \cdot K_{\text{GWPj}} \cdot n_{(\text{before})},$$

where $n_{(\text{before})}$ = the number of takeoff/landing cycles for a single flight before the closure of air-

² The fuel consumption per takeoff/landing cycle, as well as the emissions of this cycle, are given according to the IPCC guidelines for each type of aircraft.

Table 2. Scenario assumptions for reorientation of gas supplies for a prospective contingent year

	1st option	2nd option
Decrease in Russian gas supplies to Europe	By 170 billion m ³ . Renunciation of pipeline gas only	By 190 billion m ³ . Rejection of pipeline gas and LNG
New destinations for Russian gas supplies	Reorientation of 100 billion m ³ , including: – 50 billion m ³ through a new pipeline to China; – 50 billion m ³ to the Asia-Pacific region from new LNG plants	Reorientation of 120 billion m ³ , including: – 50 billion m ³ through a new pipeline to China; – 50 billion m ³ to the Asia-Pacific region from new LNG plants; – 20 billion m ³ of LNG are redirected from the European market to the Asia-Pacific region
Compensation of Russian supplies in Europe	170 billion m ³ : – 70 billion m ³ from the USA (production is increasing and additional LNG capacity is being commissioned); – 100 billion m ³ of Qatari gas is redirected from the Asia-Pacific region to Europe	190 billion m ³ : – 100 billion m ³ from the USA (production is increasing and additional LNG capacity is being commissioned); – 90 billion m ³ of Qatari gas is redirected from the Asia-Pacific region to Europe

Source: compiled by the authors.

space over the Russian Federation; $E_{t/l(\text{before})j}$ = the volume of emissions of each type of GHG in the takeoff/landing cycle in a single flight before airspace closure, tons.

The $E_{c(\text{before})}$ indicator is calculated by the formula:

$$E_{c(\text{before})} = \sum_{j=1}^3 V_{\text{fuel in cr.mode}(\text{before})} \times K_{\text{tons-TJ}} \cdot K_{c,j} \cdot K_{\text{GWP}j},$$

where $K_{\text{tons-TJ}} = 0.04392$ or the coefficient of conversion of a ton of jet fuel into TJ; $V_{\text{fuel in cr.mode}(\text{before})}$ = the volume of aircraft's fuel consumption in one-way cruising flight mode before the closure of airspace over the Russian Federation, kg/km; K_j = the coefficient of GHG emissions in cruising flight.

The value of $V_{\text{fuel in cr.mode}(\text{before})}$, t, is calculated according to the formula:

$$V_{\text{fuel in cr.mode}(\text{before})} = V_{\text{ref}} \cdot S_{(\text{before})}/1000,$$

where V_{ref} = specific fuel consumption of the airplane in cruising mode in the selected flight, reference data, kg/km; $S(\text{before})$ = distance traveled by the airplane during the same flight before the closure of airspace over the Russian Federation, km.

Emission volumes for each type of airplane taking a particular flight in cruising mode $E_{c(\text{after})i}$

and in the takeoff/landing cycle $E_{t/l(\text{after})i}$ after the closure of airspace over the Russian Federation are calculated similarly, but the formula considers the new flight distances.

CALCULATION PREREQUISITES

Reorientation of Russian gas supplies. In 2022–2023, the EU and the UK announced plans to gradually phase out energy supplies from Russia. The calculations are based on a hypothetical year in which the demand previously met by Russian supplies will be fulfilled by alternative sources, assuming trade restrictions on Russia are upheld.

To calculate the change in GHG emissions resulting from Europe's renunciation of Russian gas imports and the subsequent reorientation of international trade flows, two scenarios were considered (Table 2). Both scenarios involve redirecting Russian gas to the Asia-Pacific region (APR) via new pipeline and LNG projects, along with increased LNG imports to Europe from the US and Middle Eastern countries.

Reorientation of Russian oil supplies.

The following prerequisites were considered to assess the change in GHG emissions caused by the reorientation of international trade flows for crude oil and oil products after Europe's renunciation of Russian liquid hydrocarbons:

a) The volume of liquid hydrocarbons to be reoriented is 244 million tons (the volume of Rus-

sian exports by sea and pipeline to the West as of 2021) [source 14]³.

b) Russian crude oil and oil products are re-directed from Europe to Asia, with the ports of Primorsk, Novorossiysk, and Murmansk serving as departure points. The Amsterdam-Rotterdam-Antwerp triangle is used as the initial destination, while Singapore (representing a medium shipment distance in the APR) is considered the destination for reorientation.

c) The 244 million tons of Russian crude oil and oil products removed from the European market are fully replaced by supplies from the Middle East.

