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Abstract

Kaliningrad's CO_2 emissions from energy consumption grew approximately by 34% between 2000 and 2020. This is significantly more than either in Russia overall or in neighboring Baltic countries. One reason for the significant increase in emissions was rapid economic growth in the province, in particular before 2009. Although energy intensity of the economy declined during this period but the scale of the reduction was insufficient to offset growth in energy consumption and carbon emissions. Therefore, green growth aspirations of decoupling economic growth and environmental impacts of energy consumptions remain unmet in Kaliningrad.

Recent massive build-up of power generating capacity in the province, which was driven exclusively by energy security goals, makes any serious decarbonization of the power sector in Kaliningrad highly improbable in the next decade. This leaves energy efficiency as the key area for constraining energy consumption and associated emissions. District heating and transport are also the sectors where regional authorities can make progress towards decarbonization by using more biomass, for example. Kaliningrad is also an attractive place for testing various emissions trading mechanisms that can be later introduced across whole Russia.

Key words: the Kaliningrad Oblast, green growth, climate change, CO_2 emissions, air pollution, energy

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1. Introduction

Economic growth has put increasing pressure on the environment so far. Air pollution is responsible for an estimated seven million premature deaths worldwide every year (World Health Organization, 2021). This is several times more deaths than from AIDS, tuberculosis, and malaria combined. Growing emission of greenhouse gases mainly from the use of fossil fuels cause climate change. It will lead to more frequent extreme weather events, coastal flooding, crop failure and other negative impacts. Depletion of natural resources affects billions of people in various regions. Overall, humankind slides ever closer to the Earth's environmental limits (Rockström et. al., 2009) and current patterns of economic growth are clearly not sustainable.

At the same time, billions of people, especially in low- and middle-income countries, have dreams and aspirations of improving their social conditions and reaching the standards of living on par with those in developed countries. Meeting these aspirations requires the continuation of economic growth and even its acceleration. At least, this is the main policy goal in many countries across the globe.

The concept of "*green growth*" is intended to address the above challenge: to make sure that economic growth with accompanied rise in living standards continues while its impact on the environment does not grow and preferably reduced. More formally, according to the Organisation for Economic Co-operation and Development (OECD, 2011, 9), green growth means "*fostering economic growth and development while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies.*" In order to monitor progress towards green growth the OECD has also developed a set of quantitative indicators.

The energy dimension of green growth is, clearly, the most important one. Climate change is today's foremost global environmental problem, and it is primarily caused by the consumption of fossil fuels. Energy use is also often the main reason for local air and water pollution. The energy sector is also very large in economic terms and requires huge investment for its transformation towards a low carbon future.

This report seeks to explore the energy aspect of green growth in the Kaliningrad Oblast (or simply Kaliningrad). The report begins with a brief review of economic growth in Kaliningrad over the last 20 years. After that it explores energy trends in the province and, in particular, the changes that have occurred in the energy supply and the power sector. In the next section, I calculate CO_2 emissions stemming from energy consumption and analyze their main drivers. Finally, I describe major federal and regional policies related to climate change and greening of energy in Kaliningrad's economy.

2. Economic growth

The Kaliningrad Oblast is a small region of the Russian Federation in the south-east part of the Baltic Sea region (see Figure 1). It is surrounded by two EU member states – Poland and Lithuania, which makes it a semi-exclave of Russia within the EU.[1] Its total area is 15.1 thousand square kilometers. Province's population has been growing in recent years and in 2019 exceeded one million people. Neighboring Lithuania is approximately 2.7 times larger in terms of population and more than four times larger in terms of area.

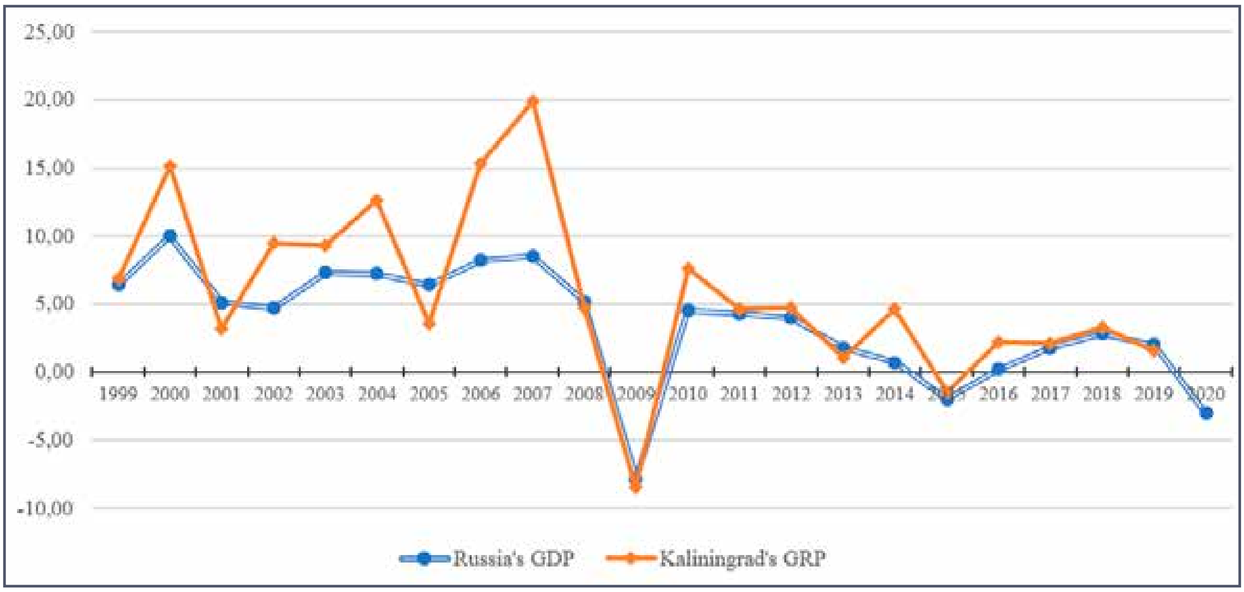
1 Kaliningrad has an access to the Baltic Sea, this is why it is a semi-exclave and not a full exclave.

Figure 1. Map of the Baltic Sea Region

Source: Wikipedia (2021d).

Over the last two decades, Kaliningrad's economy grew quite rapidly. The average growth rate during 2000-2020 was 5.3% per year[2], which is a rather high growth rate even by the emerging market standards. It exceeded growth of Russia's GDP by 1.9 percentage points. The size of Kaliningrad's economy has increased roughly by a factor of 2.5 during this time. The population in Kaliningrad over the same period increased only by 5.7%, so per capita growth figures are only slightly lower than the overall economic growth. However, the high average rate masks two distinct periods with very different economic dynamics divided by the recession in 2009 (see Figure 2).

Figure 2. Economic growth in Russia and Kaliningrad, annual growth rate, %



Source: Rosstat (2021).

