https://doi.org/10.53964/mem.2024007

https://www.innovationforever.com

Modern
Economy and Management

ISSN 2790-3214 (Online)

Open Access

Research Article

Distributional Effects of Expected Climate Mitigation Policies in Russia

Igor A Bashmakov[1*]

[1]Center for Energy Efficiency – XXI (CENEf – XXI), Moscow, Russia

[*]**Correspondence to: Igor A Bashmakov, General Director,** Center for Energy Efficiency – XXI (CENEf – XXI), 61 Novocheremushkinskaya Street, Moscow 117418, Russia; Email: bashmako@co.ru

Received: January 19, 2024 **Revised:** May 17, 2024 **Accepted:** May 21, 2024 **Published:** June 7, 2024

Abstract

Objective: The importance of assessing the socio-economic impacts of climate policies is growing as regulations are being adopted to promote decarbonization processes. Since Russia has committed to carbon neutrality by 2060, a large and diverse policy package should be launched to attain this goal. The policies need to be based on the effectiveness, equality and motivation. This paper presents the results of the first-of-a-kind research aimed to assess the impact of individual decarbonization policies on the distribution of consumer incomes and expenses for Russia.

Methods: A system of simulation models was used to estimate prospective greenhouse gases (GHG) emissions pathway for Development Driven by Decarbonization and Democratization (4D scenario) and related macroeconomic effects (evolution of prices, incomes, employment and energy expenditures across major economic sectors and industries), which were used as inputs to the simulation model distributional effect of national decarbonization (DEFEND), which was specially developed to estimate the effects of climate policies at the household level split by income deciles.

Results: This paper shows that only low carbon transition will sustain Russian economic growth by promoting reduced concentration of wealth and less centralized political system, whereas maintaining the extraction-based administratively ruled economic model will cause GDP to decline and form a "shagreen skin" economy.

Conclusion: The paper concludes that many of the explored policies have regressive distributional effects, but sophisticated socio-economic engineering can tailor neutral climate mitigation policies to help to at least maintain the balance of income and expenses compared to the basic trajectory. This study identifies data and knowledge gaps in calibrating the models that look into the distributional effects.

Keywords: economic growth, distribution of income and expenses, long-term forecasting, decarbonization, low-carbon development

Citation: Bashmakov IA. Distributional Effects of Expected Climate Mitigation Policies in Russia. *Mod Econ Manag*, 2024; 3: 7. DOI: 10.53964/mem.2024007.

https://doi.org/10.53964/mem.2024007

1 INTRODUCTION

Surveys of people across 20 countries (responsible for 72% of global greenhouse gases (GHG) emissions) in different continents with different income levels show that climate policy can be supported by three key pillars: effectiveness (the effectiveness pillar); impact on low-income households (the equality pillar); and personal interest (the motivation pillar)[1]. Another survey across 28 advanced and emerging economies echoes this finding and highlights three key policy attributes: policy effectiveness in reducing emissions; fairness of burden sharing and availability of co-benefits, such as improved air quality, health, and new jobs[2]. Therefore, assessments of how climate policies will affect the incomes and costs and who will benefit from these policies, how proportionately the burden is shouldered are important to mobilize support. The above surveys show that mere outreach to inform people about possible adverse implications of climate change is ineffective in generating such support.

In October 2021, Russia declared its commitment to achieving carbon neutrality in 2060 and two years later enshrined it in the updated Climate Doctrine of the Russian Federation.

"The key long-term goal of the climate policy is to achieve, with an account of national interests and social and economic priorities, a balance between anthropogenic greenhouse gas emissions and sinks no later than 2060." Article 21. Climate Doctrine of the Russian Federation.

It points out that a balance between cost-effectiveness and social justice can be ensured and potential conflicts of interest can be eliminated only through the political process. Here we face a problem of how justice, or fairness, is perceived. "Fairness is not about everybody getting an equal share; it is about everyone by right getting an unequal share." (Alexandr Gelman. https://quote-citation.com/life/57190, In Russian.) Different concepts of equity can be used: distributive (fair distribution of costs and benefits across groups with different incomes or among regions); procedural (ensuring both the possibility of participation and the account of the views of different groups in decision-making processes); and recognitional (fair representation guarantees for under-recognized groups)[3].

In the European Union (EU), the Gini index is 0.41 for residential energy use and 0.47 for energy consumption by passenger transport[4]. Such high values indicate substantial inequality. The poorest households are exposed to energy (or fuel) poverty, which is recognized as a very serious problem even in the rich EU, and the question of the "human right to energy", which is closely connected with the right to sustainable development, arises. The chances for support increase if the policy has a progressive distributional effect (that is, the rich, who have a much larger carbon footprint, should pay more). On the contrary, the regressive consequences of climate policies can significantly hamper their enforcement, unless they are offset by subsidies to vulnerable households[5]. A study for China shows that declining energy affordability reduces households' happiness[6]. In other words, effective and neutral or progressive policies are the key to mobilizing support and public acceptance. In this case, they can be perceived as a socially fair low-carbon transformation.

Social dialogue on fair energy transition and assessments of climate policy impacts on different industries and on the population with different income levels is not yet practiced on a large scale even in the EU[5]. In Russia, there is practically no such dialogue.

This paper is the first attempt to scope in the distributional effects of some of the policies required to achieve carbon neutrality and to assess these effects for Russia. Section 1 briefly summarizes the experience in assessing the impacts of individual decarbonization policies on the distribution of incomes and expenditures. Section 2 describes the concepts, methods, tools, and scenarios. Section 3 shows the results of the resource-based development in Russia over the recent 25 years. They are the background for the evaluation of the decarbonization impacts. This section also shows that this development path has led to what some authors are now blaming on decarbonization: the economic development has nearly stopped, the well-being of population is stagnating, and the declining real energy prices have not worked to spur economic growth. This section helps to understand if there is really much to lose after all the losses already incurred by the long-term preservation of the state-controlled resource-based economy model. Section 4 looks to assess the impact of decarbonization on the income distribution of producers. It shows that only low-carbon transition will help Russia to ensure GDP growth, whereas conservation of the current development pattern will cause GDP to decline (the "shagreen skin", or "negative growth", economy). Section 5 assesses the impact from a set of decarbonization policies on the distribution of consumer incomes and spending. It shows that sophisticated socio-economic engineering can promote neutral climate policies, in other words, ensure a balance of incomes and expenses compared to their basic dynamics trajectory. Conclusion summarizes the key findings and identifies data and knowledge gaps in studying distributional effects.

2 LITERATURE REVIEW

In addition to environmental and cost-effectiveness, the response of decision-makers and practitioners is determined by the assessments of the impacts from these measures on the distribution of incomes and costs. Assessments of the socio-economic implications of climate policies are scarce, as more attention is given to the disparities between countries. The reason for this is the lack of focus on the distributional effects and disparities across income groups or different businesses within countries and on policies beyond carbon pricing; lack of theoretical foundations for such analysis; and lack of reliable data required to calibrate models to quantify the distributional effects. However, this literature has appeared recently and is being developed[3-17], since the importance of such assessments has increased dramatically after the adoption of a variety of regulations in different countries to attain ambitions decarbonization goals. Such assessments are important to maintain the level of ambition and avoid a rollback on policies and an erosion of credibility of the implementers. Insufficient attention to long-term sustainability issues in the 2030 Agenda, which includes 17 interconnected Sustainable Development Goals (SDGs), and a high level of ambition over a quite short timeframe have resulted in only 15% of the 169 SDG-associated targets being on track[18]. It is believed that even for the EU, distributional effects had not been sufficiently studied before climate neutrality policies were developed[5]. Based on intensive literature review, this gap for the EU is being bridged to better tailor policy tools based on some consensus on the distributional effects of EU-level climate policy instruments[14]. The models in place are better suited to test distributional effects of carbon pricing, and so such studies dominate[15]. The key knowledge gaps include: lack of empirical evidence on the trade-offs between the sustainable development goals and low-carbon transformation policies; insufficient understanding of the distribution of additional costs and benefits across different groups; lack of knowledge regarding the approaches that can improve stakeholder engagement[13]. To a large extent, these knowledge gaps stem from insufficient cooperation between different experts and insufficient use of a systemic approach to exploring the complexity dimension and multiple synergies and trade-offs when studying different trajectories of the energy transition[19].

All of the GHG emission control policies break down into "framework" policies and special carbon regulations. The former induce a reduction in GHG emissions as an indirect effect, while the latter as the target one. Policy "frameworks" (market and structural reforms, energy security policies, enforcement and control tools, fiscal policies, information and market transformation tools, etc.) can have significant effects on the effectiveness of environmental and climate policies. Specific policies (low-carbon strategies, subsidies and tariff mechanisms, emission standards, bans on certain high-carbon products, taxonomy-based financing and credit mechanisms, carbon trading, carbon taxes, project-based mechanisms, public procurement, voluntary agreements and etc.) can be complementary or competitive – for example, renewable energy support schemes or GHG emissions trading schemes. In addition to the environmental, climate, and cost-effectiveness considerations, the reaction of both decision-makers and practitioners depends on how these measures are expected to affect the distribution of incomes and costs.