To calculate emissions from maritime trade of oil and oil products, Aframax tankers (80,000–120,000 tons) were used as reference [source 15].

Geopolitical decisions in aviation. To determine the proportion of flights from Europe to Asia that experienced increased distances, data from the European Organization for the Safety of Air Navigation (Eurocontrol) was analyzed. Eurocontrol reviewed the impact of the airspace over Russia closure on long-haul flights to Asia from European cities (Amsterdam, Copenhagen, Frankfurt am Main, and Helsinki) and showed that the range increased for 60% of flights [source 16].

To determine the type of aircraft used for these flights, airline ticket data was analyzed, which, in addition to travel time, indicates the type of aircraft flying to each selected destination. The aircraft type affects fuel consumption during the takeoff/landing cycle, the number of times this cycle is repeated is due to the need for intermediate refueling, and fuel consumption during cruising mode (Table 3).

The annual number of flights from Europe to Asia was calculated based on the assumption that 60% of daily flights from European airports to Asian airports are characterized by an increased range, and thus, an increase in emissions. Accordingly, the total annual number of flights bypassing Russian airspace between Europe and

Asia, as considered in our study, was calculated using the following formula:

$$Q = Q_{\text{av.daily}} \cdot D \cdot 365,$$

where $Q_{\text{av.daily}}$ = the average daily number of flights from Europe to Asia over a representative period (taken from Eurocontrol's annual report for 2022 [source 16]); $D = 0.6$ = the coefficient characterizing the share of flights from Europe to Asia from the total number of daily flights from Europe to Asia and back in 2022, with bypass of Russia; 365 = number of days in a year.

CALCULATION RESULTS

Estimation of emission changes using the example of reorientation of Russian supplies. The calculations indicate that if Europe halts the import of Russian natural gas (PG) totaling 170 billion m³ per year, there will be an increase of 124 Mt CO₂-eq. in GHG emissions, resulting from logistical disruptions. This increase is attributed to:

- Gas supplies from Russia to China amounting to 50 billion m³ through the new pipeline, leading to an increase of 22 Mt CO₂-eq. per year;

- LNG supplies from new facilities in Russia, totalling 50 billion m³ per year to the Asia-Pacific region (APR), resulting in an increase of 71 Mt CO₂-eq.;

- Growth in LNG production in the USA by 70 billion m³/year, involving an expansion of production capacity and LNG shipping, resulting in an increase of 55 Mt CO₂-eq.;

- The diversion of Qatari gas from Asia to Europe in the amount of 100 billion m³, causing an increase of 20 Mt CO₂-eq.

The discontinuation of the PG supply to Europe from Russia and reducing production by 70 billion m³ will provide an emission drop of 43 Mt CO₂-eq. per year.

If Europe were to discontinue supplies Russian LNG as well, the emissions would increase by 153 Mt CO₂-eq. In this case:

- A complete shutdown of LNG and PG Russian supplies to Europe would reduce emissions by 50 Mt CO₂-eq.;

³ In the calculation of the emissions' change from the reorientation of Russian exports, data on emissions from the Druzhba pipeline were used as reported by PJSC Transneft.

Table 3. Types of aircraft and the required number of takeoff/landing cycles for a flight to the selected destination