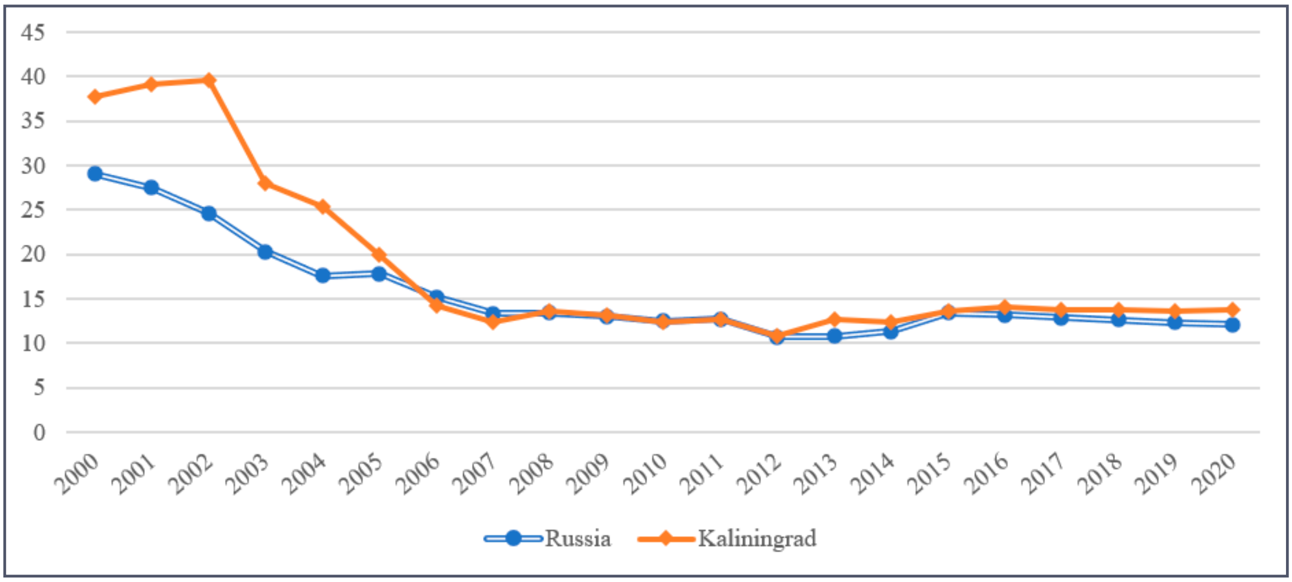
2 This is an arithmetic average for growth rate in gross regional product. Geometric average (or compounded) growth rate was lower – 5.1% per annum.

The first period started after the Russian government defaulted on its bonds in 1998. The default had caused a sharp devaluation of the ruble and a severe recession but it also helped local producers to regain competitiveness against imports. Even more important was a painful restructuring of the economy that had taken place in 1990s after the break-up of the Soviet Union and the beginning of market reforms in Russia. In 1999 the economy returned to growth, which lasted until the global financial and economic crisis of 2008. Tax and tariff advantages of the special economic zone created in Kaliningrad helped to make Kaliningrad one of the main channels for imports to Russia. Many newly created manufacturers used imported parts to assemble final consumer goods (for example, cars and consumer electronics) for sales in the mainland Russia. Between 2000 and 2008, Kaliningrad's economy grew on average by 10% per annum exceeding average growth rates in Russia by three percentage points.

After a brief but sharp recession in 2009, economic growth in Kaliningrad and Russia has renewed but at a much lower pace and with a downward trend. In 2014, the fall in oil price and Western economic sanctions related to the conflict in Ukraine led to another recession. In 2016, most of Kaliningrad's special economic zone import benefits expired and were replaced by transfers from the federal budget and some tax concessions. Overall, in 2010-2019 average growth rate in Kaliningrad declined to 3.0% per annum vs. Russia's 2.0%.

Economic growth over the last two decades has brought sizeable and important benefits. Most important benefit was an overall improvement in the standards of living. One dimension of this was a reduction in poverty – the percentage of population in Kaliningrad having income below the subsistence level dropped from 38% in 2000 to 13.7% in 2020. However, as it can be seen on Figure 3, all this progress was achieved before 2008. In recent years, this indicator stubbornly remained at the level of 13.5-14%, which was higher than back in 2007 or even during the economic crisis of 2008-2009.

Figure 3. Percentage of population with income below the subsistence level, %



Source: Rosstat (2021).

Economic growth has also helped to reduce the unemployment rate and to achieve steady improvements in housing conditions. Even improvements in such health indicators as life expectancy and child mortality can be in part attributed to growth in economic output.

While the benefits of economic growth are essential, it is also important to understand the environmental costs of economic growth. In this study, I focus on emissions of CO_2, the main anthropogenic greenhouse gas released during combustion of fossil fuels as the main indicator of environmental costs.

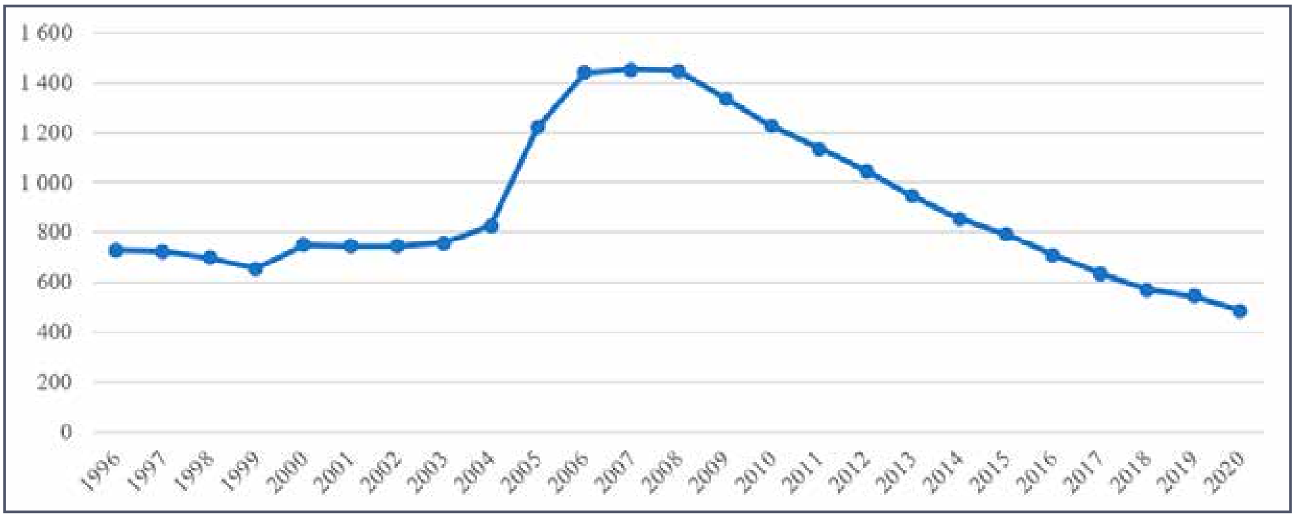
3. Energy trends

Kaliningrad's energy production and consumption are very unbalanced: practically all internally produced energy resources are exported while its energy demand is met by energy imported to the province.[3]

3.1. Energy production

Energy production in Kaliningrad is largely represented by crude oil extraction. Crude oil together with a small volume of associated gas has accounted for more than 98% of Kaliningrad's primary energy production in recent years. According to the Regional Government total proved oil reserves (ABC1) in Kaliningrad amount to 49 million tons (Kaliningrad Regional Government, 2021b). The first oil fields were discovered in Kaliningrad in the late 1960s and commercial oil production started in 1975. By the middle of the 1980s oil production reached its peak of 1.5 million tons (Mt) but then it had been on a downward trajectory. In 2004, oil production in the region got a significant boost when Lukoil started production at the offshore D-6 (Kravtsovkoe) field located approximately 20 km from Kaliningrad's coast. Kaliningrad's crude production reached its post-Soviet peak of more than 1.4 Mt per year in 2006-2008 but since then it has been declining by 9-11% per annum (see Figure 4).

