Russian pledge vs. business-as-usual: Implementing energy efficiency policies can curb carbon emissions

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61

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Aleksandra Novikova
Central European University

Anna Korppoo
Finnish Institute of International Affairs

Maria Sharmina
University of Manchester

RUSSIAN PLEDGE VS. BUSINESS-AS-USUAL

IMPLEMENTING ENERGY EFFICIENCY POLICIES CAN CURB CARBON EMISSIONS

ULKOPOLIITTINEN INSTITUUTTI
UTRIKESPOLITISKA INSTITUTET
THE FINNISH INSTITUTE OF INTERNATIONAL AFFAIRS

The Finnish Institute of International Affairs
Kruunuvuorenkatu 4
FI-00160 Helsinki
tel. +358 20 611 1700
fax. +358 20 611 1799
http://www.upi-fiia.fi/

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In June 2009, President Medvedev announced that the Russian Federation could limit its greenhouse gas (GHG) emissions growth to -10 to -15% by 2020, compared to 1990 levels. In August 2009, this commitment was confirmed by the Russian delegation as Russia's mid-term target. Russia further committed to limiting emissions by 22-25% in comparison to the 1990 level by 2020 in the EU-Russia Summit in Stockholm in November.

In 2007, Russian GHG emissions were 34% below its emissions in the Kyoto base year, 1990. As a result, both Russian pledges allow generous headroom for emission growth. Medvedev's original pledge would have translated as a roughly 30-35% emissions growth from the 2007 level by 2020, while the current offer corresponds to a 14-18% increase of emissions during the same period.
Further, the global economic downturn, which took hold during the second half of 2008, has continued to decrease Russian economic activity in 2009. The Russian GDP development has been negative in 2009; according to the Bank of Finland Institute for Economies in Transition, during January-September the Russian GDP had declined by 10.4%.[1] Furthermore, Russian industrial production fell 14% in January-August 2009, in comparison to the corresponding period in 2008.[2] This indicates that Russian GHG emissions have most likely declined since 2008; although verified data is not yet available, Russian experts have estimated that Russian emissions may have fallen to some 40% below 1990 levels during 2009.

This paper explores possible future trends of GHG emissions of Russia which are helpful for formulating a future mitigation commitment of the country. For this, the paper provides a rough forecast of national CO_2 emissions associated with fuel combustion in 2010 - 2020. The main argument of the paper is that the Russian business-as-usual energy policies can deliver the current Russian pledge in the Copenhagen negotiations.

The paper is structured in five chapters. The first section describes the overall national situation and the key national energy policies which are likely to affect the future GHG emission trends of the country. The second section details the modeling method, assumptions used, and scenarios investigated. The third section describes the modeling results and their implications for setting the Russian emission reduction target whereas the fourth section compares the findings to those of other research groups. The fifth section highlights research limitations and uncertainties.

1 RUSSIAN ENERGY POLICIES RELEVANT TO GHG EMISSIONS

This chapter outlines Russian energy policies which are likely to have an impact on the Russian emissions, and the prospects of their implementation including energy intensity and efficiency, and potential changes of the energy balance due to various policies.

1.1 Energy Intensity and Efficiency

The level of Russian energy intensity has fallen by 40% during 1996-2006 reaching about 20% improvement in real terms in comparison to the 1990 level. This happened due to the changes of the Russian economy rather than any specific policies and measures.[3] First, energy

[1] http://www.bof.fi/bofit/seuranta/venajatilastot/. Accessed 15 November 2009.
[2] "Russian Economy: Trends and Transitions", Institute of the Economy in Transition, September 2009.
[3] Tulinov, Sergey, Presentation by the Russian Federation on Mitigation Potentials, 3 December 2008, Poznan. Kulagin, Vyacheslav, "Energy Efficiency and Development of Renewables: Russia's Approach", *Russian Analytical Digest*, vol. 46/08, 25 September 2008. Korppoo, Anna; Jakobson, Linda; Urpelainen, Johannes; Vihma, Antto and Luta, Alex (2009). Towards a new climate regime? Views of China, India, Japan, Russia and the United States on the road to Copenhagen. FIIA report 19, the Finnish Institute of International Affairs. Pp. 90-92.

intensity of the economy peaked in the late 1990s as a result of the economic transition. Energy prices were too low to incentivize energy saving by rationalising industrial production together with the still prevailing resource-ignorant Soviet practices; for instance reduced output did not lead to running some production lines on full capacity while shutting some down. Rather, all the production lines remained in operation on low capacity for social welfare and technical reasons, which was very energy intensive.[4] When the economy started recovering, energy intensity improved due to the increase of this capacity utilization rate. Second, modernising the economy by closing down some of the Soviet production capacity, which was no longer useful, happened without government incentives. At the same time, only insignificant amounts were invested in modernisation of industrial capacity in the 1990s.

Hence, there is still a vast low-cost potential to improve the energy efficiency of the Russian economy. The 'until 2020' Energy Strategy estimated that Russia's has a potential to save some 39-47% of its current energy consumption.[5] Bashmakov *et al*. (2008) have estimated the technical energy efficiency potential to be 282 – 293 mtoe or 43-45% of the 2005 primary energy consumption.[6]

The new energy efficiency legislation approved by President Medvedev 23 November 2009 is aimed at fulfilling the official target to further improve energy intensity of the GDP by 40% during 2007-2020. His rationale behind this policy is linked to economic development in two ways. First, a more energy efficient economy would be more competitive internationally, and thus, more likely to support the goals to diversify the Russian economy beyond exporting natural resources. As President Medvedev stated in his famous September 2009 article *Go, Russia*: *'We sell things that we have not produced, raw materials or imported goods. Finished products produced in Russia are largely plagued by their extremely low competitiveness.'*[7] Second, the less oil and gas the Russian economy consumes, the more it can export.

The law envisages various concrete economic incentives to realize this potential. It introduces restrictions on the sale of incandescent light bulbs, sets requirements for labelling electrical equipment based on their energy efficiency, and establishes mandatory commercial inventories of energy resources, new buildings' energy efficiency, and reductions in budget spending on purchasing energy resources. The new law also introduces energy audits for the most energy-intensive organisations and sets out a basis for transition to long-term tariff regulation as well as the establishment of a common inter-ministerial energy efficiency information and analysis system.[8]

It is difficult to judge what the impact of this legislation to the Russian emissions will be due to the uncertainty of the success of its implementation, though the impact is likely to be significant even if not fully implemented.[9] The 'autonomous' improvement of energy efficiency (AEEI) by some 1% p.a.[10] ensures that part of the goal will be achieved even in the absence of additional domestic policies and measures. Therefore, a rough calculation shows

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[4] IEA (2002). Russia Energy Survey 2002, p. 234.

[5] Kulagin, Vyacheslav, "Energy Efficiency and Development of Renewables: Russia's Approach", *Russian Analytical Digest*, vol. 46/08, 25 September 2008.

[6] Bashmakov, I., K. Borisov, M. Dzedzichek, I. Gritsevich, and A. Lunin. 2008. Resource of energy efficiency in Russia - scale, costs and benefits. Report by CENEF for the World Bank. (p. 99). .

[7] Medvedev, Dmitry (2009). Go, Russia! Gazeta.ru, 10 September 2009.