Generally, literature suggests that climate actions broadly align with the SDGs, and multiple studies show that the adverse impacts of climate policies on inequality can be fully offset or substantially mitigated by careful planning and stakeholder engagement, as long as the effects potentially affecting inequality are taken into account at all stages of policy design and implementation[3-17]. However, it is a common practice whenever ministries or departments of labor, social security, and health are not involved in the development of climate policies or evaluation of their implications. Policies are typically developed by the ministries of economy, energy, ecology, etc[5]. While looking for methods to eliminate the adverse effects of certain climate policies, it is important to strengthen the role of different social groups in the discussions. The concept of equity should be implemented at all stages of policy development and implementation – targeting ("what is to be done?"), development of tools ("how to do it?"), and monitoring ("what has been done?"). All of these steps should ensure a fair distribution of the pressure and guarantee stakeholder engagement. Social dialogue about fair energy transition involving an assessment of the impacts of climate policies on different industries and on the population with different incomes has not yet become large-scale even in the EU countries[5]. This paper aims to contribute to the launching of such dialogue for Russia.

3 CONCEPTS, METHODS, TOOLS AND SCENARIOS

This paper evaluates macroeconomic and distributional implications of individual climate policies for Russia. One important problem of any economic, environmental or climate policy is the lack of assessment of the potential impact it may have on the economic agents and their ability to consolidate–formally or informally–by using a variety of institutes to promote or, on the contrary, stand out against these policies. Such analysis requires a special methodological approach. One option–the 'seven matrices' method–was proposed by the author back in 1987[20]. This method provides a basis for the assessment of the social, institutional, and political feasibility of climate policies.

A system ("a cloud") of interconnected models[21] was used in this study to estimate prospective GHG emissions pathways and their macroeconomic effects, including changes in prices, incomes, employment and energy expenditures across major economic sectors and industries. The "cloud" of models included a model for residential buildings and another one for transport (TRANS-GHG). Inputs from this set of models include country averages for personal incomes, living space and car ownership, energy prices and taxes, specific energy use by major processes (heating, hot water, other uses), specific energy use for personal cars depending on powertrain, etc. The 4D scenario[21] was chosen as the basis for the calculations to ensure carbon neutrality for Russia by 2060. The above indicators became inputs to a specially developed simulation model – distributional effect of national decarbonization (DEFEND). This model includes deciles-specific demand functions for living space, cars, energy use split by different energy sources with drivers, such as incomes, prices, taxes and subsidies (both energy subsidies and subsidies for the deployment of low carbon options), energy savings, incremental capital costs per unit of saved energy and others. As data to calibrate such functions are limited, some assumptions need to be made to run the DEFEND model (see Section c). Different income groups have different energy cost shares, different price elasticities, different car mileage, they buy cars and living space at different prices, buy different quality fuels, etc. Distributions of all such parameters across deciles are yet to be examined, but they are crucial to assess policy outcomes.

The effects of climate mitigation measures may come as either additional costs or benefits. In terms of costs, measures can be: regressive, if they disproportionately increase the share of costs in the incomes of the poorest households; progressive, if they don't; and proportional, if the costs are evenly distributed across all income groups[8]. In terms of benefits, such as reduced energy bills, it is vice versa: measures are: progressive, if low-income households get more benefits in relation to incomes, than wealthier ones; regressive, if they don't; and proportional, if they ensure equal distribution of benefits. A measure can be considered neutral if it does not affect the balance of incomes and costs compared to the baseline trajectory. In democratic societies, policy development should be heading towards proportionality. If a policy has a regressive distributional effect, compensations should be provided to low-income groups, or the policy needs to be designed in a way so as to minimize the adverse distributional effects. Vertical distributional effects (across income groups) may be significantly smaller, than horizontal ones (within each income group). This makes it difficult to assess and control the distributional effects[12]. It is important to track all economic effects, not only the direct ones (first-order impacts[16]), on incomes and expenses. For mechanisms with a carbon price, the effects are also determined by how fiscal revenues from those mechanisms are used.

Ideally, a baseline is required for each equity metric to assess how an individual measure affects the distribution of incomes and expenditures**.** Metrics can reflect indicators, such as affordability of energy, low carbon technologies uptake, sustainability of the effects, public involvement in decision-making, ensuring reliable energy supply, etc[3]. In addition, metrics, such as gender, ethnical, and generation equity, could be considered.

4 RESULTS OF AN EXTRACTION-BASED ECONOMIC DEVELOPMENT IN 2000-2023

One catchphrase by which Viktor Chernomyrdin will be remembered: "If we understand that we need to work, then there won't be much harm and we won't lose too much." (© V. Chernomyrdin). The question is, if there is really much to lose after all the losses incurred by the state-controlled extraction-based economic development? The arguments against decarbonization include: the risk of slowing down economic growth, declining or stagnating living standards, and dramatic price hikes[22-24]. Paradoxically, it is the development along the resource-based pathway in the last 15 years that has led to what decarbonization is blamed for: economic growth has nearly stopped, the living standards are stagnating, and the declining real energy prices cannot stimulate economic growth.

Post-1999 political and economic reforms (with all their diversity and contradictions) had two general parallel vectors: (1) roll-back on political competition – the decline of the democracy; and (2) roll-back on economic competition – the decline of the efficiency (Figure 1). After 1990, Russia noticeably advanced in the global democracy rankings, yet from 1999 onwards, it began to roll back and by 2022-2023 the democracy indices were even below the Soviet 1990 values. Democracy has become a decorative institution of an autocratic regime.

The collapse of democracy was accompanied by an increase in the state property index (Figure 1). Every percentage point decrease in the electoral democracy index was accompanied by 1.1% increase in the state property index. State control was established over the key financial flows generated by the raw materials industries, and so the share of the state-controlled sector was up from 31.2% in 2000 to 56.2% in 2021 (1.8 times); however, the author's estimate is more than 60% in 2022. By aborting competition and employing a purely extensive resource-based growth model with declining or stagnating efficiency of basic production factors Russia brought its GDP average annual growth rate (AAGR) down from 6.5% in 2000-2008 to 0.9% in 2008-2022, or even to 0.6-0.7% – if one is not inclined to trust the latest sly figures from Rosstat. On average, GDP AAGRs were 0.33% down per each percent increase in the state property index in 2000-2021 (mainly due to a decline in the efficiency of key production factors). Trends in Figure 2 show that when the state property index is above 55% in Russia, total factor productivity (TFP) drops to or below zero, and the economic growth stops.

Where decision-makers ignore productivity growth and cost optimization, poverty comes. Living standards were 'frozen' for 10-12 years. Rolling back on the market reforms and maintaining the resource-based pattern of economic development were two factors that completely stopped growth in real disposable income: in 2022, it was 3% below the 2012 level. Re-distribution of income in favor of wages and net taxes in 2000-2009 was accompanied by dynamic economic growth. The post-2009 reverse re-distribution of income in favour of the large capital was accompanied by economic stagnation. After 2009, the government economic policy aimed to preserve the resource-based pattern of

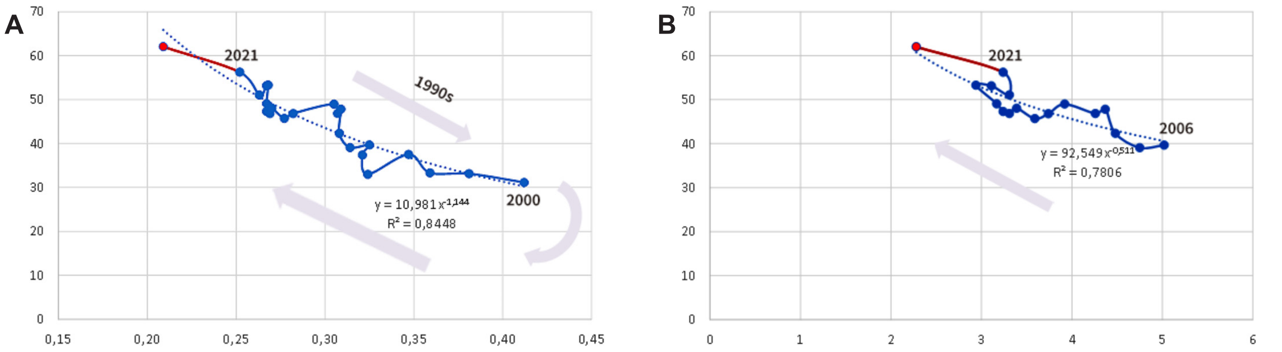

Figure 1. Democracy indices and state property index in Russia. “Back to the USSR”. A: state property index (vertical axis) as function of electoral democracy index (2000-2022); B: state property index (vertical axis) as function of Economist Democracy Index (2006-2022). *red dot is author’s estimate for 2022. Source: author based on data from Varieties of Democracy, V-Dem Interactive Maps – V-Dem (https://v-dem.net/data_analysis/MapGraph/); The Economist Democracy Index The world’s most and least democratic countries in 2022 (https://www.economist.com/graphic-detail/2023/02/01/the-worlds-most-and-least-democratic-countries-in-2022); Indices (https://ipei.ranepa.ru/ru/kgu/indeksy). The 2022 value assessed by author. GDP per capita in current dollars – WDI database.