Figure 4. Oil production in Kaliningrad, thousand tons



Source: Kaliningradstat (2013), Rugrad.eu (2021), see also Annex.

All crude oil produced in Kaliningrad is exported and all refined oil products have to be imported to the region because the province does not have an oil refinery. Discussions whether it makes sense to build a refinery has periodically emerged. However, Lukoil, the only oil producer in in the province, considers Kaliningrad's oil production as too small for a financially viable refinery project. Another factor is that there are several large refineries next to Kaliningrad, including one in Gdansk (Poland) and Mažeikiai (Lithuania).

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Future prospects for oil production in Kaliningrad are mainly associated with offshore fields in the Baltic Sea. Untapped onshore oil fields in Kaliningrad are quite small and will not be able to offset the fall in production due to the depletion of existing larger fields. Lukoil's exploratory drilling at several offshore blocks has proved to be unsuccessful but the company has recently discovered an offshore field (D-33)

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3 In this report, I use the term 'import' to denote a shipment of goods from elsewhere to the Kaliningrad Oblast, irrespective whether the goods originated from the mainland Russia or other country. The same applies to the term 'export'. The main justification for this choice is to keep the text clear and concise. However, when it is essential for analysis, I will clarify the origin or destination of goods.

4 Small amount of associated gas produced during oil extraction is supplied to local customers.

that has reserves of 21.2 Mt of crude oil (Rugrad.eu, 2021) and might help to reverse the declining trend in oil production.

Other noticeable fossil fuel resources in the region include deposits of brown coal (50-70 million tons) and peat (more than 300 million tons). Brown coal deposits are not developed mainly for environmental reasons. Peat is extracted on a limited scale by several companies and is used in agriculture and for energy production at a few district-heating boiler stations.

Currently, renewable energy production in Kaliningrad is quite limited. It is produced by small scale hydropower and wind energy installations. In 2020, the installed capacity of three existing hydropower plants (one of them was in conservation) was just 1.7 MW (0.1% of the total). However, the economic potential of local hydro resources is significantly larger. In the first half of the 20^{th} century, the province (part of East Prussia at that time) had more than 30 small and micro run-of-the-river hydropower plants, some elements of which survived to this day. The regional government estimated the total potential of hydropower in Kaliningrad at 30 MW and planned to have 12 MW of operating hydropower capacity already by 2005 (Kaliningrad Regional Government, 1999).

Kaliningrad was the place where the first modern wind farm was built in Russia. It was launched in 1998 with the assistance of the Danish government. After 20 years of service, it was closed down in 2018 and a new wind farm was built in Ushakovo on the coast of the Vistula Lagoon. It has three wind turbines with total installed capacity of 5.1 MW (0.3% of the total). In 2020, they generated 10,900 MWh of electricity, which means that the capacity factor of the wind farm was 24.4%, quite similar to the average capacity factor for onshore wind in the EU in the same year (25%) (WindEurope, 2021).

Due to its coastal location, Kaliningrad has some of the best conditions for the development of wind energy in Russia. The mean wind speed at the height of 100m is 7.6 m/s (for the whole territory), while 10% most windy places (largely at the coast) has mean wind speed 8.02 m/s (Global Wind Atlas, 2021), which is considered quite favorable for wind energy development. Most of other windy locations in Russia are located far from population centers and lack transport and grid infrastructure. Report by a consulting company, COWI, lists several sites suitable for wind power installations in Kaliningrad and estimates total capacity for these installations to be 530-600 MW (COWI, 2007). Another estimate can be made using a simple comparison with neighboring Lithuania, which has similar wind conditions, and had 548 MW of onshore wind in 2020. Given that Kaliningrad's territory is 23% of Lithuania's, comparable figure for Kaliningrad would be 126 MW. These estimates do not include the potential of offshore wind, which is more expensive.

Wooden biomass has been used to produce heat at some boilers in Kaliningrad but in recent years its use seems to be declining. Forest resources in the province are limited – forest cover is only 19%, which is significantly smaller than in Kaliningrad's neighbors. For example, the pulp and paper industry, which was quite significant in the province in the Soviet period, has practically disappeared in the last three decades largely due to a lack of competitive supply of wood. Therefore, wood is unlikely to become a substantial source of energy in the medium-term future. However, the regional government program for energy efficiency adopted in 2010 indicates that biomass feedstock from municipal solid waste and agriculture waste is the most promising source of renewable energy, mainly for heat production and co-generation. The program estimated its technical potential as 240 ktoe (kilo tons of oil equivalent) per year and economic potential as 156 ktoe per year.

Overall, the internal energy production without crude oil covers less than 1% of Kaliningrad's energy demand. Essentially all coal, natural gas and refined oil products have to be imported to the region.

3.2. Energy supply

In 2020, total primary energy supply in Kaliningrad was 2.6 million tons of oil equivalent (toe). Natural gas was by far the largest source of energy – it accounted for 73% of total energy supply. Its supplies in 2020 was 1.9 million toe, increasing since 2000 by a factor of five. A small amount of natural gas is extracted together with crude oil (associated gas) but more than 99% is supplied from the mainland Russia through a pipeline crossing Belarus and Lithuania. Approximately 60% of natural gas is used to generate electricity, another 20% to produce heat, and the remaining 20% is used by households for cooking and heating, by industry and other final users. In the power sector natural gas has become almost exclusive fuel. Rapid development of gas distribution network in recent years has been an important driver for growth in natural gas demand: the level of gasification (i.e. the percentage of households that have access to the gas distribution network) increased from 58% in 2010 to 81% in 2018 (Central Dispatch Office, 2019).

Refined oil products have the second largest share in Kaliningrad's energy supply after natural gas. In the early 2000s, a substantial part of oil products (fuel oil) was used by boilers to produce heat. Since then, natural gas has been steadily replacing fuel oil in this application. Currently most of oil products (approximately 80%) is used for transport, primarily for cars and trucks.

Coal accounts for just 3% of Kaliningrad's primary energy supply. Its consumption has been declining in the last two decades. In the early 2000s, coal was the main fuel for producing heat at boilers. It has been also used by many households in rural areas for heating and cooking. However, the development of gas distribution network allowed many users to switch to more convenient and environmentally friendly energy carrier – natural gas. Kaliningrad's energy balance that summarizes data on production, supply and consumption of various energy carriers is presented in Table 1.