[8] Dmitry Medvedev signed a law on energy saving and energy efficiency, the President of Russia website, 23 November 2009. Available at http://eng.kremlin.ru/text/news/2009/11/222959.shtml. Accessed 25 November 2009.

[9] New Russian energy law leaves CO2 cuts uncertain, PointCarbon 13 November 2009.

[10] This level of the AEEI is extensively discussed, for instance, in the Third Assessment Report of the Intergovernmental Panel on Climate Change.

that the 40% energy intensity improvement goal set by President Medvedev only actually requires an additional improvement of energy intensity by some 28% beyond the natural progress of efficiency. Further, the policy requires an additional improvement only by 17%, if the past-year rate of efficiency improvement (some 4% p.a. as demonstrated by the 1996-2006 improvement pace) gradually declines to reach the AEEI rate in 2020 in the absence of new policies and measures over the next decade. This study illustrates two alternative paths of implementation of the current energy efficiency policy.

1.2 Changes in fuel mix

During 1990-2006, the Russian energy balance (Figure 1) has very clearly moved towards the less carbon-intensive natural gas and away from oil and coal. Also the nominal share of nuclear has increased due to the reduction of the total.

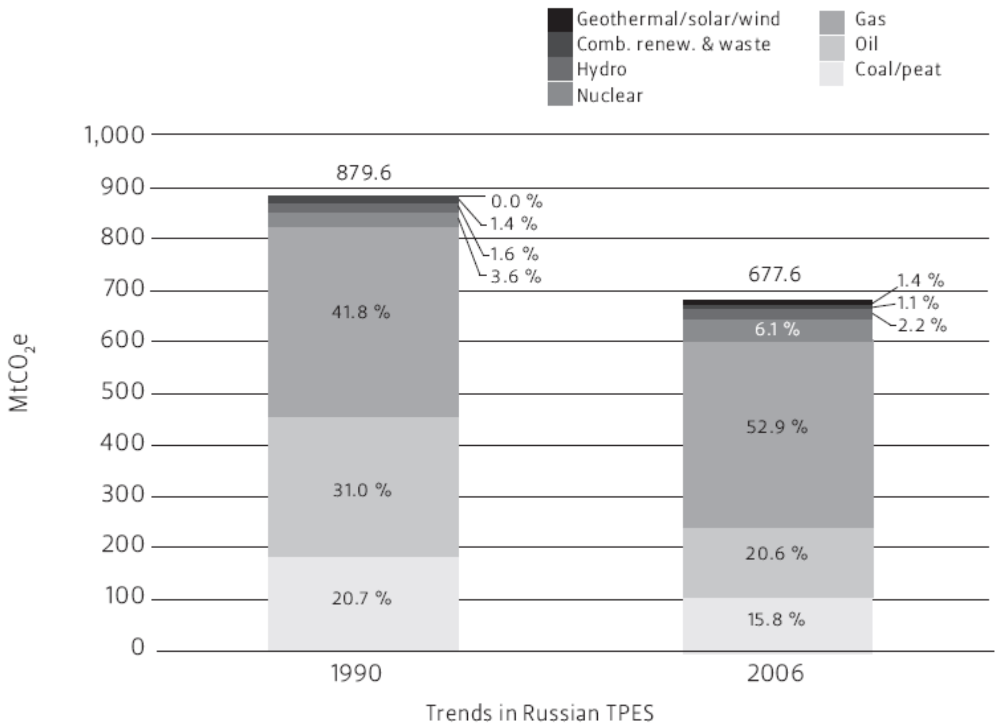

Figure 1 Comparison of the Russian total primary energy supply in 1990 and 2006
Source: IEA Energy Balances of Non-OECD Countries, 2008 Edition; Korppoo *et al.* (2009).
NOTE: Excludes electricity trade.

The Energy Strategy until 2020 outlined a progressive shift from gas to coal in order to save gas for exports, and called for 75% increase in coal production during 2000-2020.[11] This dynamic could have a dramatic impact on Russian emissions for two main reasons: first because coal is significantly more carbon intensive than gas, and second, due to the lower efficiency of the coal combustion capacity in Russia compared to the more modern gas combustion equipment. However, it is not straight-forward to implement this ‘call-for-coal’ to reverse the ‘dash-for-gas’. The IEA has doubted the realism of the policy based on the competitiveness of coal against gas and oil, the ability of the sector to attract private

[11] IEA (2002). Russia Energy Survey 2002. OECD/IEA, p. 149.

investment as well as technological and geographical challenges.[12] Both the lack of investments and the underdevelopment of the Eastern Siberian and Far Eastern energy infrastructure were also listed as problems in the most recent Energy Strategy until 2030.[13] Indeed, during 2000-2008, the share of coal in the Russian fuel balance actually dropped from 16.2% to15.7%.[14] As shown in Table 1, the originally advocated increase in the share of coal products, as well as the cut in the share of gas, by 2020 was somewhat downgraded in the current Energy Strategy until 2030 in comparison to the previous strategy.

Table 1 Comparison of the 2008 fuel balance to the projections of Russian Energy Strategies

	Data	Projection ES-2020	Projection ES-2030	
	2008	*2020*	*ca. 2020§*	*2030*
Gas	53%	45-46%	50-51%	45-48%
Oil products	19%	22-23%	20-21%	22-23%
Coal and coal products	18%	20%	17-19%	18-19%
*Other**	10%	12%	11-12%	12-14%

Sources: Energy Strategy of Russia until 2020, May 2003, p.31. Energy Strategy of Russian until 2030, November 2009, Annex 4.
* Nuclear, hydro and renewables
§ '2nd phase' – timing not defined exactly

The Russian government is eager to sustain the activities of the Russian nuclear power industry, both in terms of domestic and export activities. To ensure this, the nuclear industry has been kept under state control, and is governed by state strategies and funding. However, there is a plan to make the main actor of the nuclear sector, Energoatom, self-sufficient of funding based on its export activities. According to the federal nuclear programme for 2007-2015, the share of nuclear of the total electricity generation should increase from 15.7% to 18.6%.[15] As also shown in Table 1, in the latest Energy Strategy the share of nuclear combined with hydro and renewable electricity is projected to grow only from 10% in 2008 to some 12-14% by 2030 of the total fuel balance. This already includes the policy of increasing the share of renewables. In addition, state budget from which the nuclear sector is funded may experience difficulties due to the current economic crisis. Hence, it seems that the development of the nuclear sector would succeed in replacing the old capacity to be decommissioned within the next decades. As a result, in this study, the share of nuclear power is expected to remain more or less unchanged.