City of departure	Destination	Airplane type	Number of takeoff/landing cycles to cover the entire distance
Amsterdam	Bangkok	<i>Boeing 777-300ER</i>	1
Amsterdam	Delhi	<i>Boeing 777-300ER</i>	1
Amsterdam	Seoul	<i>Boeing 777-300ER</i>	1
Amsterdam	Singapore	<i>Boeing 777-300ER</i>	1
Copenhagen	Beijing	<i>Airbus A321</i>	1
Copenhagen	Shanghai	<i>Airbus A322</i>	2
Copenhagen	Singapore	<i>Airbus A323</i>	2
Frankfurt am Main	Beijing	<i>Airbus A340-300</i>	1
Frankfurt am Main	Hong Kong	<i>Airbus A340-600</i>	1
Frankfurt am Main	Shanghai	<i>Boeing 777-300ER</i>	1
Frankfurt am Main	Bangalore	<i>Boeing B747-401</i>	1
Frankfurt am Main	Mumbai	<i>Airbus A340-300</i>	1
Frankfurt am Main	Delhi	<i>Boeing B747-401</i>	1
Frankfurt am Main	Kansai	<i>Airbus A323</i>	2
Frankfurt am Main	Chennai	<i>Airbus A340-300</i>	1
Frankfurt am Main	Male	<i>Airbus A340-301</i>	1
Frankfurt am Main	Qingdao	<i>Airbus A340-302</i>	1
Frankfurt am Main	Seoul	<i>Boeing B747-400</i>	1
Frankfurt am Main	Tokyo	<i>Boeing B747-401</i>	1
Helsinki	Bangkok	<i>Airbus A323</i>	2
Helsinki	Delhi	<i>Airbus A324</i>	1
Helsinki	Hong Kong	<i>Airbus A325</i>	2
Helsinki	Phuket	<i>Airbus A326</i>	2
Helsinki	Seoul	<i>Airbus A340-600</i>	1
Helsinki	Shanghai	<i>Airbus A340-601</i>	1
Helsinki	Singapore	<i>Airbus A340-602</i>	1

Source: compiled by the authors.

– In the USA, the need to increase gas production, LNG production, and LNG marine shipping by 100 billion m³ would increase emissions by 78 Mt CO₂-eq.;

– Diverting 20 billion m³ of Russian LNG from existing projects to Asia would stimulate emissions growth by an additional amount of 21 Mt CO₂-eq.;

– Reorientation of Qatari gas supplies from Asia to Europe in the amount of 90 billion m³ would add another 18 Mt CO₂-eq. (Figure 1).

The reorientation of maritime trade in oil and oil products due to imposed geopolitical restrictions will increase global emissions by 132 Mt CO₂-eq., including:

– Reorientation from Baltic ports to Asia adds 49 Mt CO₂-eq. as a result of the increased distance;

– Reorientation from Arctic ports to Asia adds 1 Mt CO₂-eq.;

– Reorientation of oil from the Druzhba pipeline to tanker shipping to Asia adds 26 Mt CO₂-eq.;

– Exports of the total volume of oil products from Europe to Asia adds 64 Mt CO₂-eq.

to the shorter distance compared to Asia shipments (Figure 2).

At the same time, redirecting trade flows of Middle Eastern liquid hydrocarbons from Asia to Europe reduces emissions by 8 Mt CO₂-eq. due

Estimation of emission changes using the example of geopolitical decisions in aviation. In addition to shifts in the global energy trade structure,