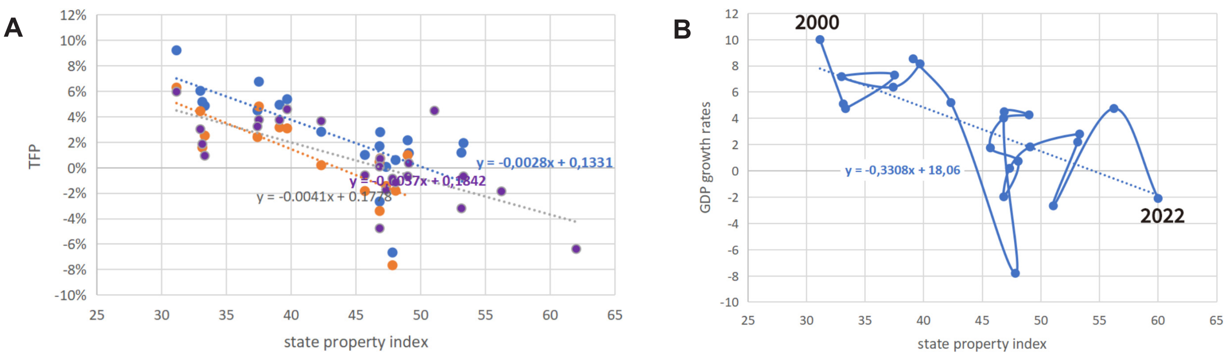

Figure 2. State property index, TFP and GDP growth rates. A: Relationship between various assessments of TFP* and state property index; B: State property index and GDP growth rates. *Evolution of TFP for entire economy from Our World in Data and KLEMS, and for non-oil-and-gas sector based on CENEf-XXI’s RUS-DVA model. Sources: built based on[18,25-28].

economic growth and had a significant negative distributional effect: one fifth of the GDP was redistributed in favour of large businesses. According to Rosstat, in 2009-2022, the share of wages in GDP dropped by significant 13.5 p.p., the share of net taxes was also down–from 16.6 to 8%. This helped increase the share of gross profit by 22.1 p.p.

The stratification of the Russian society by the level of wealth is driven by an oligarchic resource-based development model and has aggravated noticeably after 2009: the richest 20% of Russians get nearly half of the whole income, of which the even richer 10% account for about 30%. These incomes and wealth are concentrated mainly in the hands of the owners of resource extracting and processing companies.

The 2000-2008 rise in real energy prices was accompanied by energy efficiency improvement and acceleration (rather than slowdown) of economic growth. A 12-70% drop in real energy prices over 2014-2022 for a variety of industrial products did not allow it to accelerate economic growth, but hampered or stopped energy efficiency improvements. Post-2008 trends led to, first, a super-coupling, i. e. a nearly complete coincidence of the rates of change in GHG emissions and in GDP during 2008–2021[28], and then in 2022 to a “reverse decoupling”, i. e., an increase in GHG emissions along with a decline in GDP[29].

5 DECARBONIZATION: IMPACTS ON PRODUCERS’ INCOMES DISTRIBUTION

There is going to be no economy in the future other than low carbon one. Transition to the low-carbon pathway will ensure Russia’s economic growth, whereas conservation of the resource-based pattern will, in the worst case, halve Russia’s GDP (the “shagreen skin”, or the “negative growth”, economy). If TFP grows from recently fixed negative values up to 0, then GDP will be only 2-10% down in 2060. Shirov and Kolpakov[30] provide more optimistic estimates of GDP dynamics to 2060, but they agree that scenarios with active decarbonization policies ensure higher growth rates. No available projections for Russia to 2050-2060 claim the opposite. GDP per capita and personal consumption per capita growth is only possible by increasing TFP to 0.4% or higher values (Figure 3), through the decarbonization of the economy based on the best available technologies, by promoting democratization and strong competition, that is along a development path close to 4D scenario – Development Driven by Decarbonization and Democratization, which requires improved institutions and

https://doi.org/10.53964/mem.2024007

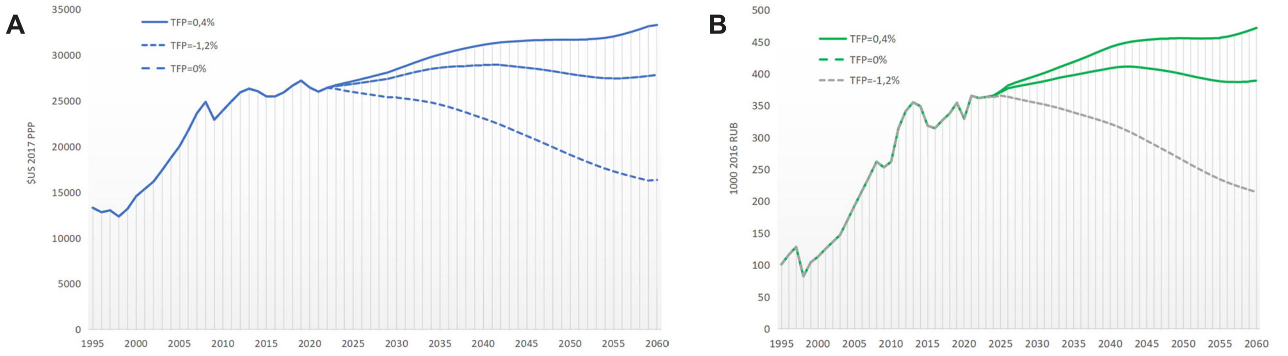

Figure 3. Evolution of GDP and personal consumption per capita. A: GDP per capita; B: personal consumption per capita.

Table 1. Evolution of the Role of Oil-and-Gas Sector (%)

Share of Oil-and-Gas Sector	2022	2030	2060
GDP	19.4	14.6	4.4
Consolidated budget	21.8	16.4	5.1
Exports	58.1	38.8	9.0
Investments	17.0	15.8	12.3

business climate, openness of trade and return to the global economy, enhanced infrastructure, and improved skills and the ability to use them[21,31].

One key long-term challenge for Russia is the exhaustion of its oil-and-gas rent, which has been a pillar for the Russian economy over the last quarter of a century. By 2060, the share of oil-and-gas revenues in GDP and in consolidated and federal budgets will drop 4-fold (Table 1).

While the government is increasing the tax pressure on the oil-and-gas sector, hard-to-recover oil and gas reserves will be impossible to develop with a substantial tax pressure. Fuel oligarchs are a powerful group which strongly oppose low carbon transition in Russia by dictating the low level of ambition for its climate policy. Being unable to influence global decarbonization processes, they want to keep the shrinking market niches, so they have to reduce the carbon footprint of their products and claim that Russian oil, gas, coal, metals, and other basic materials are the "greenest" in the world. As the product niches in international markets are gradually shrinking, they are desperately fighting for domestic markets and trying to slowdown the low carbon transition in Russia.

Redrawing the economic landscape in favour of the non-oil-and-gas sector will meet with desperate resistance from the oil-and-gas business, but will inevitably entail redrawing of the country's governance. Non-oil-and-gas business is much more diversified compared to the oil-and-gas sector. Therefore, its growth will definitely be associated with the development of democratic institutions and competition – both political and economic. Otherwise, there is no way to increase TFP, and the economy will be stagnating or shrinking. Diversification of income sources will lead to more even wealth and incomes distributions and will make it impossible to preserve the current ultra-centralized system of inter-budgetary relations, and so the role of regions in the country's governance will be significantly increasing. The oligarchs of the basic materials industry (non-oil-and-gas) differ in their views regarding decarbonization policies and measures.

The most significant distributional effects are generated by structural changes in the economy, which result from changes both in external factors (external demand for goods and services) and "framework" policies (including moving towards, or away from, the market economy) and special decarbonization policies. Development along the oil-and-gas and basic-materials path has reduced the share of wages in GDP, while transition to low carbon development will cause the wages share in GDP to increase due to the accelerated development of knowledge-intensive industries and services, in which the share of wages in value added is much higher. This will be reflected in the more even income distribution in the entire economy.

Given the limited number of people employed in oil and gas production and processing, a gradual decline in this sector output will have little impact on the labour market, which is facing a persistent labour shortage. Decarbonization-driven decline in coal production will have little impact on the national economy, but will significantly affect the economy and employment of coal-mining regions and will require proactive decisions to diversify their economies.

The dynamic electrification of all sectors of the economy will cause a significant part of the income to be re-distributed in favour of the power industry in general and low-carbon generation in particular. This sector will create additional labour demand for the generation, transmission, distribution and storage of electricity, which can be covered by the released workers from heat supply, coal, oil and gas industries.

Deployment of carbon pricing mechanisms is becoming critical to maintain and expand the market niches for Russian basic materials. CBAM mechanisms could potentially

https://doi.org/10.53964/mem.2024007

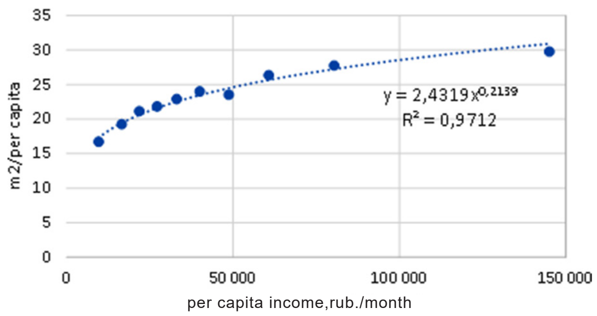

Figure 4. Living space per capita as a function of income.

bring: additional incomes in the EC and other markets (if accompanied with proactive decarbonization in the Russian industrial sector), or losses of no more than 1,5 bln US$/year (if decarbonization policies are weak). Such losses are only one third of what Russian businesses have "naturally" lost from the 2022 sanctions[32]. Carbon regulations (carbon intensity standards, procurement of "green" basic materials, introduction of carbon pricing, etc.) will cause the prices of basic materials to substantially grow; however, prices of final products will show only a limited growth, and the general level of basic materials prices will not go much above the "natural" price volatility. With 108 $US/tCO2 carbon price in 2060, a Russian-made car will become 1.2-5.6% more expensive, and so AAGR will be 0.14% compared with the "natural" 16% car price growth as fixed in the first 9 months of 2023.