Another recent piece of legislation promotes increasing the share of renewable energies in Russian electricity generation from less than 1% to 4.5% by 2020, excluding large-scale hydro power[16]. As shown in Table 2, Russia's estimated economic potential[17] in renewable

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[12] IEA (2002). Russia Energy Survey 2002. OECD/IEA, p. 162.
[13] Energy Strategy of Russia until 2030. Order 1715-p, approved by the Russian government 13 November 2009, p. 55.
[14] The Institute for Energy Strategy, Основные статьи расчетного топливно-энергетического баланса России, 2000-2008 гг.. Available at http://www.energystrategy.ru/stat_analit/TEB(2000-2008).doc. Accessed 2 December 2009.
[15] Federal Programme 'Development of Nuclear Energy Sector in Russia 2007-2010 with prospects until 2015, #605, approved by the Russian Government 6 October 2006
[16] Guidelines for State Policy of Energy Efficiency Increase through Use of Renewables for the Period up to 2020.

energy[18] lies at 30% of its total primary energy supply[19]. In 2006, only 4.7 % of TPES was derived from renewables and waste, 2.2% of it hydro[20]. The Russian Energy Strategy includes a section on renewable energy, however, it does not establish any concrete measures to promote them. In addition, peat, which is as carbon-intensive fuel as coal, is included in the category of renewables; depending on the share of peat, this may reduce the beneficial effect of this policy on the Russian emission trends.[21] This study also illustrates the impact of the announced renewables policy if fully implemented even though it is difficult to judge whether this will actually be the case.

Table 2 Economic potentials of the main renewable energy technologies[22] (mtce)

Small hydro[23]	Geothermal	Biomass	Wind	Solar	Low heat
65,2	115	35	10	12,5	36

Source: IEA[24]

2 RESEARCH METHODOLOGY

The scenario analysis is conducted from two perspectives. First, minimum and maximum boundary trends of national CO_2 emissions are estimated. Then, scenarios of CO_2 emissions are developed for different cases of GDP energy intensity and fuel mix. Before the method for finding boundaries and building scenarios is described, the section below provides some key assumptions important to take into account before the main discussion.

2.1 Assumptions

2.1.1 Limitation of CO_2 emissions from fuel combustion

Only CO_2 emissions associated with fuel combustion are studied in the paper. According to the UNFCCC (2008)[25] in 2006, CO_2 emissions contributed ca 77% to the total national GHG emissions; CO_2 emissions associated with fuel combustion represented ca 88% of the total CO_2.

Order 1-R, 9 January 2009.

[17] Economically viable segment from the technologically feasible part (technical potential) out of the total existing potential (gross potential).

[18] Estimated in 1993.

[19] As measured in 2001.

[20] Idem.

[21] Energy Strategy of Russia until 2030. Order 1715-p, approved by the Russian government 13 November 2009, p. 74-6.

[22] According to Russian categorization, which are more stringent than the IEA definition in the case of small hydro power, and less stringent than the IEA definition in the case of low potential heat power.

[23] Russian definition: capacity of 30 MW or less. (IEA: 10 MW or less.)

[24] IEA, *Renewables in Russia. From Opportunity to Reality*, available at: http://www.iea.org/textbase/nppdf/free/2000/renewrus_2003.pdf

[25] United Nations Framework Convention on Climate Change (UNFCCC). 2008. Inventory 2006. Submission 2008. Russian Federation.

2.1.2 Activity indicators

Modelling the boundaries relies on a sectoral approach. The following sectoral activity indicators are used for modelling sectoral energy consumption and associated emissions:

- Value-added for the industry and the transportation,
- Floor area for the residential sector,
- Demand for energy (electricity, heat and petroleum products) for the transformation sector.

Assumptions behind the value-added forecast are described in the next section. A sectoral activity indicator for the residential sector – the floor area – is estimated through a linear regression (see Annex 1) based on the 2000-2006 data[26]. The national demand for energy is calculated as a sum of the demand for electricity, heat, and petroleum (each demand is estimated through electrical, heat, and petroleum sectoral intensities of energy-using sectors and activity indicators of these sectors; additionally, the self-consumption of the transformation sector is estimated and added).

2.1.3 GDP forecasts

This paper applies two cases of GDP growth based on different assumptions.

In case 1, the value added is projected to 2020 using its previous records[12] (in national currency, in constant 2005 prices) and the GDP growth rates. The GDP growth rates to 2014 are those forecasted by International Monetary Fund[27] as of October 2009; beyond 2015, these rates are estimated as the previous year rate plus a 2% GDP increase per each incremental US$10 in the oil price (based on Ollus 2007[28]). The historical Urals prices in a base year are taken from the Energy Information Administration and projected until 2020 with the annual growth rate of 2%[29]. The resulting GDP growth rates are presented in Table 2.

In case 2, a GDP growth is limited to ca 4% based on its 2013 WEO forecasted value (Table 3). This case does not assume a linkage to oil prices as a contrary to the main case. The case follows an opinion that taking into account the current investment level and capital funds turnover, the Russian economy does not have a capacity for higher GDP growth rates in the long-term as argued also by others[30].

Table 3 GDP growth rates, 2009-2020

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Case 1	-7.6%	1.5%	3.0%	3.7%	4.2%	5.0%	5.3%	5.5%	5.8%	6.0%	6.3%	6.6%
Case 2	-7.6%	1.5%	3.0%	3.7%	4.2%	4.2%	4.2%	4.2%	4.2%	4.2%	4.2%	4.2%

Source: Calculations based on International Monetary Fund (2009), Ollus (2007) and EIA DOE (2009).

[26] Federal Service of National Statistics (GOSKOMSTAT). 2007. Russian Annual Statistic Book.

[27] International Monetary Fund, World Economic Outlook (WEO) Update, October 2009. Global Economic Slump Challenges.

[28] Ollus, Simon-Erik, "Natural resources – a blessing or a curse?", in *New conditions of growth in Russia*, by Seija Lainela, Simon-Erik Ollus, Jouko Rautava, Heli Simola, Pekka Sutela and Merja Tekoniemi. BOFIT Online: 2007 No. 7.

[29] Energy Information Administration, Department of Energy of the US Government (EIA DOE). 2009. Short term energy outlook 2009.

[30] BOFIT Russia Desk. BOFIT Russia Forecast for Russia 2009-2011, 29 September 2009. The Bank of Finland. P. 3.

2.2 CO_2 emission boundary scenarios

The aim of the section is to define the boundary scenarios of CO_2 emissions of Russia that could be useful in formulating the long-term aim to achieve. To find such storylines, two cases were viewed. For the minimum boundary, it was assumed that the whole amount of the potential for energy efficiency improvement known today is realized by 2020. For the maximum boundary, "frozen" energy-efficiency of the national GDP is assumed in 2009-2020. Further, the main calculation procedures are detailed.

2.2.1 Minimum storyline

To start, energy demand of the energy-using sectors and the energy transformation sector is assessed based on the balances prepared by the International Energy Agency[31]. Sectoral intensities of using fuels, electricity, heat, and petroleum were calculated for the 2005 base year. As Section 2.1.2 describes, sectoral intensity for the industry, services, and transportation is calculated as energy used per value added unit; for the residential sector the intensity is energy used for a square meter. For the transformation sector, fuel intensities to produce electricity, heat and petroleum for energy-using sectors and self-consumption are estimated.

The potential for efficiency improvement by sector and by fuel/energy type was applied to the 2005 energy intensities. The technical potential[32] for efficiency improvement[33] is taken from the most comprehensive research on this subject for Russia up to date, Bashmakov et al. 2009[34]. It was assumed that the minimum intensities found in this way can be achieved throughout the whole economy by 2020. Intensities in 2006–2019 were interpolated between 2005 and 2020 levels.

Then, the demand for energy is estimated to 2020 based on the activity indicators (see section 2.1.2) and the intensity indicators described above. The energy demand afterwards is translated into emissions through emission factors of fuels taken from the latest Russian Federation emission inventory[35].

