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Assessment of the impact of greenhouse gas emissions reduction measures on the social and economic situation in Uzbekistan

UZBEKISTAN | 2020

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CONTENT

ACRONYMS/SYMBOLS USED

CDM	Clean Development Mechanism
CC	Climate change
CCGT	Combined cycle gas turbine
CMI	Construction materials industry
DEV	Devaluation
dlab(j)	Share of sector j in employment structure across all industries
DSW	Domestic solid waste
ECI	Economic Complexity Index
EML_IND	Employment in Sector
ENI	Energy intensity
EXP	Export
FAOLU	Forestry and other land uses
FDI	Foreign Direct Investment
FEC	Fuel and energy complex
FoC	Freedom from Corruption
GEF	Government Effectiveness
GHG	Greenhouse gases
GTU	Gas-turbine unit
GDS	Gross Domestic Savings
(INF)	Inflation
INV	Investments
IPM	Industrial processes and manufacturing
IPPC	Intergovernmental Panel on Climate Change
I-O Approach	Input-Output Approach
KOF	Globalization Index
Lab	Labor
NDC	Nationally determined contribution
NRS	Natural rent
RES	Renewable energy sources
RoL	Rule of law index
SBPE	Small business and private entrepreneurship
SDGs	Sustainable Development Goals
TPP	Thermal power plant
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
Uzhydromet	Hydrometeorological Service Center of the Republic of Uzbekistan
UZS	Uzbek Soum (national currency)
WDI	World Development Indicators
WDI	World Development Indicators (Индикаторы мирового развития)

Introduction

Uzbekistan committed to the global climate change response immediately after the adoption of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992. The Convention seeks to achieve a stable concentration of greenhouse gases in the Earth's atmosphere at a level that would not allow dangerous anthropogenic influence on the climate system. Uzbekistan signed the Convention in 1993, ratified the Kyoto Protocol[1] in 1999, and in 2017 signed the Paris Climate Agreement[2], which "replaced" the Kyoto Protocol.

On its way towards implementing the Paris Agreement, Uzbekistan formulated its own commitments (its nationally defined contributions or NDCs) to reduce greenhouse gas (GHG) emissions. The country's contribution is to help reduce specific emissions per unit of GDP by 10% by 2030 compared to 2010.

The current task is to define a new amount of Uzbekistan's emission reduction commitments for the next period (up to 2030). Although the Paris Agreement does not provide for a binding mechanism for the member-states to declare and achieve their NDCs, it nevertheless requires "ambition" and "progress" in their revision. . In other words, the subsequent commitment amount is supposed to be larger than the previous.

However, ambitious NDCs mean a transition to an active climate policy, or a transition from the "brown" development scenario (the current model of economic development with a focus on energy sector) to the "green" development scenario (implying climate change mitigation and adaptation measures). The transition to "green" development will require huge investments that should seek to respond to socio-economic challenges of development. Moreover, the amount of these investments increases with the increase of NDC ambitions (i.e. with stricter emissions reduction measures). The size of the new commitments should be optimal, i.e. such that the costs of achieving such level of ambitions do not exceed the costs of eliminating the negative socio-economic effects that may arise as it is achieved.

The purpose of this analysis is to develop recommendations for formulation of new Uzbekistan's emissions reduction commitments in the context of the Paris Agreement through the assessment of the emissions reduction measures' impact on the socio-economic situation in the country.

This analysis comprises 6 sections and 6 annexes.

Section One describes Uzbekistan's current involvement in global climate change response and gives an overview of where it stands regarding its current emissions reduction commitments.

Section Two proffers 8 conclusions/hypotheses which were subsequently reflected in the calculation methodology used to assess the impact of emission reduction measures on the socio-economic situation in Uzbekistan. The findings are based on the analysis of 29 current studies published over the past 10 years.

Section Three presents the results of the analysis of the conditions that shape specific emissions dynamics in Uzbekistan. It consists of three parts:

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[1] The Kyoto Protocol was signed in 1997 in Kyoto, Japan. The goal is to combat global climate warming by reducing emissions in developed countries and countries with economies in transition by 5.2% compared to 1990.

[2] Law of the Republic of Uzbekistan "On the ratification of the Paris Agreement" No. 491 of 02.10.2018.

1) Analysis of specific emissions dynamics by the key emitting sectors for the period of 1990-2017. For the calculations, the statistics of Uzhydromet (the amount of emissions) and the State Statistics Committee (the volume of production by sector) were used);

2) Analysis of the macroeconomic and institutional conditions that influenced the scale of specific emissions in the key five emitting sectors in Uzbekistan for the period of 1990-2017. These conditions were "searched" by the method of pairwise correlation and the method of econometric modeling among a large number of macroeconomic and institutional indicators contained in the World Bank database (World Development Indicators, WDI).