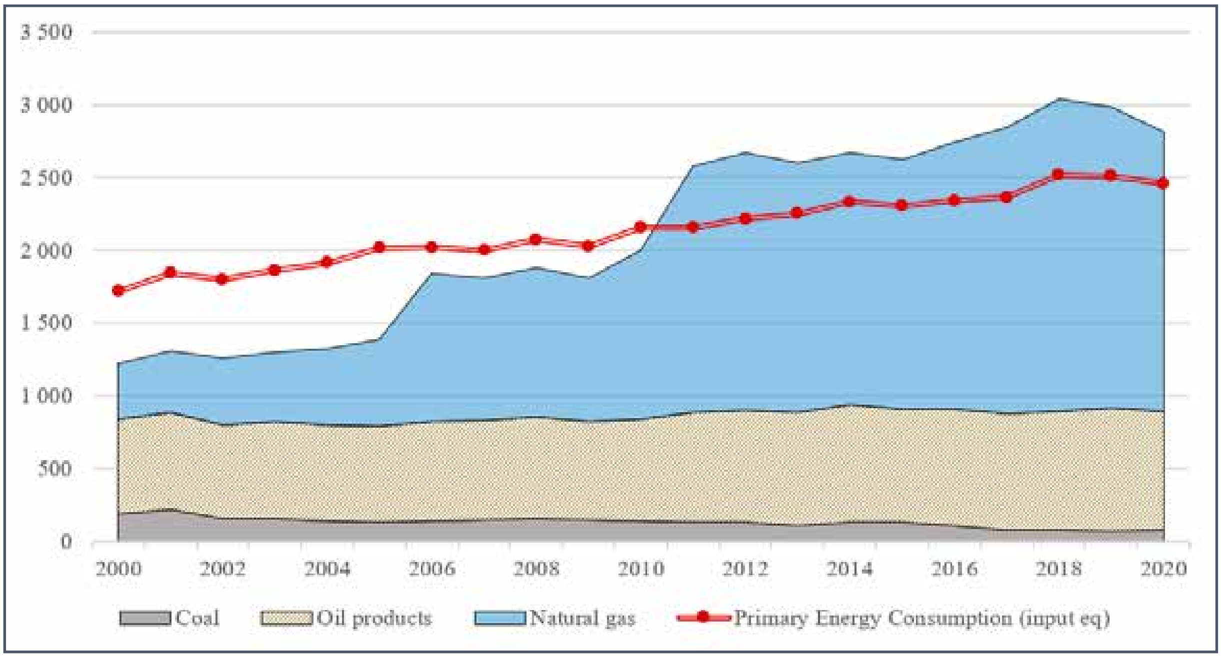
Table 1. Simplified energy balance for Kaliningrad, 2020, ktoe

	Crude oil	Coal	Oil products	Natural gas	Other solid fuels (peat)	Renewables (wind, hydro)	Electricity	Heath	Total
+ Primary production	487	0	0	10	5	2			504
+ Imports	0	73	812	1,914	0	0	19	0	2,818
- Exports	487	0	0	0	0	0	192	0	679
= Primary energy supply	0	73	812	1,924	5	2	-173	0	2,644
Electricity generation		-1	-1	-1,143	0	-2	550	0	
Heat generation		-63	-42	-378	-1	0	0	418	
Distribution losses		0	0	0	0	0	-45	-62	
Final energy consumption	0	9	769	403	4	0	332	356	1,874

Sources: see Annex.

Figure 5 illustrates the changes in the consumption of fossil fuels and primary energy over the period of 2000-2020. The difference between primary energy and fossil fuel consumption represents, first of all, imports and exports of electricity, and to a much smaller degree renewable electricity generation (as I mentioned earlier it has been insignificant). Until 2011 Kaliningrad imported electricity, therefore its primary energy consumption was larger than the amount of fossil fuels it consumed. After 2011, the situation has been reversed. For consistency, I assumed that imported electricity was generated from fossil fuels with the same efficiency as in Kaliningrad in 2020 (at 48%).

Figure 5. Kaliningrad's fossil fuel consumption and primary energy consumption, ktoe



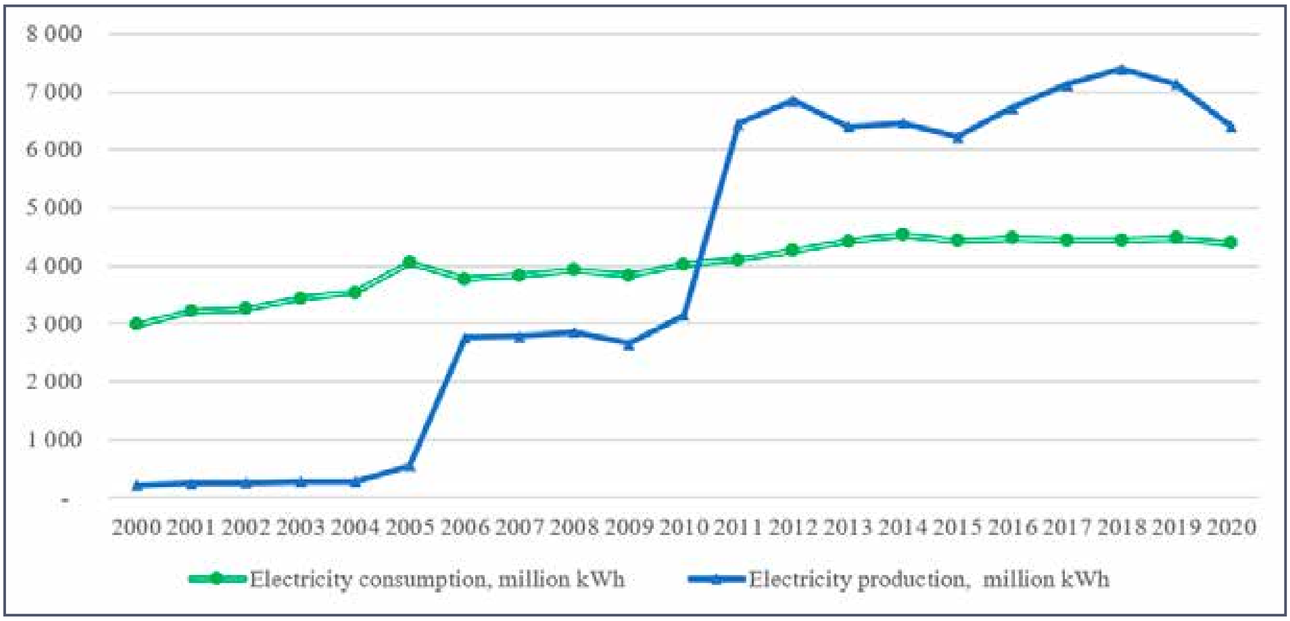
Sources: The author's calculations, see also Annex.

Note: primary energy consumption is calculated on an input-equivalent basis, i.e. power generation from renewables and electricity trade is accounted based on the equivalent amount of fossil fuel input required to generate that amount of electricity in a thermal power plant with the efficiency of 48%, the same as in Kaliningrad in 2020.

3.3. Power system

The power system of Kaliningrad has been significantly transformed over the last 20 years. The main goal of this transformation was to increase energy security of the province. In 2000, Kaliningrad relied on electricity supplied from Lithuania and the rest of Russia for 93% of its electricity consumption (see Figure 6). By 2018, Kaliningrad was exporting 42% of electricity it was generating. At the end of 2020, it had 1919 MW of the installed power capacity, which was 2.4 times higher than its own peak power consumption registered over the past five years.

Figure 6. Electricity production and consumption in Kaliningrad, million kWh



Source: Rosstat (2021).

This rapid increase in electricity generating capacity was achieved via investment of state-owned companies, which have built several new power stations. First, in October 2005, the first unit of the gas-fired combined heat and power plant, known as CHPP-2, was brought online. The second unit followed in December 2010. The CHPP-2 has the installed capacity of 875 MW(e). It was one of the first power plants in Russia based on a Combined Cycle Gas Turbine (CCGT) technology. The plant made Kaliningrad self-sufficient in electricity generation, and since 2011, it has been able to export excess electricity to Lithuania.

In 2012, Lithuania adopted legislation on the integration of its power system into the European grid (Ministry of Energy of the Republic of Lithuania, 2020). This means that the country will leave the BRELL energy system, which links it (and Kaliningrad) to Russia's power system. This step will make Kaliningrad an energy island unable to either to receive or send electricity through Lithuania's grid. The security of electricity supply under such conditions requires that the power systems should be able to withstand the loss of its largest component (this rule is known as the N-1 reliability criteria). This criterion implies that Kaliningrad must have enough of the generation capacity to satisfy the demand even without the CHPP-2 (see more on this in Usanov and Kharin, 2014).