2.2.2 Maximum storyline

The maximum storyline describes the case of the efficiency of GDP not changing since 2007. To find the energy demand, the constant GDP intensity was multiplied by the GDP forecast, the results were translated to emissions using the emission factors of fuels.

2.3 Scenarios linked to energy intensity improvement and fuel mix change

The aim of this section is to describe the scenarios modeled for cases of different energy efficiency improvements and fuel mix changes. Such scenarios combined with the results of the previous section give an understanding of the level of ambitions of the country's mitigation commitments.

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31 International Energy Agency (IEA). Energy balances of non-OECD countries. Online database.

32 The technical (technological) potential estimates from the source were used. According to the authors, technological potential only provides hypothetical energy efficiency opportunities, with no account of implementation costs and limitations

33 No fuel substitution is available.

34 Bashmakov, I., K. Borisov, M. Dzedzichek, I. Gritsevich, and A. Lunin. 2008. Resource of energy efficiency in Russia - scale, costs and benefits. Report by CENEF for the World Bank. (Table 2.1 on p.14 and Table 9.4 on p. 100-101).

35 United Nations Framework Convention on Climate Change (UNFCCC). 2008. Inventory 2006. Submission 2008. Russian Federation.

2.3.1 *Scenarios for energy intensity*

According to the Concept of the Long-Term Social and Economic Development of Russia to 2020[36] (further: the Concept), the dynamics of the country's energy intensity in 2020 will be determined by a structural transformation of the economy and efficiency improvement as shown in Figure 2 below. For the paper, besides frozen-efficiency two types of intensity scenarios are developed using forecasts from the Concept - these are decreases of the energy intensity of the Russian economy to 77% and 59% of its 2007 level by 2020 according to *pessimistic* and *innovation* scenarios respectively. These intensity rates are applied to the GDP forecasted to 2020 as described in Annex I. The results of the energy demand forecast is translated to CO_2 emissions using different structures of fuel mix discussed below and CO_2 emission factors.

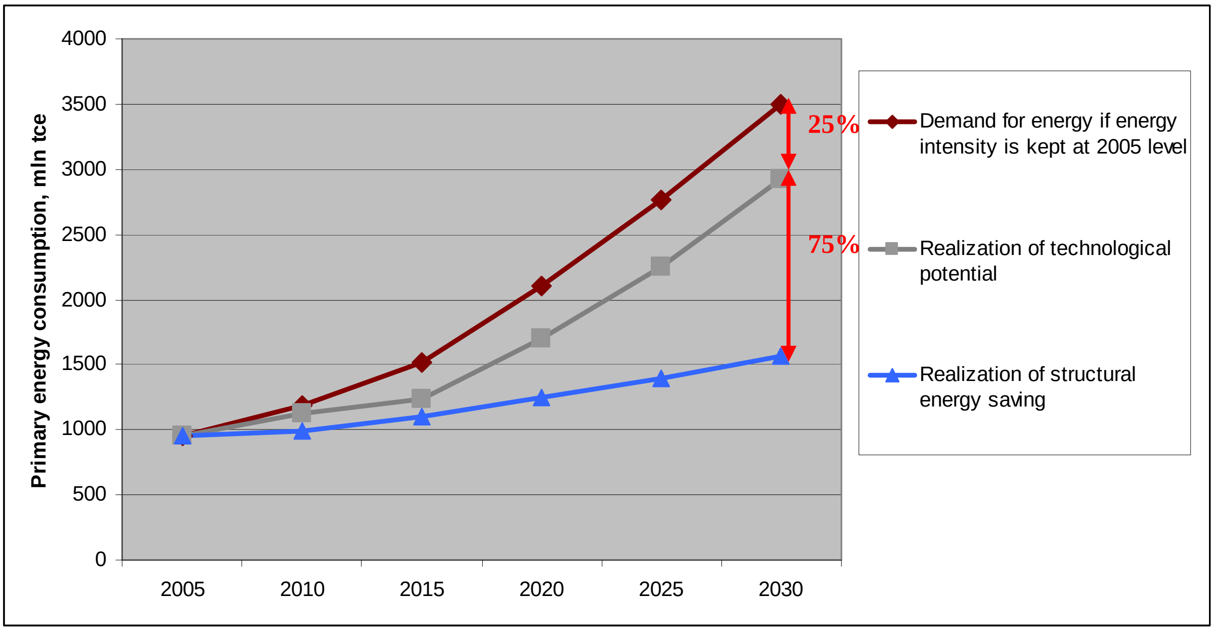

Figure 2 Assessment of energy demand and energy savings in Russia

Source: Institute of Energy Strategy, 2009.

2.3.2 *Scenarios for fuel mix*

The structure of fuel mix consumed by the country is either considered constant or is in accordance with the *positive* scenario of the Energy Strategy of the Russian Federation[37] (further: the Strategy). Both structures are provided in Table 4. Other cases considered a) the conservative scenario of the Strategy (a storyline approximately between the current balance and the positive scenario) and b) a growing coal's share according to the positive scenario otherwise constant parameters did not differ significantly from the positive scenario and therefore they are described here.

[36] Ministry of Economic Development and Trade of Russia (MERT). 2009. The Concept of the Long-Term Social and Economic Development of Russia to 2020.
[37] Ministry of Industry and Trade of the Russian Federation (MINPROMTORG). 2007. The Energy Strategy of Russian Federation to 2030, (project).

Table 4 Fuel mix structure in Russia, 2006 and 2020

Fuels	2006 balance	Positive scenario, 2020
Coal	17,2%	18,5%
Oil and refinery products	18,0%	17,2%
Natural gas	54,5%	47,1%
Nuclear and hydro energy	9,1%	10,5%
Other innovation sources	1,3%	6,6%

Sources: IEA (2009) and MINPROMTORG (2007).

In summary, scenarios are developed for two cases of the future energy intensity – 41% and 23% lower than its 2007 level – and two cases of fuel mix – a constant one and with renewables' share of 6.6% in 2020.

3 RESEARCH FINDINGS

3.1 Boundary cases

Figure 3 and 4 present the results of modelling boundary cases, namely the frozen-efficiency case and oppositely the case with fully realized efficiency potential. The real CO_2 emissions will take place somewhere between these boundary cases.

With the higher GDP growth assumption, a 'frozen-efficiency' case exceeds the 1990 level in 2017, while the lower economic development under the 'frozen-efficiency' case would only reach the 1990 level in 2019-2020. This demonstrates the importance of economic growth as a factor behind GHG emission trends.

Both Figures 3 and 4 attest that the potential for CO_2 emission reduction is very significant and represents more than a half of emissions corresponding to the frozen-efficiency case. Furthermore, the potential is likely to be even higher since some new mitigation technologies may appear during the next fifteen years.