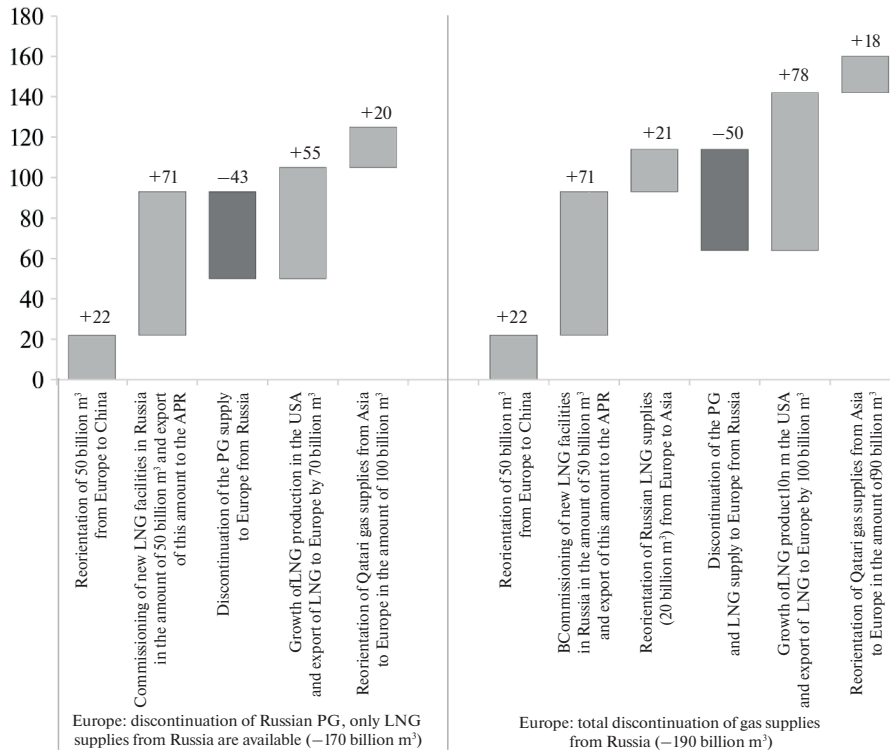


Figure 1. Change in emissions resulting from Europe's renunciation of Russian gas depending on the calculation assumptions, Mt CO₂-eq.

Source: compiled by the authors.

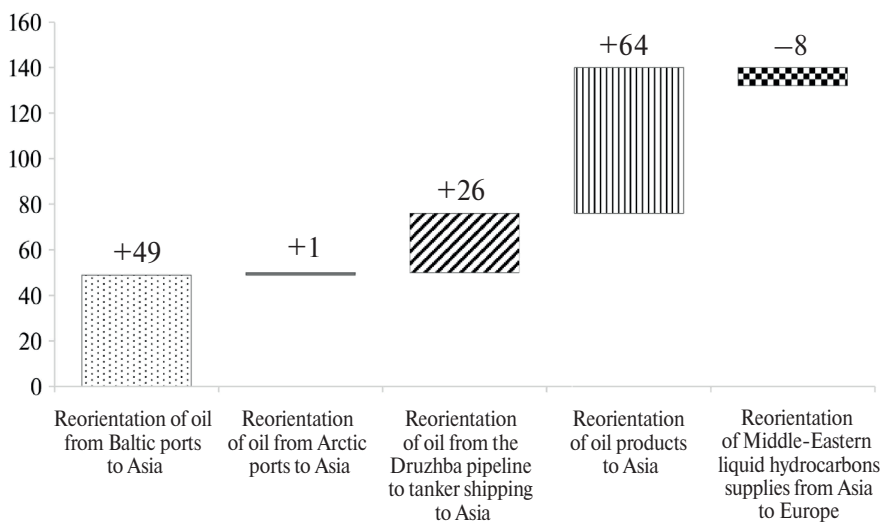


Figure 2. Change in emissions resulting from Europe's renunciation of Russian liquid hydrocarbons, Mt CO₂-eq.

Source: compiled by the authors.

air travel has also been impacted by restrictions. Russia's vast territory serves as a crucial transit link for passenger and cargo transportation on routes between Asia, Europe, and North America. Similarly, EU territory has traditionally functioned as a transit link for routes from Russia to North and Latin America, as well as certain African countries. Due to mutual airspace restrictions, flight routes have been significantly altered, resulting in longer flight times. The logistics of moving citizens and cargo between Russia and EU countries have also become more complex, with routes now passing through third countries, often increasing the distance by 2–3 times. Given the availability of baseline data, this article only considers the impact of passenger transit over Russia, estimating a minimum level of additional emissions from air transportation. It is evident that in practice, the emissions volume will be higher. The calculation shows that the closure of airspace over Russia, which changes the distance for flights between Europe and Asia, adds an additional 2.6 Mt CO_2 -eq. per year to global emissions.

A comprehensive analysis of emissions growth.

The reorientation of oil and gas trade flows due to the renunciation of energy resources from Russia, as well as the need for planes traveling between Europe and Asia to bypass Russian airspace, has led to an additional annual increase in oil demand of 18–19 million tons and LNG demand of 355–444 thousand tons per year. The total increase in global emissions will amount to 261–290 Mt CO_2 -eq. which is comparable to the total emissions of all Scandinavian countries (Sweden, Norway, Denmark) and Finland in 2021 (Figure 3).