6 DECARBONIZATION: IMPACTS ON THE DISTRIBUTION OF CONSUMERS' EXPENDITURES

6.1 Distributional Effects from Low Carbon Measures in Residential Buildings

The impact of low carbon policies is assessed below by components for which statistical data are available by deciles: housing and personal vehicles energy use or energy costs. In command economies, income does not have any tangible impact on the distribution of per capita living space[33]. The balance between income and housing space was destroyed, and the distribution function of housing space by income remained nearly flat for decades and only began to change after the transition to a market economy was launched. In 2022, the elasticity coefficient of the living space from income in Russia was 0.21 (Figure 4). The existence of a minimum guaranteed ('social') living space and the fact that housing is considered a basic need means that this coefficient is less than unity in all countries. In Russia, it may be rising for a while before it stabilizes.

In 2022, the average share of residential energy costs in income (ECS_{inc}) was 3.4%. The average energy cost share in consumer expenditures (ECS_{exp}) varied between 6.5 and 6.8% in 2012-2018 and then went steeply up to 7.8% in 2019 and to 8.3% in 2020 with a subsequent drop to 6.4% in 2021 and to 6% in 2022 (Figure 5). The main contribution to ECS_{exp} comes from the district heating costs. The share of district heating costs is less dependent on the income level, since it is mostly a function of the living space, which is weakly related to the income. Up to the income level of 40 thousand rubles/person/month (sixth decile), the elasticity coefficient for the ECS_{exp} for district heating is nearly zero, and for higher income levels it drifts to (-)0.48. A similar dependence of ECS_{exp} on income exists for DHW supply. Electricity and gas uses are closely related to income: demand to income elasticity coefficients are 0.5 for electricity and 0.9 for gas[34].

Energy price instruments in Russia work effectively wherever residential customers are technically able to control their energy use. Panel regression analysis across more than 80 Russian regions shows that price elasticity of district heat for space heating is -0.22, which reflects a limited technical ability to adjust heat consumption depending on heat prices (district heat control mostly takes place at heat sources, central or building level heating points) – i. e. low technical elasticity. Since full control of hot water (DHW), electricity, gas, and other fuels consumption is in the hands of consumers, specific energy use to price elasticities for these resources are close to -1[34]. This is the "minus one phenomenon": with time energy efficiency becomes inversely proportional to energy price[35]. The average ECS_{exp} is close to the first threshold of households' ability to pay their energy bills. This threshold is similar across different countries, irrespective of the energy prices or development stages: 3-5% of the household income, or 4-7% of their expenditures[35]. The further one goes beyond this threshold, the lower the payment discipline, or the level of comfort drops to, or below, the level of survival[36-38]. Stepping over the threshold also reduces the share of expenditures to purchase residential real estate[35].

The second threshold for households' ability to pay their energy bills is the ECS_{exp} threshold for the lowest income households. As soon as it gets above 7-10% of the income or above 9-13% of consumer expenditures (net of support for the "energy poor") –no measures, no matter how severe, can improve energy payments collection rate; and if the accumulated debt is large and power supply can be cut off, then energy consumption drops to the level of mere survival. This second threshold is key for the development of programs to support the energy (fuel) poor[36-39]. In England, households were classified as fuel poor if they had to spend more than 10% of their disposable household income (before tax, but including benefits) to maintain a "satisfactory" home comfort. For heating, this means 21°C in the main living area and 18°C in other rooms. In 2022, 3.28 million, or 13.4% of households in England were classified as energy poor. In the UK, at the beginning of 2023, this number reached 7.5 million households[39]. The financial pressure on the low-income households (first to sixth deciles) in 2012-2022 was down, whereas on the better-off households (seventh to tenth deciles) it somewhat increased (Figure 5). If everybody paid their full energy bills, the share of the energy poor in Russia would have been approximately 6% in 2022 (if the

https://doi.org/10.53964/mem.2024007

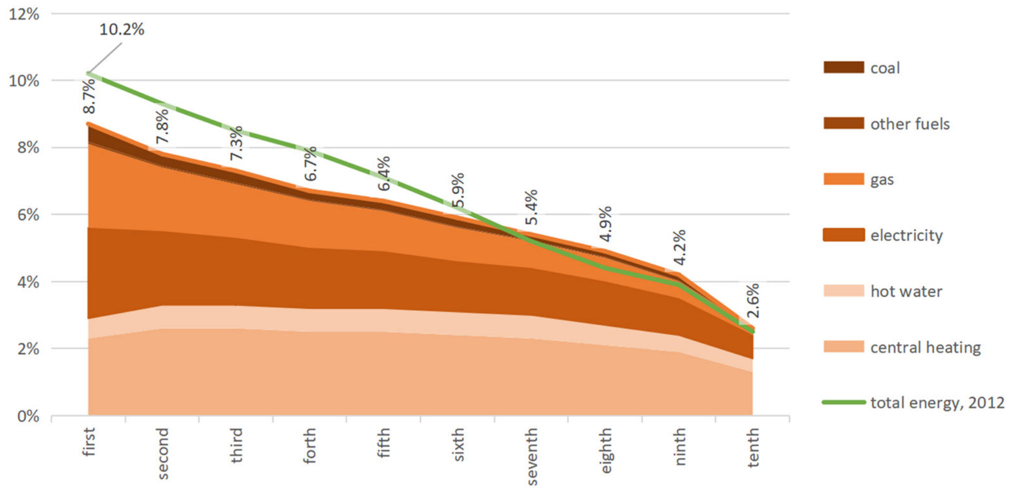

Figure 5. ECS in consumer expenditures distribution by deciles in 2022.

ECS_{exp} threshold is taken to be 10% of income) or 19% (if the threshold is taken to be 7%). Social support helped bring the share of the energy poor in Russia to nearly zero in 2022, if the energy cost share (ECS) threshold is set at 10% of income, or to 1-2%, if this threshold is set at 7%.

In Russia, three main schemes of providing social support to pay energy bills are financed from different levels of budgets (from federal to municipal). First, social support for individual categories of people and households. It is related to the status, not income. Second, tariff subsidy for heat. In some municipalities, heat tariffs are set below the full costs, and the gap is covered from municipal budgets. Subsidies are provided in municipalities with relatively low incomes, however, they are not linked to the income of energy users. Third, subsidies for the poor to cover the gap between their housing, energy and other communal bills and the upper thresholds set at 10-22% of household income. In 58 regions of the Russian Federation they are set at 22%. In other 24 regions, this share is 15–21%, in 3 it is below 15%, and in Moscow it is 10%. In the UK, there are similar schemes to increase household solvency: the Winter Fuel Payment, the Warm Homes Discount, and the Cold Weather Payment[39]. Statistics do not provide data on the distribution of these support schemes by deciles. The first two schemes are not related to the income level, while the third one suggests that the support goes down as income grows and, starting from the sixth decile, it is down to zero. This assumption was made based on the analysis of the distribution of the share of energy poor in the UK by deciles[39]. As a result, the share of household expenses in covering full energy costs does grow with higher incomes, but even for the wealthiest decile it is below 100%.

Three low carbon policies are considered: energy efficiency building codes; subsidies for energy efficient renovation of apartment buildings; carbon price mechanisms to encourage energy efficiency improvements in residential buildings. The level of subsidies determines the degree of participation in the programs and the degree of compliance with regulations. The DEFEND model estimates two effects: additional costs for purchasing energy-efficient housing and savings on one-year space heating for a class A+ building. Not all of the critical parameters of the DEFEND model are backed by statistical data, so the distributional effects were assessed using a number of assumptions in addition to the statistical data. The assumptions are as follows: The share of new housing purchase expenses in income by deciles is established based on its average value – 3.2% of income – adjusted by deciles by the expenses/incomes ratio for each decile to the average ratio. As a result, it stays at 1.2% for the first decile and at 4.1% for the tenth.

The price of housing on the primary market differs by deciles. Its average 2022 value was 122 thousand rubles/m^2. For the first decile, it is taken at 89.9 thousand rubles/m^2 growing up to 155 thousand rubles/m^2 for the tenth. This parameter is used to estimate the average annual purchase of residential space by different deciles.

Part of the housing is provided in new buildings under various social programs and is financed from the budget and other external sources. This amounts to approximately 5% of the newly built housing. It is assumed that when moving to higher deciles, this share decreases as the square of the ratio of the expenses/income ratio for each decile to average ratio across all deciles.

Incremental capital costs of construction of a class A+ residential building (where energy use for space heating is 40% below the base level) are 2,460 rubles/m^2, or 5% of the average construction costs of a new apartment building.

Only part of the incremental capital costs is subsidized. If the share of subsidies is zero, the effect of introducing administrative energy efficiency requirements (building codes) for new buildings is assessed.