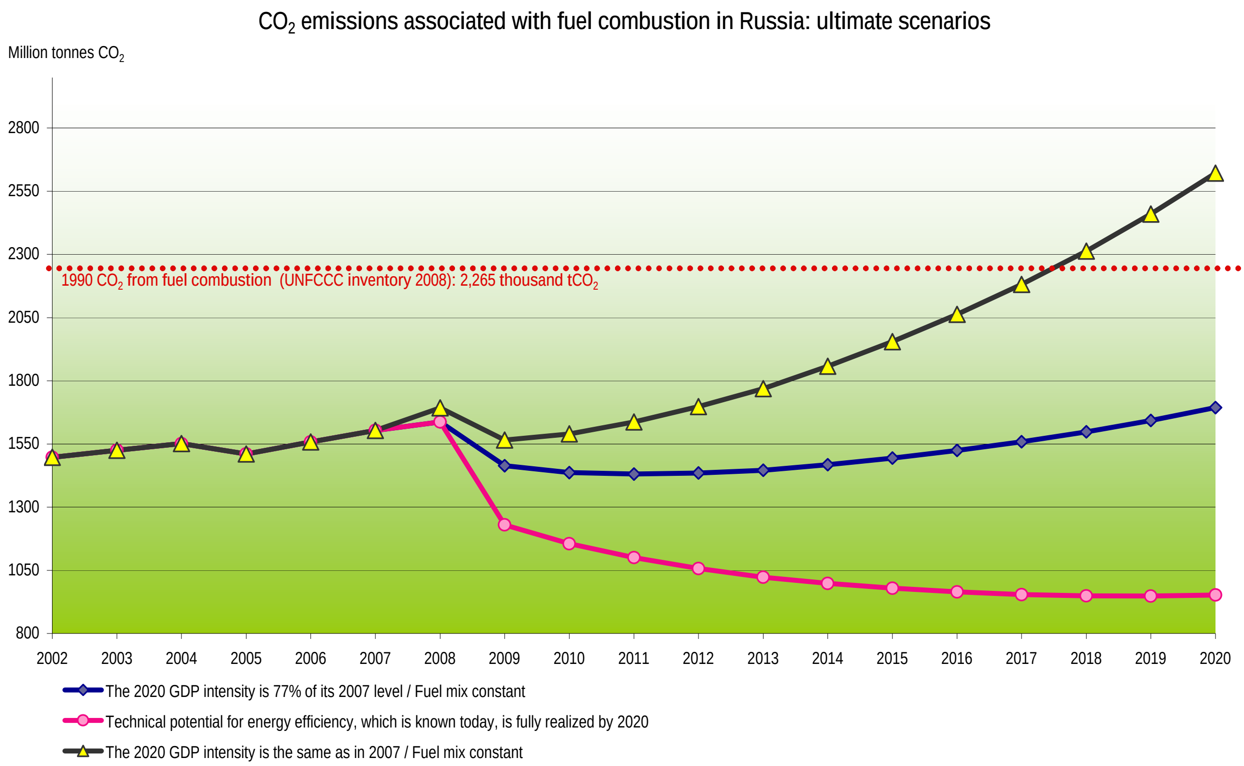

Figure 3 CO_2 emissions associated with fuel combustion in Russia in 2002 – 2020 (GDP growth is linked to oil price, steady increase up to 6.6% in 2020)

It is very interesting that the pessimistic scenario corresponds to a case when the rate of energy efficiency improvement changes during 2007 - 2020 from ca 4% to 1% per year (a blue line on Figures 3 and 4). The annual rate of 4% characterized energy efficiency improvement (AEEI) in Russia during 1990-2006[38] whereas 1% per year is so-called natural autonomous energy efficiency improvement happening due to natural market forces and development. As a result, due to inertia, in the absence of efficiency and mitigation policies, the real CO_2 emissions will likely to be close to this AEEI case and in a situation of any additional efforts the emissions are between this AEEI case (the 2020 ending point of this scenario is around 2008 emissions level) and the "potential-realized" case.

[38] Korppoo, Anna; Jakobson, Linda; Urpelainen, Johannes; Vihma, Antto and Luta, Alex (2009). Towards a new climate regime? Views of China, India, Japan, Russia and the United States on the road to Copenhagen. FIIA report 19, the Finnish Institute of International Affairs.

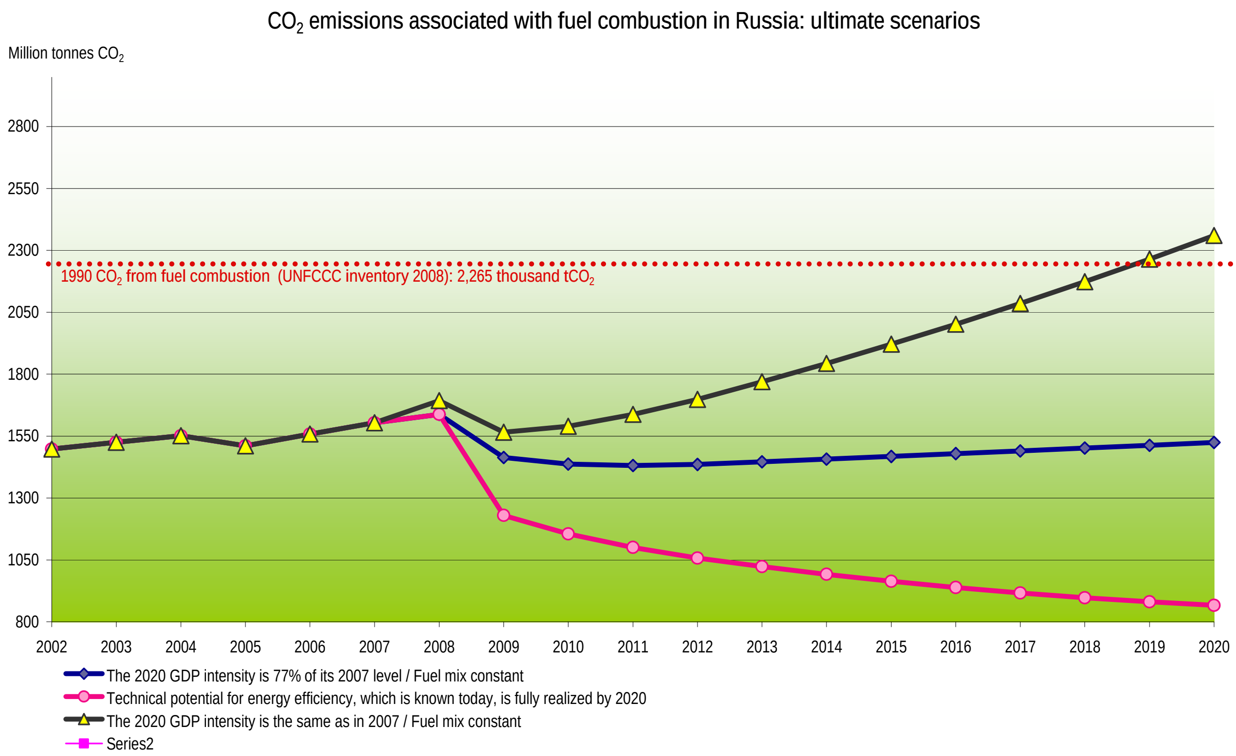

Figure 4 CO_2 emissions associated with fuel combustion in Russia in 2002 – 2020 (GDP growth is limited to ca 4%/yr.)

The ‘frozen-efficiency’ cases represent theoretical boundaries of emissions only. Indeed, the maximum storyline is unrealistic due to the ‘autonomous’ energy intensity improvement as well as sustaining economic growth without efficiency improvements is impossible on longer term, while, the minimum storyline is unrealistic because it would be very expensive to the Russian economy to pursue, and no incentives exist for such investments.