To respond to this challenge in 2015 Russia's Government decided to build four new power stations with the total capacity of 979 MW. It was done very quickly – the first station was brought online already in 2017 and the last one in 2020. All, except the last one, use natural gas as a fuel.

In 2020, natural gas accounted for generating 99.6% of all electricity. In essence, the dependence on the imports of electricity has been replaced by even stronger dependence on the external supplies of natural gas. From an energy security viewpoint, dependence on natural gas rather than on electricity is far more preferable. Natural gas is much easier to store and it can be transported by sea in a liquified form by specialized LNG tankers. Indeed, in recent year Gazprom, state owned Russian gas company, has made major investment in the expansion of underground gas storage and built an LNG gas terminal in order to be able to supply gas to the province without using the natural gas pipeline crossing Belarus and Lithuania.[5]

The environment was hardly a primary goal during this build-up of power capacity. However, the replacement of coal by natural gas for district heating and household consumption has brought important benefits of reducing air pollution including inside houses. On the negative side, excess power capacity existing in the province (compared with its peak consumption) practically excludes the possibility of any meaningful development of renewable electricity production unless electricity export becomes a feasible option.

4. Carbon emissions and air pollution

Burning fossil fuels releases carbon dioxide (CO_2), a major greenhouse gas. Its rising anthropogenic emissions is the leading cause of global warming. Fossil fuel combustion accounts for more than 80% of all anthropogenic emissions of CO_2. The rest comes from deforestation (Wikipedia, 2021a). In the past decade, there has been no significant changes in Kaliningrad's forest area, therefore deforestation's contribution to carbon emissions should be insignificant in Kaliningrad's case.

Data on the consumption of fossil fuels allows us to calculate carbon emissions from fuel combustion in Kaliningrad. Emissions can be calculated using either production-based (also known as territorial-based) or consumption-based approaches (Wikipedia, 2021b). Production-based approach measures emissions based on the location of fossil fuel usage. Consumption-based approach assign emissions to the place where the final consumption of goods and services takes place. It requires the calculation of the emissions 'embodied' in internationally traded goods and services, which requires the use of Input-Output models. Currently, production-based emission accounting is the approach used by official statistical agencies.

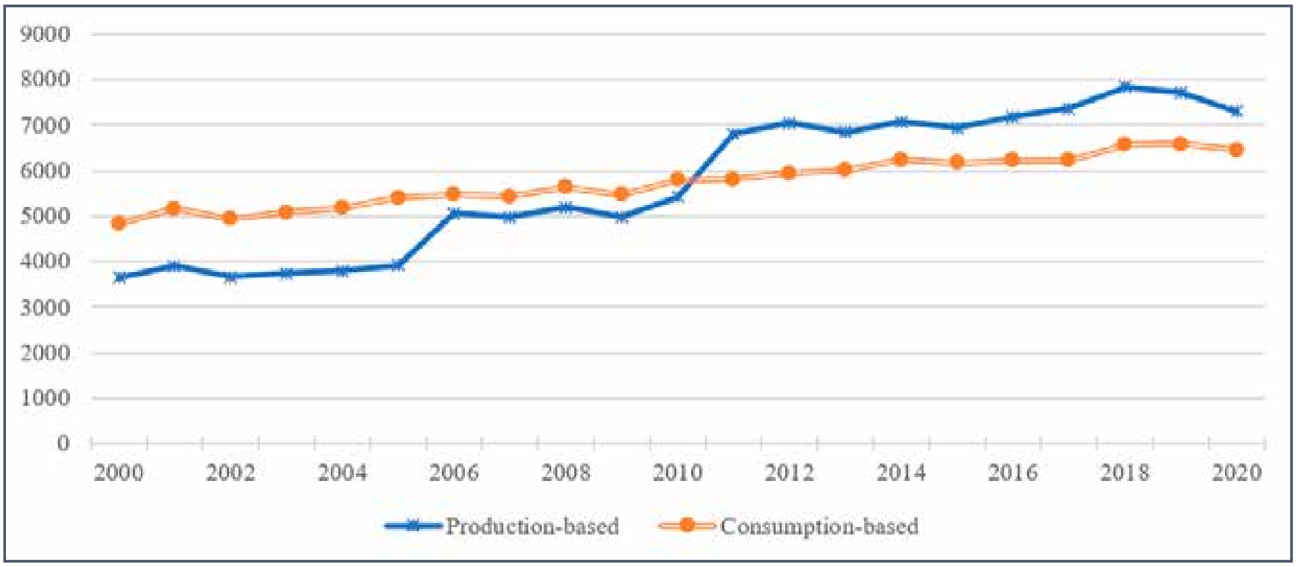
For Kaliningrad, the two approaches give quite different results because of the importance of electricity trade in the energy balance of province. Full consumption-based emission accounting is beyond the scope of this report but taking into account the carbon emissions connected with electricity trade produces more informative emission estimates.

5 Underground gas storage facility currently has capacity of 174 million m3 of working gas inventory but Gazprom plans to expand it to 800 million m3 by 2025. For more information on this project see Gazprom (2021).

To calculate CO_2 emissions, I used the default emissions factors for various fuels listed in 2006 IPCC Guidelines for National Greenhouse Gas Inventories. For the consumption-based emissions, I assume that all flows of electricity across the borders of the Kaliningrad Oblast have been generated from the same fuel (natural gas) and with the same efficiency as in Kaliningrad in 2020. This assumption is generally valid after 2011 when Kaliningrad became a net exporter of electricity – because the same power station, CHPP-2, has produced a lion's share of electricity generated in Kaliningrad. It is less valid before that. However, this assumption produces more consistent estimates of carbon emissions directly linked to electricity consumption in the province than would be the case with somewhat arbitrary choice of particular sources of electricity imports. In any case, there is no publicly available information on sources of Kaliningrad's electricity imports.

Results of calculations are shown in Figure 7. Unsurprisingly this chart looks quite similar to Figure 5 and Figure 6. Production-based carbon emissions are higher than consumption-based ones after 2011 because Kaliningrad exports a substantial amount of electricity that it is generated within the province.

Figure 7. Kaliningrad's CO_2 emissions from fuel combustion, thousand tons of CO_2



Source: The author's calculations.

Overall, production-based carbon emissions doubled over the period between 2000 and 2020, while growth in consumption-based emissions was approximately 34%.

For further analysis, I will use carbon emissions calculated using the consumption-based accounting framework because they better reflect intrinsic consumption of energy in the province. For most countries, including Russia, electricity trade is only a very small part of the overall energy balance, and adjusting carbon emissions for its impact would not have a material impact on carbon emissions. However, in the case of Kaliningrad such an adjustment is quite significant.

4.1. Decomposing and benchmarking Kaliningrad's trends in emissions

How does Kaliningrad's increase in carbon emissions of 34% compare to emission trends in Russia overall? BP data shows that carbon emissions in Russia over the same period actually declined by 1% (BP, 2021). The difference is quite significant and calls for an explanation.

The first thing to notice is that the consumption of primary energy increased much more significantly in Kaliningrad than in Russia: by 43% vs. 10%. The difference in the growth of energy consumption explains a lion's share of carbon emissions changes. Faster decarbonization of energy supply in Russia adds another couple of percentage points in explaining the difference. Largest contribution to decarbonization has been made by a reduction in coal use and its replacement by cleaner natural gas. This trend was common both in Russia in general and in Kaliningrad. What was missing in Kaliningrad, was increased generation and consumption of nuclear energy, which has a low carbon footprint over its life cycle.[6] In Russia, nuclear energy production grew by 47% between 2000 and 2020, making an important contribution to decarbonization. In 2020, nuclear energy represented 7% of total Russia's energy consumption (BP, 2021).