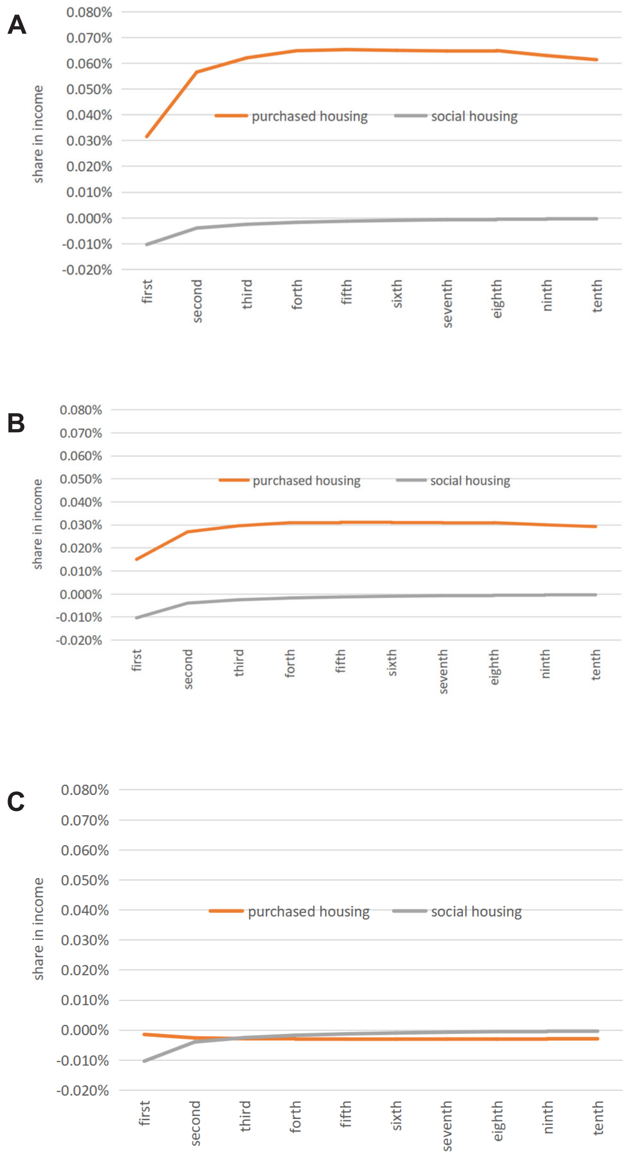

Figure 6. Distributional effects of mandatory energy efficiency requirements for new residential buildings. A: introduction of administrative requirements for energy efficiency of new buildings; B: 50% subsidies for incremental capital costs; C: 100% subsidies for incremental capital costs.

Introduction of administrative requirements to improve the energy efficiency of new buildings has, in general, a progressive effect for the first four deciles; beyond that, the effect becomes proportional and slightly declines for the tenth decile. The relatively small financial pressure on the first deciles is attributed to the low share of expenses for housing purchase in their incomes. For deciles from the fourth and onwards, the additional pressure reaches 0.068% (or 0.065% – with an account of heat savings) (Figure 6).

It is important to compensate this additional pressure through subsidies to cover the incremental costs of improving energy efficiency and by developing programmes to provide social housing to low-income families in new energy-efficient buildings. Where subsidies cover half of the incremental capital investments, the above conclusions are valid, but the additional pressure is halved. Where subsidies cover full incremental capital costs, the effect is neutral, i. e. there is no additional pressure on any decile. If the assumptions about the level of incremental capital investments are modified, the conclusions about the nature of the effect do not change, yet the level of additional pressure is affected. Providing social housing has a progressive effect (in terms of cost savings), since saving an equal amount of heat is more effective in terms of relieving the pressure on poor households, even though their average housing space is smaller.

In Russia, there are no requirements that specify mandatory energy efficiency targets for apartment buildings retrofits or targets for the annual share of energy efficient retrofits for apartment buildings. According to the Federal Housing and Public Utilities Agency (FHPUA), with financial support provided in 2021, energy efficiency improvements were packed into the renovations of 54 apartment buildings with 355 thousand m^2 total floor area. Incremental investment costs sum up to 203 million rubles, or 571 rubles/m^2 on average. The FHPUA provided 80 million rubles in reimbursement for these costs (39%). Energy savings amounted to an average of 26%, or 32 million rubles, annually. The mechanism for co-financing energy-efficiency retrofits of apartment buildings in Russia was tested, debugged, has proved its efficiency, yet was abandoned after the meager budget of this program had been exhausted. Funds had been allocated on a competitive basis, and the amount of co-financing was determined by the expected savings. The share of apartment buildings with profound energy-efficiency retrofits across the whole country is below 0.2% of the total apartment building area, which is 10 times below the desired 2%.

Reviving and upscaling of the FHPUA mechanism was considered. Calculations using DEFEND model were based on the actual distribution of per capita living space depending on the income. It was also assumed that:

on average, energy-efficiency retrofits are accomplished in 2% of the apartment buildings floor area annually and deliver specific heat savings of 30%; capital costs of such energy-efficiency package are on average 571 rubles/m^2; buildings with the highest specific energy consumption (the right-hand side of the energy efficiency benchmarking curve) have a priority for energy-efficient retrofits; distribution of population with different income levels, living in buildings with different time in service, is uneven: better-off people live in newer buildings. Therefore, it is assumed that the share of buildings selected for retrofits for the lowest income decile is 50% above average (3% per year), and for the highest income group is 50% below average (1% per year).

Two levels of subsidies to cover the incremental costs of energy-efficient retrofits were considered: 60% and 100% (Figure 7).

https://doi.org/10.53964/mem.2024007

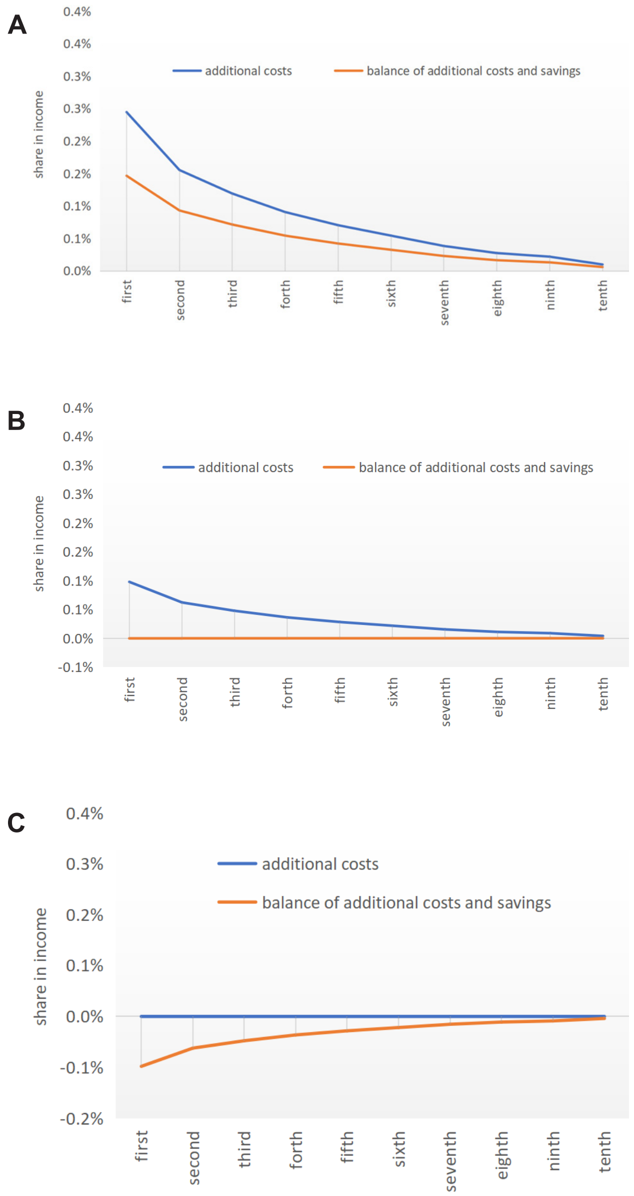

Figure 7. Distributional effects of mandatory energy efficiency requirements for residential buildings retrofits. A: Introduction of administrative requirements for improved energy efficiency after buildings retrofits; B: Subsidies to cover 60% of costs of energy efficiency retrofits as part of buildings renovation; C: Subsidies to cover 100% of costs of energy efficiency retrofits as part of buildings renovation.

Introduction of administrative requirements to improve energy efficiency of buildings through retrofits has a regressive effect (Figure 7A). It is slightly mitigated by expected savings on heating bills, but it takes 2.5 years for the additional costs to pay back from savings. This finding for Russia is in line with literature[8,16]. The cost savings are smaller for higher-income deciles. 60% of subsidies to cover the incremental costs produce the neutral effect balanced by the costs and additional annual energy savings (Figure 7B). Full subsidies to cover the incremental costs of energy efficiency retrofits result in a proportional effect in terms of costs and a progressive effect with an account of the resulting energy savings (Figure 7C). Depending on the payback period requirements, it is possible to establish the share of subsidies required to achieve a neutral effect.

The DEFEND model was also used to assess the distributional effects of the introduction of carbon price mechanisms. It was run with the following assumptions: Energy consumption is broken down by space heating, hot water supply, and other needs. For each of these, the fuel mix includes: coal, liquid fuel, natural gas, other solid fuels, electricity, and district heat. Specific energy consumption and the prospective fuel mix are borrowed from the 4D scenario. They are assumed to be equal for all deciles.

Average Russian energy prices for residential consumers are used. On the 2060 horizon, they are growing 1% faster, than the consumer price index.

In the main version of the calculations, carbon price is introduced in 2031 at 3 USD/t CO_2. It then grows annually by 3 USD/t CO_2 to reach 108 USD/t CO_2 in 2060. Calculations are in rubles. The exchange rate is 127 rubles/USD in 2030 and 132 rubles/USD in 2060.

In the main version of the calculations, the current energy subsidies for the housing sector remain, including social support for individual categories of people, compensation of the difference in tariffs, and subsidies for the poor.