The conclusion is that with a high probability CO_2 emissions will be around the 2008 level or below in 2020. It is physically not possible that they exceed the 1990 level – as even the frozen-efficiency case exceeds this level by 2017. Furthermore, the potential of existing mature efficiency technologies may allow CO_2 emissions in 2020 being below 2008 level by half.

3.2 Scenarios for alternative efficiency and fuel mix cases

Based on the possible range of emission trends established in the previous section, this section discusses the scenarios for CO_2 emissions depending on different efficiency and fuel mix cases. Based on the conclusions of the previous section, these scenarios to 2020 are likely to be around or lower than the AEEI case and it is impossible for any of them to exceed the 1990 level.

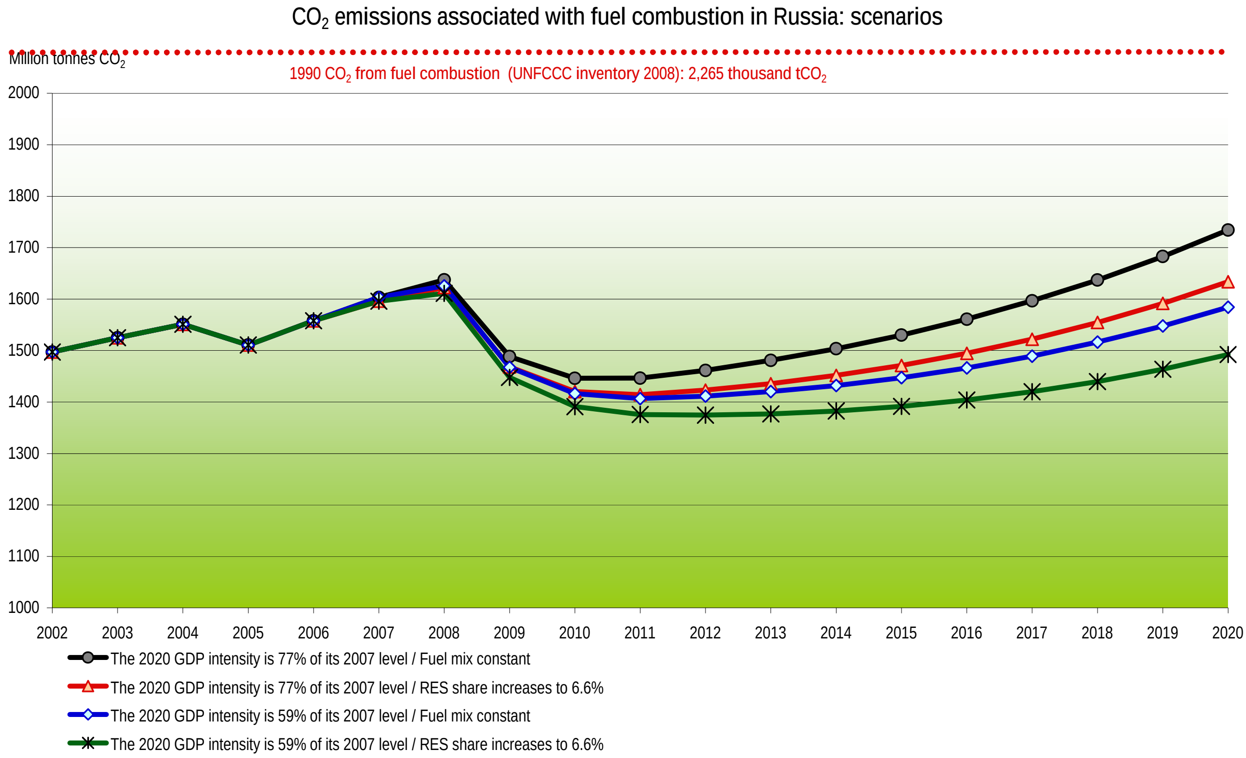

Figure 5 Scenarios of CO_2 emissions to 2020 for different efficiency and fuel mix cases (GDP growth is linked to oil price, steady increase up to 6.6% in 2020)

Regardless of the GDP growth assumption, all scenarios demonstrate a downswing in emissions in 2008-2013 related to the global economic crisis up to 12-18% of the 2008 level. Even though this effect is very significant, its significance depends on the extent of economic restructuring which remains unclear.

The case based on the higher economic growth assumption (Figure 5), demonstrates that the difference in 2020 between the pessimistic (close to the AEEI case) and the positive scenario with 41% efficiency improvement over 2007 level represents ca. 150 million tons of CO_2 (ca. 6.5% of 1990 emissions). The 41% efficiency improvement case is still significantly above the 'fully-realized' potential case, and therefore, is likely to be achieved with modest efforts. Further, this case shows that even the renewable energy commitment of 6.6% by 2020 generates an emission reduction of ca. 140 million tons of CO_2 by 2020 (ca. 6.1% of 1990 emissions).

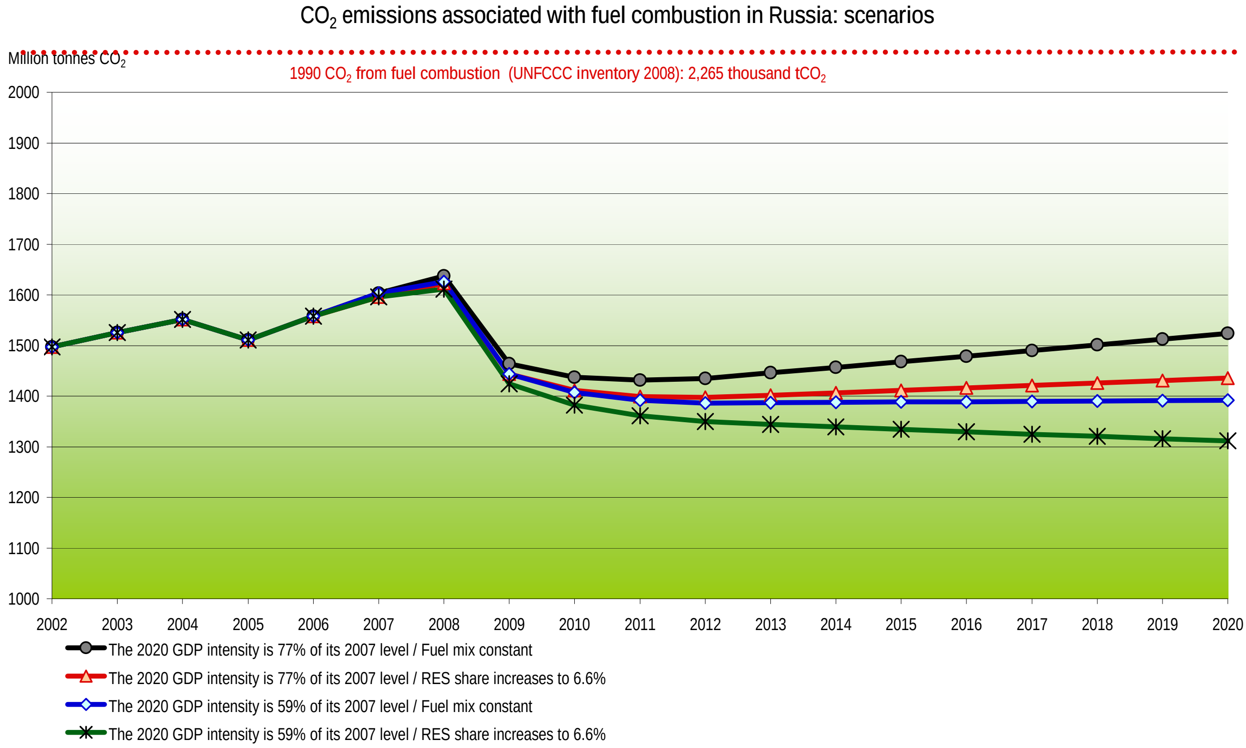

Figure 6 Scenarios of CO_2 emissions to 2020 for different efficiency and fuel mix cases (GDP growth is limited to ca 4%/yr.)