Faster growth in primary energy consumption in Kaliningrad is, in turn, associated with more rapid economic growth in the province. Between 2020 and 2000 Kaliningrad's economy expanded by a factor of 2.5, while Russia's economy increased only by 81%. While economic growth was much faster than growth in energy consumption, both are still correlated with each other. This shows that there has been no full decoupling between economic growth and energy consumption in Russia and in its western province.

Despite rapid growth in energy consumption, Kaliningrad has quite energy efficient economy in comparison to other Russian regions. Data published by Rosstat shows that in 2019 the energy intensity of Kaliningrad's economy (energy consumption per one Ruble of gross regional product [GRP], an inverse of energy efficiency) was one of the lowest in the country – Kaliningrad had the fourth lowest value of this indicator among almost 90 Russian regions. Regions with low energy intensity in Russia, including Moscow and St. Petersburg, tend to have GRP per capita much higher than that in Kaliningrad. Similar results appear when we look at the electricity intensity – Kaliningrad again has some of the lowest values in Russia.

Sectoral structure of Kaliningrad's economy and, more specifically, absence of energy intensive sectors, for example, those targeted in the proposed EU Border Adjustment Mechanism – steel, aluminium, cement, and fertilizers – seems to be a key factor explaining relatively energy efficient nature of Kaliningrad's. Industry share in Kaliningrad's economy was 29% in 2019, which was five percentage points lower than in Russia overall. But if in Kaliningrad, industry accounted for the same 29% share of all electricity consumption, in Russia the corresponding figure was 53%!

To better understand trends in carbon emissions it is useful to apply the Kaya identity, which expresses the emission level as the product of four factors: human population, GDP per capita, energy intensity (energy per unit of GDP), and carbon intensity (emissions per unit of energy consumed) (Wikipedia, 2021c). It can be expressed as follows:

$$F \equiv P \times \frac{GDP}{P} \times \frac{E}{GDP} \times \frac{F}{E}$$

where: *F* – carbon emissions (from fossil fuel combustion)

P – population

GDP – Gross domestic (or regional) product

E – energy consumption.

Correspondingly:

GDP/P – GDP per capita

E/GDP – energy intensity of the economy

F/E – carbon intensity of energy.

The last two factors are the main levers through which we can reduce carbon emissions without serious reductions in the level of GDP per capita and therefore make progress towards the green growth objectives.

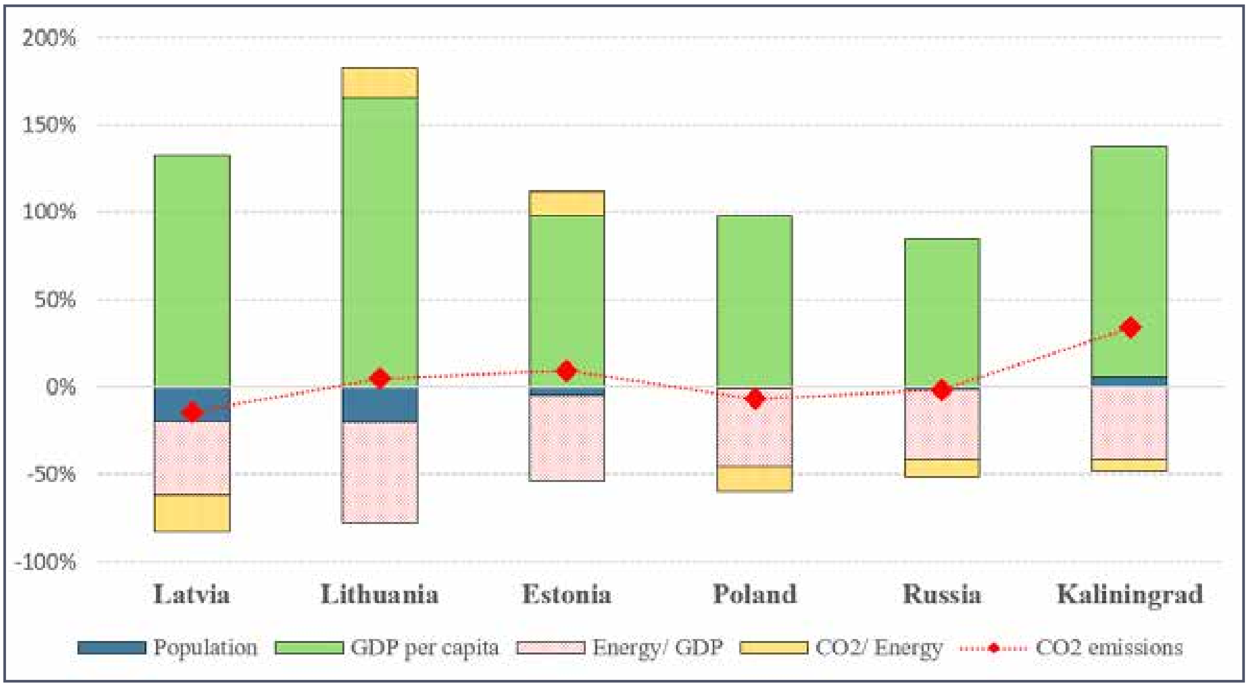
Figure 8 below shows overall change in carbon emissions from 2000 to 2020 and its decomposition into four factors for Kaliningrad and Russia as a whole.[7] For comparison, it also shows changes in carbon

6 Rosatom, state nuclear monopoly, initiated construction of the Baltic Nuclear Power Plant in Kaliningrad in 2010 with an expectation that it would export electricity to the EU. Lack of interest from potential buyers of electricity forced Rosatom to suspend its construction in 2013.

7 Looking at Figure 8, it should be kept in mind that the same percentage changes for increases and decreases are not equivalent. For example, a 100% increase in one factor would be cancelled by a 50% decline in another factor. For smaller absolute changes the difference between positive and negative percentage changes become smaller: a -10% decrease is cancelled by +11.1% increase.

emissions and the corresponding factors over the same period for three Baltic countries – Lithuania, Latvia, and Estonia – which are close to Kaliningrad and have similar level of economic development.

Figure 8. CO_2 Emissions and their decomposition using the Kaya identity, 2020 vs 2000



Sources: World Bank (for population and GDP) (2021), BP (for energy and CO2 emissions) (2020), the author's calculations.

The above figure shows that Kaliningrad had the highest increase in carbon emission among this group. This can be attributed to an increase in population and rapid economic growth. Declines in energy and carbon intensity, which were generally similar to other members of the benchmark group, were not able to offset fully increases in the other factors.