In the future, personal incomes evolve in line with GDP in the 4D scenario. The elasticity of the share of household total expenditures relative to income is -0.25 (estimated for 2022).

Average per capita living space grows in the 4D scenario, and the values by deciles are distributed in accordance with the decile to average ratios observed in 2022.

Specific GHG emissions from power and district heat production are set in the 4D scenario.

The effect of carbon pricing is regressive. It can be made neutral or progressive by modifying the social support mechanisms without increasing the amount of such support. With the above assumptions, the introduction of a USD108/tCO_2 carbon price in 2060 will increase the ECS in income for the first decile by 1.2%, and for the tenth only by 0.2% (Figure 8A). This result is valid if the existing schemes of providing social support to households to pay their energy bills are preserved.

There are a variety of social support mechanisms that can be tuned to follow the worst first principle[39]. Under the existing scheme, benefits and subsidies to cover the tariff gap are provided regardless of the income level. An alternative scheme, which includes higher subsidies for the first deciles and elimination of support for the last

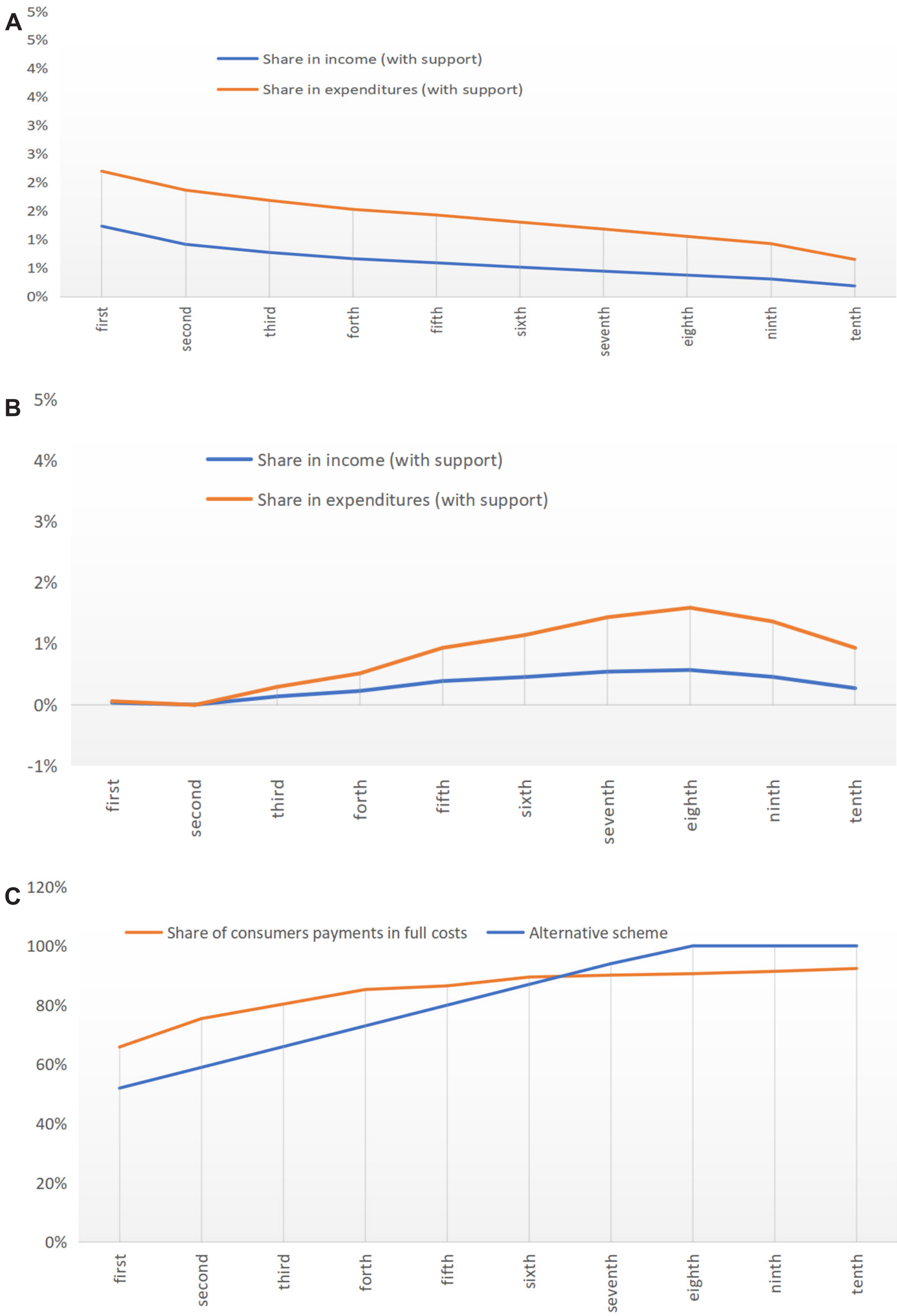

Figure 8. Distribution by deciles of housing ECSs increments driven by carbon price. A: change in ECS induced by introduction of USD108/tCO_2 carbon price in 2060; B: change in ECS induced by introduction of 108 USD/t CO_2 carbon price in 2060 and by change in social support scheme; C: change in social support scheme.

three deciles (Figure 8C) ensures a neutral effect of carbon pricing for the first two deciles and a weak progressive effect for the rest (Figure 8B).

6.2 Distributional Effects of Decarbonization of Personal Vehicles

According to Rosstat, the share of personal transport costs in household expenses was up from 4.9% in 2012 to 7.4% in 2019. The share of fuel costs in incomes is lower: 2.9% in 2022. In Russia, it is close to the upper limit of the range for many countries, where it varies cyclically in the narrow range of 2 to 3% of personal income before tax[35]. It is regressive in Russia: for the first four deciles it is 3.6-3.8%, while for the tenth it is 2%.

Liquid fuel subsidies (damper) in Russia are equivalent to a negative carbon tax of (-100/tCO_2). It has a weak progressive effect (in terms of cost savings). In 2022, subsidies for motor

https://doi.org/10.53964/mem.2024007

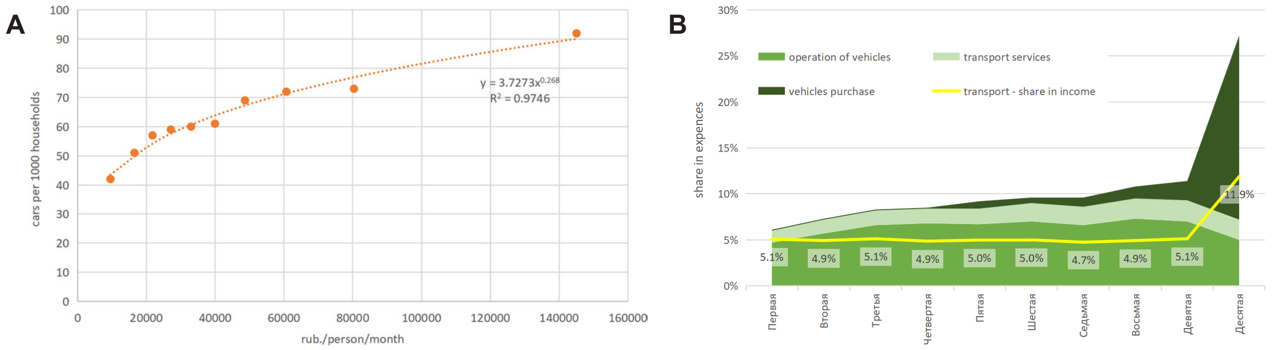

Figure 9. Car ownership as a function of income (A) and the share of transport costs in total expenditures and incomes (B).

liquid fuels (damper payments) amounted to 2.16 trillion rubles, or approximately 28 rubles/liter. If we assume that car mileage has no sensitivity to fuel price, then this subsidy policy is progressive (in terms of cost savings), since savings on the ECS_{inc}, as we move from the first to the tenth decile, are down from 2.1% to 1.1%. However, if we assume that mileage depends on price with an elasticity coefficient ranging between -0.4 for the first decile and -0.2 for the tenth, the effect becomes nearly proportional for the first deciles and weakly progressive for the others, since the damper mechanism brings the cost 1.5-2% down for the first nine deciles and only 1.2% down for the tenth.

Calculations based on the 4D scenario using the TRANS-GHG model[21] show, that low carbon transition in transport causes passenger car ownership to decline from 328 cars/1,000 people in 2022 to 254 in 2030 and further down to 160 in 2060, i.e. to 56 and 35 cars per 100 households respectively. Both numbers are below the 2022 values. Figure 9 shows that as income grows, car ownership per 100 households scales up with an elasticity of 0.27. However, from the seventh to the ninth decile car ownership is practically saturated. For the tenth decile, the share of costs related to the purchase of vehicles is steeply up, while the share of vehicles operation costs is down. The share of vehicles operation costs follows the ∩ law with a strongly extended apex. The share of all transport expenditures in income (yellow line) is almost neutral for the first nine deciles and goes steeply up for the tenth.

According to the peak theory, per capita personal vehicle mileage peaks as the income rises and then steadily declines. According to the saturation model, car usage plateaus as the income grows. In the 4D scenario, decarbonization in transport relies on a significant change in the intensity and structure of personal mobility in accordance with the peak model. In the DEFEND model, the ownership rate slightly grows for the first deciles, and goes down for the other deciles. On the 2060 horizon, it will decline substantially for all deciles. An important argument in favour of choosing the peak model for Russia is the inability of Russians in all deciles to significantly increase their car ownership for the very slow expected growth of their incomes and the 2022-2023 skyrocketing growth in car prices.