The case based on the more conservative assumption of GDP growth illustrates that even in the absence of efficiency and mitigation policies (the AEEI case) the 2020 emissions will be below the 2008 level by some 7–20% which translates into 33-37% below the 1990 emissions. The difference between the pessimistic and the positive scenario with 41% efficiency improvement over 2007 level results in ca. 130 million tons of CO_2 i.e. some 5.8% of the 1990 emissions. Further, in this case the renewable energy commitment of 6.6% by 2020 results in a reduction of ca 90 million tons of CO_2, or 5.5% of the 1990 emissions.

Furthermore, the model demonstrates that, with the current assumptions and Russian strategic plans, lower energy intensity of the economy plays a more important role in mitigation than a growing share of renewables in the fuel mix. However in the long run it is likely that, after the emission-reduction potential of decreasing energy intensity is exhausted, a “cleaner” fuel mix will keep driving the emissions further down. However, the inclusion of the carbon-intensive peat in the category of renewables may reduce such impact. At the same time, the model demonstrates the importance of the GDP growth as a factor defining emission growth: the more optimistic GDP growth assumption leads to a constantly growing emission trend, while the more conservative GDP development path generates a flat trend of emissions.

3.3 Implications for emission reduction targets

Under the more optimistic GDP growth assumption, ca. 25-30% limitation of 1990 level emissions by 2020 is likely to represent a business-as-usual scenario of energy sector emissions in terms of the already established energy efficiency and renewables policies assumed implemented. The less optimistic GDP growth assumption brings this number down to ca. 33-37%.

A 25% emission reduction in 2020 as compared to the 1990 is likely to represent the no-regret one under the more optimistic GDP growth assumption since it is can be achieved with the natural efficiency improvement of the economy without significant changes in fuel mix. The equivalent number for the less optimistic GDP growth assumption is 33%. Further, as shown by the technological potential illustrated in Figures 3 and 4, up to 60% of the 1990 level are available but with significant costs to the Russian economy.

4 COMPARISON TO FORECASTS OF OTHER RESEARCH GROUPS

This section compares the modeling work presented in this paper to other independent modeling work to establish how deep a pledge Moscow could adopt. Various Russian and foreign modeling scenarios arrive at a similar "no-lose" emission trend around 20-25% below 1990 levels by 2020.

Internationally, Russia has been studied alone or as a part of the Former Soviet Union in models with a global coverage including the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, World Energy Outlook of the International Energy Agency, Annual/Short-term Outlooks of the Energy Information Administration of the Department of Energy of the USA, and the IIASA.

Table 5 Comparison to the no-regret emission trends outlined by other studies

Source	No-regret emissions by 2020	Remarks
IEA: WEO	-23%*	
EIA	-19%*	World Energy Projections Plus 2009
IIASA	-23%/-27%	MERGE E3 model
CENEf	-10%/-20%*	ENERGYBAL-GEM 2050 model
HSE	-15% / -25%*§	TIMES model
This paper GDP high	-25%/ -30%*§	Scenario approach
This paper GDP low	-33%/ -37%*§	Scenario approach

Sources: IEA (2009), How the energy sector can deliver on a climate agreement in Copenhagen: Special early excerpt of the World Energy Outlook 2009 for the Bangkok UNFCCC Meeting; Energy Information Administration (2009), International Energy Outlook 2009; Digas et al. (2009), On Costs and Benefits of Russia's Participation in the Kyoto Protocol, IR-09-001, IIASA; Bashmakov (2009), Nizkouglerodnaya Rossija in 2050, Center for Energy Efficiency (CENEf).
§ economic crisis taken into account
* CO_2 emissions from fuel combustion only

Domestically, there are two main research groups, namely the Center for Energy Efficiency of Russia (CENEf) [39] and the Moscow Higher School of Economics (HSE). The former uses the ENERGY-GEM model to 2050 to investigate CO2 emissions only from the energy sector (all kinds of fossil fuel combustion), and produced a range of scenarios. The most likely 'no-regret' scenario, 'carbon plateau', foresees a reduction of emissions by 10-20% of 1990 level by 2020.[24]

The latter initially studied the power and heat sector emissions and concluded that CO_2 emissions in the sector will grow until 2020 in most ambitious scenarios, and will decrease in

[39] Bashmakov, I. Lowcarbon Russia: 2050. Cenef: Moscow.

after 2020. Even in the most optimistic cases of energy growth rate emissions will never reach 1990 level by 2020 in the sector. Further, the Russian Energy Strategy until 2030 projects GHG emissions from the energy sector to reach 1990 level (100-105% of 1990) only 2030, while they would remain approximately 10% below 1990 level in 2020.[40]

As shown in Table 5, a 20% reduction of emissions seems to be the average business as usual trend supported by most of the studies, while some are suggesting even deeper trends. Therefore, outcomes of the more optimistic GDP growth scenario is supported, depending on the study in comparison. However, most modeling work has not taken into account the recent economic crisis, and most of the models cover energy sector emissions only. This leads to higher emission estimates in comparison to total emissions since many of the non-energy sectors' emissions have declined in Russia. This may support the 33% no-regret emission trend presented by the lower GDP growth assumption scenario.

5 POTENTIAL LIMITATIONS AND APPLICATIONS OF THE WORK

The research is a subject to assumptions and limitations detailed in this section. Above all, the research is based on a spreadsheet model subject to the data available to the authors. The attempts to model economies which have a significant data deficiency are widely criticized nevertheless in our opinion, modelling is the only known tool to predict the future. Also, the authors would like to highlight the simplicity of the model which results in both advantages and disadvantages. On one hand, the model should be relatively simple and transparent to balance between its complexity and the time required to collect and estimate the input parameters and assemble them together into the model. On another hand, the disadvantage is that some important factors may be overlooked. At the same time, we rely on the opinion of experienced experts[41] that both simpler and more complex models may provide results with similar magnitude of errors especially if the background data are of poor quality. Therefore, the results of the research should be used and interpreted with caution, at the same time we believe that they provide the preliminary basis and attract attention to the likely happening emission trends. The next sections put focus on some specific assumptions and limitations.

5.1 Data limitation

A natural limitation of the work stems from either total absence of data or lack of consistent and reliable data. For example, in many instances, Russian statistical sources do not coincide, are unclear or contradict. For instance, it is not fully clear how the Renewable Law in Russia corresponds to the Energy Strategy scenarios. Also, in case the data are not available, extrapolation or interpolation is used. In addition, since more than one statistical source is used there might be certain discrepancies in the data they report due to differences in their methodological approaches.