More general conclusion from Figure 8 is that two factors had the largest and systematic impact on the changes in emissions – economic growth and decline in energy intensity. Lower energy intensity on its own was not able to fully compensate increases in emissions due to economic growth. Countries that achieved a decrease in carbon emissions over this period (Latvia, Poland and Russia) also made progress to a lower carbon intensity of energy supply.[8]

4.2. Air Pollution

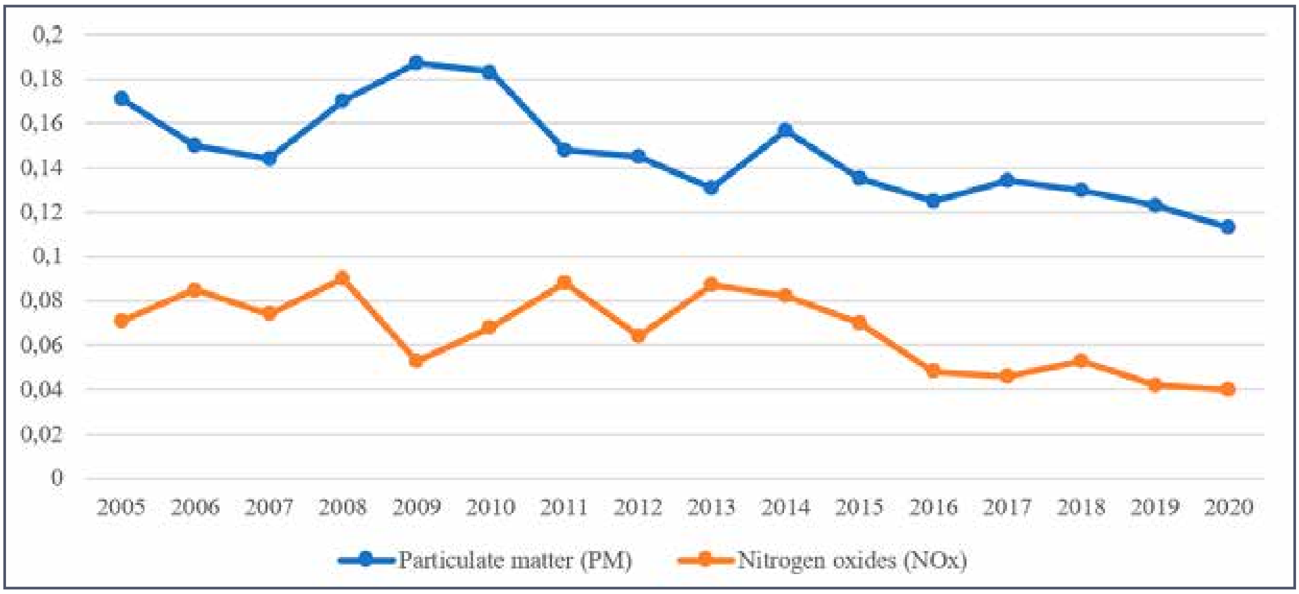
Besides emissions of greenhouse gases, the consumption of fossil fuels also produces a number of other air pollutants. They include nitrogen oxides (NO_x), sulfur oxides (SO_x), carbon oxides (CO_x), particulate matter (PM) and other. These pollutants cause illness and premature deaths as well as non-health costs such as increased corrosion, deforestation, reduced agricultural output.

In Kaliningrad, the largest emitter of air pollutants is road transport, which in 2020 was responsible for 83% of emissions (Kaliningrad Regional Government, 2021a). The number of motor vehicles in the same year reached 494 thousand, which is quite significant for the region with population of just about one million people. Other emitters include power plants, boilers and industrial plants. The concentration of air pollutants in the city of Kaliningrad has had a downward trend in recent years (Figure 9) and overall air quality in the city can be considered as good.[9]

8 Perhaps accidentally, all three of them also had a population decline during this period.

9 This is the grade that IQAir.com, on-line service for air quality assessment based on satellite measurements, provides for Kaliningrad , see https://www.iqair.com/russia/kaliningrad

Figure 9. Average concentration of air pollutant in the city of Kalininngrad, mg/m3



Source: Kaliningrad Regional Government (2021a).

The gasification of the heat sector was instrumental in improving air quality by switching old boilers using coal and fuel oil to natural gas or closing them down. Another important factor has been stricter requirements for car fuels and new cars in terms of pollutants and emissions.

5. Environmental policy

Until last couple of years, climate change mitigation was not a top priority for Russian policy makers. Although Russia signed and ratified the Kyoto Protocol and the subsequent Paris Agreement, the two global treaties aimed at reducing greenhouse gas emissions, it was not doing much for reducing these emissions.

There are many reasons for this. Perhaps the most important one is the fact that the Russian economy is strongly dependent on fossil fuels for exports earnings and cheap energy that they provide to the domestic economy. Decarbonization policies that lead to significant reductions in demand for fossil fuels will have strong negative impacts on the Russian economy. Second, since Russia generally has a cold climate most of its population probably would not mind some increase in temperature. Higher temperatures are also likely to increase land available for agriculture and increase agricultural yields at least in the medium-term perspective because higher CO_2 level increases crop yields and growth through an increase in the photosynthetic rate. Finally, Russia's energy consumption and GHG emissions dropped precipitously during the transition to a market economy in 1990s. Therefore, any earlier targets aimed at reducing emissions and using as a base period the year of 1990 was far from binding for Russia.

The situation has changed recently. President Vladimir Putin now seems to be convinced that global warming is real and it will create numerous risks for Russia. In November 2020, he signed decree #666 that set up a goal of reducing GHG emissions in Russia to 70% of 1990 level by 2030. In June 2021, the Russian Parliament adopted a law on limiting greenhouse gas emissions (despite its name the law does not limit emissions and mainly introduces a requirement for large emitters to provide reports on their greenhouse emissions). Russia's Federal Government also adopted 'The Low Carbon Strategy for Socio-Economic Development till 2050' in November 2021. The proposed EU Carbon Border Adjustment Mechanism was also important in bringing climate change issues on business and public policy agenda because Russia is likely to be the most affected country by this new EU tax.

At the regional level, there has been not much interest to the problem of climate change. Official documents of Kaliningrad's Regional Government barely mention the climate change or greenhouse gases. For example, state regional program "*Environment*" («Окружающая среда») adopted in January 2014 does not contain anything on climate change. The regional law on the environmental policy mentions only research on adaption to climate change but has nothing on mitigation.

However, the regional authorities tend to quickly catch up with new trends emanating from the federal center. For example, recently Kaliningrad's regional government expressed interest in joining the first regional experiment in Russia on carbon emission trading planned for large emitters on the Sakhalin Island. Largest exporter in Kaliningrad, agricultural group Sodruzhestvo, is supporting this initiative because it might facilitate its exports to the EU. The company said that some of its buyers in Europe are already asking for the calculation of the carbon footprint for its products (Khlebnikov, 2021). It can be expected that soon some official policy documents on climate issues might appear from the Kaliningrad's regional government as well.

It is worth to mention two climate-related projects that are currently being implemented in Kaliningrad. In 2021, Kaliningrad was chosen as one of seven regions to set up a carbon testing area. Such testing areas are intended for conducting research on the carbon cycle for different ecosystems. Kaliningrad' testing area was opened in November, 2021. It is going to specialize in the research on the carbon cycle at sea and on peatlands.

Kaliningrad also recently became a location for a large photovoltaic (PV) cell production plant with a capacity of 1GW per year, which is currently under construction. It is a project of Unigreen Energy, specializing in green energy investment. In January 2021, the company became a resident of Special Economic Zone in Kaliningrad, which provides some tax benefits for the project. Its planned investment in the project amounts to 15.4 billion Rubles (circa 185 million EUR), making it the largest green energy project in the province (Administration of the Special Economic Zone in Kaliningrad, 2021).

6. Conclusions

Kaliningrad's carbon emissions increased by 34% between 2000 and 2020, while in Russia they declined. The main reason behind such a substantial increase in emissions was more rapid economic growth in the province, especially in the first decade of this century. Increased economic activity required more energy resources, and they came mainly in the form of increased supplies of natural gas to Kaliningrad. Energy intensity of Kaliningrad's economy declined over this period but it was not enough to stop growth in emissions. This tells us that the green growth aspirations of decoupling economic growth and natural resource consumption (in particular, fossil fuels) have so far remained unmet.