The distribution effects of providing subsidies to purchase electric vehicles were assessed using the DEFEND model with the following assumptions: Subsidies are assumed to stay at 925,000 rubles per car to 2030 and then decline to 200,000 rubles per car in 2060; Real prices of gasoline and diesel vehicles are set at the 2022 levels adjusted for inflation. Average car price growth outpaces the consumer price index, similarly to the dynamics observed in 2000-2022. The real price of electric cars is assumed to be 2.4 times higher in 2022, than that of gasoline cars, but it is 34% down in 2030 and 70% down in 2060; Based on Rosstat's data and the data from the Russian car market, a dependence of the average purchased car price on the deciles' income was formed. The mean car price for the tenth decile is 3 times higher, than the mean price for the first decile. With average configuration, the most expensive of the 25 best-selling models in the market (Toyota RAV4) was 5 times more expensive, than the cheapest model (Lada Niva).

The share of expenses to purchase a car for each decile was determined based on Rosstat's 2019 data. Data for 2020 (COVID19 pandemic year), for 2021 (revival from COVID19 pandemic) and 2022 (sanctions related to the military operation) are less reliable.

The structure of purchased new cars by power train is estimated using the TRANS-GHG model depending on the car ownership cost[21].

Subsidies for purchasing electric vehicles have a weak progressive effect (in terms of cost savings) up to the ninth decile inclusive, growing for the tenth decile, yet not to exceed 0.12% of income – against the background of the 7-10% baseline share of income spent to purchase cars in 2060. The share of vehicle purchase costs (primarily cars, but also two-wheelers, trucks, and motor boats) in the incomes of the first nine deciles is very small and only slightly changes over time (Figure 10). By 2060, the effect will be noticeable only for the tenth decile: this share will decrease, as electric vehicles will become cheaper and the sales volume will grow.

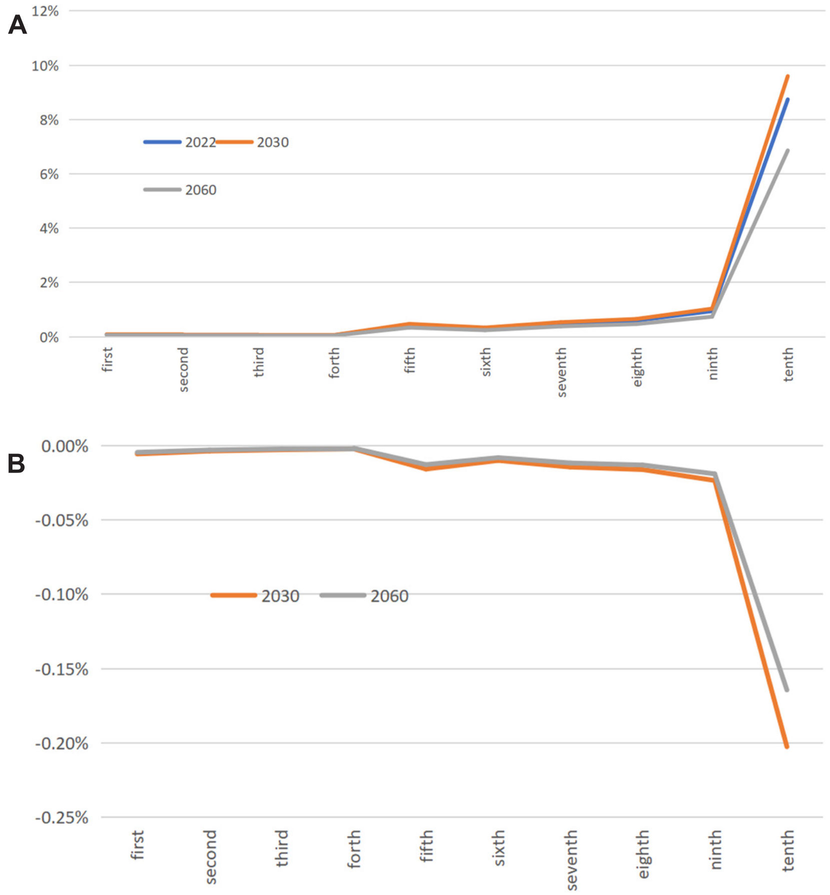

Figure 10. Effects from subsidies to purchase electric vehicles by deciles. A: the share of expenses to purchase passenger cars in income (excl. subsidies for electric vehicles); B: change in the share of expenses to purchase passenger cars, incl. subsidies for electric vehicles.

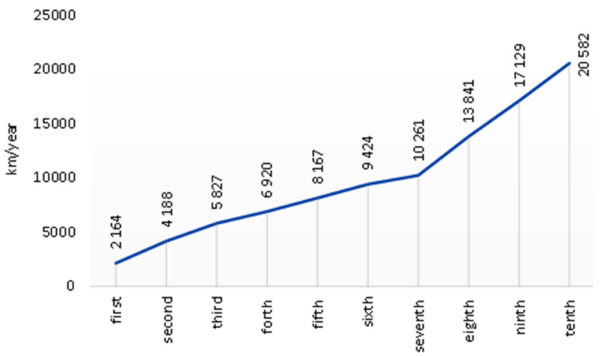

Figure 11. Distribution of average annual car mileage across deciles.

One important factor in assessing the distributional effects of carbon price on motor fuels is the multiple difference in average annual vehicle mileage across deciles: for the tenth decile, it is almost an order of magnitude higher, than for the first (Figure 11). The Russian statistical agency does not provide average vehicle mileage for the country as a whole or by deciles. These data were estimated based on the share of vehicle operating costs in consumer expenditures. The calculation also used data on the structure of the private car fleet by powertrain and the corresponding fuel prices. For gasoline, a slight quality adjustment for deciles was made. The multiple difference in mileage can be attributed to a variety of reasons. Poorer households tend to own cars with longer service life, despite their poorer technical shape. Average mileage per year of a car that has been in service for 15 years is almost twice lower, than of a new car[40]. People commute long distances only if they have higher salaries, than could be offered by the nearby employers. Many wealthy people live in the suburbs, because they have higher demand for personal space and privacy, and therefore are less inclined to use public transport, despite the time lost daily in traffic jams.

The first deciles benefit more from the implementation of the concept of peaking cars ownership and gradual cars electrification, which is necessary for the decarbonization of personal road transport. These measures reduce the share of personal fuel expenditures for all deciles. The average ECS_{inc} drops from 2.9% in 2022 to 2.1% in 2030 and to 1.2% in 2060. This decrease is associated with a reduction in the car ownership for the upper deciles and practical stabilization for the lower deciles due to the high (nearly prohibitive for the lower deciles) car prices, and later with the growing share of electric vehicles, the prices of which are expected to be substantially lower in 2060, than for liquid fuel-driven cars, and the costs of ownership will converge around 2030. The effect of ECS_{inc} reduction may be partially offset by an increase in the share of expenditures to purchase passenger cars. For example, in the USA, a 1% change in the share of fuel expenditures incurred a 0.3-0.4% change in the share of car purchase expenses (with the opposite sign[35]). In Russia, part of this effect will be offset by an increase in the share of spending on public transport and taxi services.

Introducing a carbon price for motor fuels has a weak regressive effect. On average, with a USD10/tCO_2 price in 2030, the ECS_{inc} will be 0.05% up, and with a USD108/tCO_2 price in 2060 the ECS_{inc} will be 0.3% up. These effects were assessed using the DEFEND and TRANS-GHG models with the following assumptions: Personal car ownership peaks and then decreases; fuel and electricity prices increase annually by inflation plus one percent plus the carbon price make-up component. Specific GHG emissions from power generation are borrowed from the 4D scenario[21]; specific fuel consumption decreases, as the fleet rotates and powertrain structure evolves in the 4D scenario; The structure of the vehicle fleet by power train evolves as in the 4D scenario.

The maximum increase in the share of public transport costs in income driven by the introduction of a carbon price does not exceed 0.05%. As private mobility declines, the share of income spent on public transport goes up. In 2012-2021, the share of expenses on public transport (for all types of transport) was down from 3% to 1.9% of total expenses. In 2022, it was back to 3%. In relation to income, it amounted to 1.7% in 2022. The ECS for public transport is 17-29% in sales, depending on the type of transport. The introduction of a carbon price of USD10/tCO_2 in 2030 and USD108/tCO_2 in 2060 will limit liquid fuel and electricity price growth to 10% and 6% respectively. As a result, only a limited increase in public transport expenditures can be expected. An investigation of the welfare effects of transport decarbonization policy portfolios (bus rapid transit network; fuel tax; 'fuel efficiency' policy assuming mandatory use of low emission vehicles) across 120 cities to 2035 shows that these three policies have positive effects (including for human health) ranging between 0.3 and 0.6%. Additional costs are estimated at 0.1% for bus rapid transit network; -0.1 for fuel tax; and 0.4 for fuel efficiency[41].