It is important to note that the above calculations represent only the lower end of the impact that geopolitical constraints have on emissions. In reality, the growth in emissions will be much higher, as numerous other sources of greenhouse gases (GHGs) were not discussed in the article. These include air cargo transportation, passenger flights from Russia, trade in coal, timber, and wood products, rail and road transit through Russia, changes in tourist routes requiring longer travel distances, limitations in technology

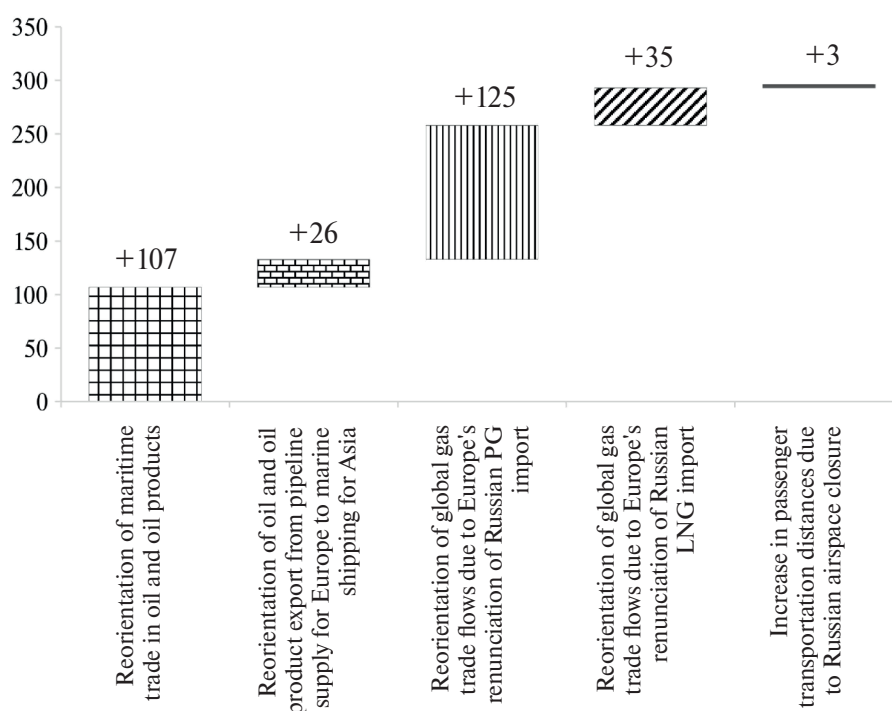


Figure 3. Cumulative change in global emissions resulting from Europe's renunciation of Russian gas and liquid hydrocarbons and closure of airspace over Russia, Mt CO_2 -eq.

Source: compiled by the authors.

transfer and the ability to switch to more efficient solutions, the supply of agricultural products to and from Russia, and the shipment of consumer and industrial goods through new, more complex, and longer logistics chains, among others [sources 17, 18, 19].

The inclusion of these factors is complicated by the limited availability of necessary data. However, it is likely that incorporating every factor mentioned above would increase the emissions difference by at least another 40–60%. Thus, the total *CO2* emissions resulting from geopolitical tensions between Russia and Western countries, according to our estimates, could reach approximately 390–435 Mt *CO2*-eq. per year. This figure corresponds to the total GHG emissions of the UK and exceeds those of major European economies such as France, Spain, or Italy.

CONCLUSIONS

Controlling emissions and preserving the environment in a rapidly developing world with a growing population is a significant challenge that will greatly influence the achievement of further sustainable development. The example analyzed shows that sub-optimal logistics, resulting from restrictions between Russia and Western

countries, alone leads to an increase in emissions equivalent to the *CO2* emissions of the UK economy, one of the top ten economies in the world by GDP. In fact, a new major source of emissions is emerging on the global emissions map, one that, unlike others, does not provide any positive economic benefits. Simultaneously, the demand for fuels is rising, as are global production and consumption costs, freight costs, and overall trade costs. As a result, consumers will pay more for the final product, leaving less money for other essential needs, including efforts to combat climate change.

Existing and potential restrictions on global trade are not limited to Russia's relations with the EU and the USA. Their potential impact on *CO2* emissions is far greater. Therefore, optimizing supply chains and creating appropriate incentives should be a critical component of global emission reduction policies. This challenge requires cross-country collaboration and cannot be addressed solely by national goals and targets, as highlighted in the 2015 Paris Agreement. Thus, an additional area of focus within the low-carbon agenda becomes evident: the development of mechanisms that facilitate the creation of optimal global logistics for freight and passenger transportation.

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