5.2 The world 2009 crisis, oil price, GDP growth

The ongoing financial crisis not only inevitably shortens a planning horizon but also increases probability of estimate errors. Second, volatility of some input data such as oil prices also contributes to the uncertainties underlying within the model in the case of the higher GDP growth assumption. Furthermore, the model assumes that the rate of GDP growth is (almost) endogenous, i.e., it is influenced only by the dynamics of oil prices. In practice, the GDP growth is also determined by many other factors such as population dynamics, technological

[40] Energy Strategy of Russia until 2030. Order 1715-p, approved by the Russian government 13 November 2009.

[41] Koomey, J. Turning Numbers into Knowledge: Mastering the Art of Problem Solving. 2nd edition. Oakland, USA: Analytics Press.

changes, and capital flows. Finally, Russian government's policies are prone to changes and modifications that might render forecasting a difficult task.

5.3 No account of implementation costs

The work provides an expert opinion on the ambitions of emission reductions but it does not quantify the investment costs related to reducing emissions. That is, estimating the country's technological potential it does not give an explicit indication of its economic/market potential to reduce the economy's energy intensity and to switch to cleaner energy sources.

Despite these drawbacks, the work is valuable as one of the few attempts to support policy recommendations related to Russia's participation in potential climate change agreement. The results can help to substantiate climate- and energy-related policy decisions as well as be used for further research in this area.

6 CONCLUSION

In preparation for the Copenhagen climate negotiations, Russia has pledged close to its business-as-usual emission trend in order to secure headroom for the increased emissions intrinsic to economic growth; this is one of the main goals of Russian climate policy in the international fora.

GDP development is the most important factor driving emission trends in the case of Russia. Of the energy policies discussed in this paper, energy efficiency policies are expected to have the most significant impact on the emission trends, and it seems likely that some of the energy intensity improvement would take place due to the autonomous improvement trend even in the absence of additional policies. The impact of the changes in the fuel mix, especially renewable energy policies, seems less certain. Even though the share of coal will probably not increase dramatically, no practical policies to promote renewable energy sources are in sight. Further, the inclusion of peat under the category of renewables may alter the impact of renewables policy to emissions

The relevance of the Russian business-as-usual energy policies as mitigation policies depends on the success of their implementation. In the past, energy efficiency policies in particular have remained unimplemented for various reasons, such as low energy prices, lack of financial basis, lack of a clear division of responsibilities and legal complexities. Since the last efforts through legislation to improve energy efficiency in the 1990s, the Russian economy has been reformed to a significant extent. For instance, energy prices are much higher. But many potential problems such as lack of clarity of the division of responsibilities and legal complexities remain inherent to the system. Hence, the implementation of some of the current progressive initiatives may not succeed fully.

Participating in an international climate regime is unlikely to influence the Russian emission trends. But this study illustrates that energy policies already part of the Russian business-as-usual activities as such can limit emission growth trends if implemented, even though they are introduced to improve the competitiveness and economic efficiency of the Russian economy rather than to cut emissions. Therefore, a useful approach would be to support the implementation of the existing set of emissions-curbing policies, for instance the energy efficiency policies, of which the Russian government is more likely to feel ownership. Furthermore, there is certainly a large potential to further cut emissions beyond business-as-usual, for instance due to the low level of energy efficiency and the significant untapped renewable energy potential.

Finally, the outcome of the scenarios should not be seen in isolation of other big picture issues relevant to Russia’s contribution to international climate policy. Beyond emission trends, Russia’s further options to adopt a deeper target for Copenhagen depend on whether the first commitment period surplus will be transferred and to what extent, and how much credit is Russia going to gain from forest carbon sinks.

ANNEX 1: EQUATIONS USED IN THE MODELING

The analyses were completed using Microsoft Excel spreadsheets. This section reviews the relevant calculation procedures.

The minimum trajectory of the national CO_2 emissions:

Equation 1 $CO_{2s,i} = \sum_k (Fuel_{s,k,i} \times EmissionFactor_k)$,

where

$Fuel_{s,k,i}$ - fuel k consumed in year i for a sector s - is estimated according to Equation 2; $EmissionFactor_k$ - emission factor of fuel *k*.

Equation 2 $Fuel_{s,k,i} = Activity_{s,i} \times FuelIntensity_{s,k,i}$,

where

$Activity_{s,i}$ - a sectoral activity indicator; value added for the industry and the transportation, floor area for the residential sector (Equation 3), and demand for energy (electricity, heat and petroleum products) for the transformation sector.

$FuelIntensity_{s,k,i}$ - electricity- and heat-associated emissions of energy-using sectors are allocated to the transformation sector; estimated as the 2005 intensity level minus the whole technical potential for efficiency improvement[42] known today.

Equation 3 $FloorArea_i = 0.0308 \times GDP / cap_i + 15.374$

Countrywide CO_2 emissions in year i are calculated as a sum of emissions associated with combustion of fuels (Equation 4, k -fuel type).

Equation 4 $CO_{2i} = \sum_k (Fuel_{k,i} \times EmissionFactor_k)$

Fuel k consumed in year i is estimated through its share in the total; the latter is a product of GDP and its energy intensity expected in year i (Equation 5).

Equation 5 $Fuel_{k,i} = GDP_i \times EnergyIntensity_i \times Share_{k,i}$,

[42] No fuel substitution is available.

ANNEX 2: TECHNICAL ENERGY EFFUCIENCY POTENTIAL IN RUSSIA, MTOE

Sectors	Coal	Oil	Petroleum	Gas	Other solids	Electricity	Heat	Total	2005 consumption
Transformation sector	**49.33**	**2.5**	**10.08**	**141.82**	**5.27**	**11.9**	**20.86**	**240.85**	**439.19**
electricity generation	23.87	0	2.53	64.88	1.73	0	0	93.01	186.75
heat generation	23.31	0.46	7.38	71.02	3.47	1.82	0	107.46	194
fuel production	2.15	2.04	0.17	5.92	0.07	10.08	19.95	40.39	85.21
Industry (inc. services)	**8.44**	**0**	**3.09**	**13.07**	**1.46**	**14.03**	**21.82**	**61.91**	**164.6**
municipal utilities	0	0	0.01	0	0	0.36	0.34	0.71	3.61
services sector	0.01	0	0.02	3.12	0.01	4.6	7.44	15.2	36.31
agriculture	0.02	0	1.53	0.08	0.04	0.73	0.5	2.90	6.21
fishery	0	0	0	0	0		0	0	0.04
mining	0	0	0.14	0	0	0.37	0.6	1.12	7.19
manufacturing	8.41	0	1.19	9.86	1.4	7.72	12.9	41.49	109.54
construction	0	0	0.2	0.01	0.01	0.25	0.04	0.50	1.7
Transport	**0**	**0**	**21.29**	**14.95**	**0**	**1.67**	**0.39**	**38.3**	**94.4**
Residential	**0.57**	**0**	**0.18**	**10.16**	**0.19**	**3.82**	**38.5**	**53.42**	**108.73**

Source: Bashmakov et al. 2008, Table 9.4 on p. 100-101.

Note: the potential on the transformation sector and energy-using sectors (industry, transport, residences) cannot be added because of their double-counting.