7 CONCLUSION

This paper is the first attempt to scope in distributional effects of a limited list of policies required to achieve carbon neutrality and to assess these effects for Russia. As climate policies are providing more and more significant effects on the distribution of economic costs and benefits, the assessment of distributional effects becomes a key for low-carbon transformation to be perceived as socially fair and to gain public support. The findings show that, after decades of following a state-controlled resource-based low productivity economic model, Russia, indeed, has little to lose in the transition to low carbon pathways. Moreover, a failure to launch effective decarbonization policies involves high risks of transition to a continuously shrinking economy. Transition to low carbon development will be associated with the diversification of income sources and more even wealth and incomes distributions. The reduced concentration of wealth will make it impossible to maintain the current ultra-centralized political system. Given the limited number of people employed in fuel extraction and processing, a gradual switch towards low carbon economy will have little impact on the labour market, which is facing severe shortages, but declining employment in coal-mining regions will require proactive decision-making. Carbon regulations will cause the prices of basic materials to substantially grow, but not beyond recently registered upper boundaries of their "natural" volatility.

For many simulated policies, assessments of the pressure sharing effects of decarbonization policies on households' expenses show they are regressive; however, sophisticated socio-economic engineering, careful planning and stakeholder engagement can significantly mitigate or even fully offset the adverse distributional impacts of such policies, which, in the end, will have neutral distributional effects.

This study and literature review highlight data and knowledge gaps to be addressed by future research. Calibration of models for separate income deciles requires bridging data gaps, such as differences in price elasticities, in car mileage, in acquisition prices for cars and living space, in quality of purchased fuels, in age of buildings, etc. Distributions of all such parameters across deciles are poorly studied yet, but they are crucial to assess policy outcomes. A better theoretical basis is required to address the sufficiency aspects for living space and car ownership. Furthermore, robust theory and tools are needed to supplement assessments of short-term direct effects by evaluation of indirect and long-lasting ones.

Acknowledgements

The author is grateful to Myshak A, Bashmakov V, Borisov K, Dzedzichek M, Lunin A, Lebedev O, and Shishkina T of CENEf-XXI for their assistance in data collection and models calibrating, and to R. Baron of 2050 Pathways Platform for his contribution to the discussion of the paper concept.

Conflicts of Interest

The author declared no conflict of interest.

Abbreviation List

4D scenario, Development driven by decarbonization and democratization
AAGR, Average annual growth rate
DEFEND, Distributional effect of national decarbonization
ECS, Energy cost share
EU, European Union
FHPUA, Federal housing and public utilities agency
GHG, Greenhouse gases
SDGs, Sustainable development goals
TFP, Total factor productivity

References

[1] Dechezleprêtre A, Fabre A, Kruse T et al. Fighting climate change: International attitudes toward climate policies. National Bureau of Economic Research. Cambridge, UK, July 2022.[DOI]

[2] Dabla-Norris ME, Helbling MT, Khalid S et al. Public perceptions of climate mitigation policies: Evidence from cross-country surveys. International Monetary Fund: Washington, USA, 2023.[DOI]

[3] Forrester SP, Satchwell AJ. Developing an Equity Framework for State Regulatory Decision-Making. Electricity Markets & Policy. Energy Analysis & Environmental Impacts Division. Lawrence Berkeley National Laboratory: Berkeley, USA, 2023.

[4] Büchs M, Cass N, Mullen C et al. Emissions savings from equitable energy demand reduction. *Nat Energy*, 2023; 8: 758-769.[DOI]

[5] Eurofound. Distributional impacts of climate policies in Europe, Publications Office of the European Union: Luxembourg, 2021.

[6] Qiu H, Sha Y, Zhang Y. Energy affordability and subjective well-being in China: Causal inference, heterogeneity, and the mediating role of disaster risk. *Energ Econ*, 2024, 129: 107180.[DOI]

[7] Gough I. Carbon mitigation policies, distributional dilemmas and social policies. *J Soc Policy*, 2013; 42: 191-213.[DOI]

[8] Zachmann G, Fredriksson G, Claeys G. The distributional effects of climate policies. *Bruegel Blueprint Ser*, 2018; 28: 2018.

[9] Markkanen S, Anger-Kraavi A. Social impacts of climate change mitigation policies and their implications for inequality. *Clim Policy*, 2019; 19: 827-844.[DOI]

[10] Burtraw D, Domeshek M, Keyes A. A review of how the economic impacts of different carbon pricing policies may be distributed across households. Carbon Pricing 104: Economic Effects across Income Groups. Accessed 4 May 2020. Available at:[Web]

[11] Ohlendorf N, Jakob M, Minx J C et al. Distributional impacts of carbon pricing: A meta-analysis. *Environ Reso*, 2021; 78: 1-42.[DOI]

[12] Vona F. Managing the distributional effects of environmental and climate policies: The narrow path for a triple dividend. OECD Environment Working Papers. OFCE: Paris, France, 2021.[DOI]

[13] Halsnæs K, Some S, Pathak M. Beyond synergies: understanding SDG trade-offs, equity and implementation challenges of sectoral climate change mitigation options. *Sustain Sci*, 2024; 19: 35-49.[DOI]

[14] Gancheva M, Akbaba B, Geraci M et al. Policy instruments to tackle social inequalities related to climate change. Policy Department for Economic, Scientific and Quality of Life Policies. Available at:[Web]

[15] Campagnolo L, De Cian E. Distributional consequences of climate change impacts on residential energy demand across Italian households. *Energ Econ*, 2022; 110: 106020.[DOI]

[16] Claeys G, Mouel ML, Tagliapietra S et al. 2024. Chapter 3 - The Distributional Effects of Climate Policy. In The Macroeconomics of Decarbonisation Implications and Policies. Cambridge University Press: Cambridge, UK, 2024.[DOI]

[17] Bashmakov I. Distributional effects of expected climate mitigation policies in Russia. Accessed 22 April 2024. Available at:[Web]

[18] Bennich T, Persson Å, Beaussart R et al. Recurring patterns of SDG interlinkages and how they can advance the 2030 Agenda. *One Earth*, 2023; 6: 1465-1476.[DOI]

[19] Carr-Whitworth R, Barrett J, Colechin M et al. Delivering net zero in the UK: twelve conditions for success. *Environ Res Lett*, 2023; 18: 074041.[DOI]

[20] Bashmakov I. On the implementation and analysis of the results of macroeconomic forecasts (seven matrices method). System for processing macroeconomic information. Nauka. 1987; 117-132.

[21] Bashmakov I, Bashmakov K, Borisov M et al. Russia's carbon neutrality: pathways to 2060. CENEf-XXI. Available at:[Web]

[22] Porfiriev BN, Shirov A, Kolpakov AY. Low-carbon development strategy: prospects for the Russian economy. *Mirovaia ekonomika i mezhdunarodnye otnosheniia*, 2020; 64: 15-25.[DOI]

[23] Porfiriev BN, Shirov AA, Kolpakov AY et al. Opportunities and risks of the climate policy in Russia. *VOPROSY ECONOMIKI*, 2022; 2022: 72-89.[DOI]

[24] Shirov AA. Sustainable development, climate, and economic growth: strategic challenges and solutions for Russia. Accessed 23 March 2021. Available at:[Web]

[25] Our World in Data. 2023. Total factor productivity, 1970 to 2019. Available at:[Web]

[26] KLEMS. National Research University Higher School of Economics. Accessed December 2019. Available at:[Web]

[27] Indices (ranepa.ru). Available at:[Web]

[28] Bashmakov I, Myshak A, Bashmakov VA et al. Russian energy balance, energy efficiency, and energy-related GHG emission accounting system. *Energ Effic*, 2023; 16: 67.[DOI]

[29] Bashmakov I, Myshak A, Bashmakov VA et al. Assessment of the technological factor contribution to energy efficiency improvements and to the evolution of energy related GHG emissions in Russia. Fundamental and Applied Climatology. 2023; 9: 403-431. Available at:[Web]

[30] Shirov AA, Kolpakov AY. Target Scenario of Low Greenhouse Gas Emissions Socio-Economic Development of Russia for the Period until 2060. *Stud Russ Econ Dev*, 2023; 34: 758-768.[DOI]

[31] Bashmakov I, Bashmakov V, Borisov K et al. Russia on the pathways to carbon neutrality: forks on roadmaps. Accessed December 2023. Available at:[Web]

[32] Bashmakov I, Bashmakov VA, Myshak A et al. Sanctions and CBAM: Implications for the Russian industry. Accessed December 2022. Available at:[Web]

[33] Buckley RM, Gurenko EN. Housing and income distribution in Russia: Zhivago's legacy. World Bank Res Obser, 1997; 12: 19-32.[DOI]

[34] Bashmakov I, Myshak A.Analysis of factors driving energy intensity of gross regional product for FR regions. Energosberezhenie (Energy saving). 2024. Available at:[Web]

[35] Bashmakov I, Myshak A. “Minus 1” and Energy Costs Constants: Sectorial Implications. *J Energy*, 2018; 2018: 8962437.[DOI]

[36] Bashmakov I. Readiness and willingness of population to pay for housing and communal services. *VOPROSY ECONOMIKI*, 2004; 2024: 136-150.[DOI]

[37] European Commission. Commission staff working paper. An energy policy for consumers. Accessed 2010. Available at:[Web]

[38] Eurostat. Living Conditions in Europe, 2014 Edition, European Union, 2014. Available at:[Web]

[39] Hinson S, Bolton P. Fuel poverty. The House of Commons Library, UK Parliament. Accessed 24 March 2023. Available at:[Web]

[40] Methodology for estimating the residual value of vehicles with an account of their technical condition. Methodology for estimating the residual value of vehicles with an account of their technical condition. Kontur.Normativ (kontur.ru). Accessed 12 August 1998. Available at:[Web]

[41] Liotta C, Viguié V, Creutzig F. Environmental and welfare gains via urban transport policy portfolios across 120 cities. *Nat Sustain*, 2023; 6: 1067-1076.[DOI]