In the past few years, climate change has become one of the top policy issues for Russia's federal authorities. This should translate into more attention to constraining carbon and other greenhouse gas emissions. What options exist for Kaliningrad to reduce its carbon emissions?

Recent and very substantial investments in power generation mean that the power supply system in the province is essentially fixed for at least a decade and not much can be changed there. Therefore, policy actions should focus on other sectors of the economy. One of them is the heating sector. It is very large in terms of energy consumption and mostly under control of municipal authorities. One option would be an increased use of biomass including from waste as a fuel for heat production. This would also help with waste management problems, which are currently one of the top priorities for federal and regional policymakers. Renovating or closing down old and inefficient old boilers could help to improve efficiency and reduce fuel use. Reducing losses in the heating distribution system is another area where more progress can be made.

Much more attention should be paid to energy efficiency. In general, it is considered as one of the most cost-efficient ways of reducing energy consumption and carbon emissions. However, regional authorities do not show much interest in this area. Federal Ministry of Economic Development noted that Kaliningrad was one of ten regions where there was no regional financing of energy efficiency initiatives in 2018-2019 (Ministry of Economic Development, 2020, 16). Dusting off 2010 Regional program for energy efficiency, which contains many useful measures but now seems forgotten, would be a substantial first step.

Kaliningrad's exclave location makes it a natural place for experimenting with new policies for reducing greenhouse gas (GHG) emissions. Kaliningrad regional authorities already indicated their desire to join the Sakhalin experiment on CO_2 emissions trading. This would be very useful for testing various forms of market design, measuring, reporting and verification requirements suitable for the Russian practices and legislation. Such experience can be used to design all-Russian emission trading scheme, which is likely to become a reality at some point.

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Annex: Data sources

Getting a reliable picture of energy trends at a regional level in Russia is not an easy task. Official statistics does not provide a comprehensive set of data in this respect and does not publish energy balances. Data that exists often contradicts each other. There is no data on regional greenhouse gas emissions.

To deal with these problems it is necessary to use various data sources, cross-verify them, and impute missing or contradictory data. This annex describes the data sources that I used in the paper, their reliability and estimates made in the case of missing or unreliable data.

There are three main data sources for collecting data related to energy in Kaliningrad:

1. Russian official statistics agency – Rosstat – and its regional branch – Kaliningradstat.
2. Kaliningrad regional government (it collects data from regional and municipal companies).
3. Large energy companies, e.g. Gazprom, Inter-RAO, Lukoil, etc.
4. Specialized agencies / data providers.

More specifically, I used the following studies and documents in this paper:

1. COWI (2007) Kaliningrad Fuel and Energy Balance, Draft Report, (study conducted by the EU-funded project EuropeAid/120746/C/SV/RU), http://www.cenef.ru/file/Kaliningrad%20Energy%20Balance%20(eng).pdf (Accessed 10 December 2021). This is a very comprehensive study, which discusses the data sources and methodology for compiling energy balances. It also develops Kaliningrad energy balance for 2005 and provides additional information on various energy sources and fuels in Kaliningrad for the period of 2000-2005. The main data sources in this report come from Kaliningradstat and regional government. I used data from this report for 2000-2005 in the current study. The major adjustments were made only for oil products (as described later).

2. Kaliningrad Regional Government Decree #882 dated November 24, 2010 "On Kaliningrad Regional Program for Energy Savings and Increase in Energy Efficiency for 2010-2015 and Prospect till 2020" (in Russian: "О региональной Программе в области энергосбережения и повышения энергетической эффективности Калининградской области на 2010-2015 годы с перспективой до 2020 года"). This program, among other useful information, contains an energy balance for Kaliningrad for 2008.

3. In recent years Kaliningrad regional government publishes *Plan and Program for Future Development of Kaliningrad's Electricity Sector* on an annual basis. The latest one was approved in May 2021 and is intended for the period of 2022-2026. (In Russian: Распоряжение Губернатора Калининградской области от 28.05.2021 №19-р "О схеме и программе перспективного развития электроэнергетики Калининградской области на 2022-2026 годы и признании утратившими силу отдельных решений Губернатора Калининградской области"). As its name suggests this document mainly deals with the power sector but it also contains detailed information on the heat sector in the province and provides retrospective energy balances for the last few years. Unfortunately, the quality of data in these balances leaves much to be desired. This in particular concerns data on coal and refined oil products. Figures for the consumption of these fuels can differ by a factor of two or even three for two consecutive years without any explanation. The similar magnitude of variation exists in various editions of this document for consumption numbers in the same year.

Below I describe data sources I used, as well as my estimates and calculations.

1. Data on crude oil and associated gas production in the province up to 2013 was provided by Kaliningradstat. After that it stopped publishing these numbers to protect specific company information because Lukoil is the only oil producer in Kaliningrad. However, Lukoil sometimes itself announces its annual production figures. For other years data can be easily estimated using the industrial production index for the extractive industries published by Kaliningradstat.

2. Data on electricity generation and consumption provided by Rosstat is reliable, consistent and

verifiable. In recent years Inter-RAO, a large power generating company responsible for 99% of power generation in Kaliningrad, publishes data on fuel consumption for each of its power plant. Older data on fuel consumption for generation of electricity also exists and can be judged as relatively reliable.

3. Data on heat production is provided by Kaliningradstat. Data on the consumption of fuels for generating heat is provided by the regional government.

4. Data on natural gas supply and consumption. Natural gas is supplied to the province by Gazprom using the same pipeline that supplies gas to Belarus and Lithuania. There are some relatively small differences in figures from various sources. However, they can be cross-verified (including data from Gazprom) and a resulting error unlikely to be more than 1%.

5. Data on coal supply and consumption is less reliable. Most of coal has been used for heat production and such data can be judged as more or less reliable. Data for final consumption of coal is less reliable but such consumption is small and does not have a material impact on overall figures. Consumption of coal has been declining over the last two decades because of switching from coal to natural gas.

6. Data on the consumption of refined oil products presents the main challenge. The main reason for this is a decentralized nature of their supply and consumption. Data from official statistics seems to underestimate their consumption in the region. Data from the regional government shows huge variation even for the same year. I used a starting point data on the consumption of oil products from the energy balance for 2008 from the Energy Efficiency Program. It seems the most reliable and provides a breakdown for the final consumption by a sector. I also used data on oil product consumption for Russia as a whole from the latest edition of BP Statistical Review of World Energy. Calculations of oil product consumption on a per capita basis suggest that in 2008 per capita consumption in Kaliningrad was 80% of the Russia's average. Given large uncertainty in various sources, I calculated Kaliningrad's overall consumption for the studied period by multiplying 80% of the Russia's per capita consumption for a particular year by Kaliningrad's population in the same year. The resulting estimate obviously follows the overall Russia's trend in oil product consumption. The accuracy of the resulting is admittedly low (my estimate is ±10%). More accurate estimates of oil product consumption is one of the main areas for improving data of carbon emissions in Kaliningrad.

7. Energy related emissions of CO_2 have been calculated using the default emissions factors for combustion of various energy carriers as given by the IPCC in its Guidelines for National Greenhouse Gas Inventories (2006). These default factors were multiplied by the consumption of the corresponding energy carriers in Kaliningrad. The same methodology is used by the BP Statistical Review of World Energy 2021. Because I used data on energy consumption and carbon emissions for benchmark countries from the same source, it should be comparable to Kaliningrad's data.

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