3) Comparison of specific emissions dynamics in Uzbekistan with worldwide green development benchmarks. As such, the average estimate of the size of specific emissions among the top 15 developing countries that have shown the best results in reducing CO2 emissions per $ 1 of GDP over the past 15-20 years was calculated. These countries, in turn, were selected from 75 developing countries around world available in the World Bank database (WDI).

Section Four presents calculations of the full scale of emissions, that is, not only for the five key GHG emitting sectors (direct emissions), but also for all 78 sectors that form Uzbekistan's economy (direct and indirect emissions). Although these calculations are crucial for assessing the scale of possible social and economic effects, such calculations have never done in Uzbekistan before. Indirect emissions can only be estimated based on model calculations. These calculations are based on the "Input-Output" Model[3] using the multiplier technique.

Section Five contains calculations of the impact of emissions reduction measures on economic indicators (output) and social indicators (employment, income from employment) exemplified by the energy sector. The choice of the sector is determined by the fact that the most complete information is available for this sector to model the consequences of resource saving measures. The effects that should be expected for the economy when implementing resource-saving measures in the energy sector (reducing the unit cost of natural gas for the production of a unit of electricity) are modeled on the basis of the Input-Output model.

Section Six proffers recommendations to consider national interests (in social and economic aspects) when identifying new commitments of the country to reduce emissions (in the context of the Paris Climate Agreement).

[3] The Input-Output model refers to the balance sheet method of forecasting economic phenomena – the traditional and most common ones in the economy. The balance sheet method involves the development of balance sheets, which are a system of indicators in which one part, which characterizes resources by source of income is equal to the other showing the distribution (use) in all directions of their consumption.

1. Uzbekistan›s involvement in the global climate change response: the current status of its emission reduction commitments

Uzbekistan committed to the global climate change response immediately after the adoption of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992. Uzbekistan signed the Convention in 1993 and ratified the Kyoto Protocol in 1999. The country's representative in the UNFCCC is its Hydrometeorological Service Center (Uzhydromet) under the Cabinet of Ministers of the Republic of Uzbekistan.

Cooperation with the UNFCCC involves submitting periodic country reports in the form of National Communications providing a complete picture of all measures that have been taken, currently implemented and planned in the country to address climate change (CC) related challenges. Preparation of national communications results from analysis, research and extensive consultations with government ministries and departments, think tanks, expert communities and non-governmental organizations. Most of the calculations are based on the UNFCCC guidelines.

The first national communication was prepared in 1999. It included data from the inventory of GHG emissions for 1990-1994, materials for calculating GHG emissions, an assessment of Uzbekistan's vulnerability to climate change, and a general description of climate change mitigation and adaptation measures.

The second national communication was prepared in 2008. It complemented the emissions database including an assessment of the mitigation potential, vulnerability and adaptive capacities of different sectors of the economy, an assessment of risks and needs to develop early warning systems for climate hazards. It also analyzed the compliance of the systematic observations with the requirements of the Global Climate Observing System and the principles of climate monitoring.

The third national communication was prepared in 2016 with the results of the emission inventory for the period of 1992-2012, the observed changes in climate characteristics, as well as an analysis of policies and measures to reduce emissions for CC adaptation.

After the ratification of the Kyoto Protocol, Uzbekistan adopted a number of regulatory tools and policies to handle CC such as the National Strategy for Sustainable Development (1999), the Strategy for Water Conservation and Rational Water Use in Irrigated Agriculture (1999), and the National Strategy for Reducing Greenhouse Gas Emissions (1999). In 2006, the country established the Inter-Agency Council for Clean Development Mechanism (CDM)[4] Projects and the National Authority for the CDM (Ministry of Economy), while endorsing the

[4] In essence, CDM is the opportunity for developed countries to implement emission reduction projects in developing countries and receive "certified emission reductions" (CERs) which they took into account when they evaluated the progress with their own national emission reduction targets.

Regulations on the Implementation of CDM Projects[5] and launching extensive works to improve hydrometeorological services.[6]

The Kyoto Protocol was replaced by the Paris Climate Agreement (adopted in December 2015, entered into force on November 4, 2016). The goal of the agreement is to step up efforts to keep the global average temperature rise by 2100 at 2 0C lower than that of the pre-industrial era and to do everything possible to keep global warming within 1.5 0C (currently, the average temperature is 0.75 0C higher than the annual average in 1850-1900). The participating countries formulate their Nationally Determined Contributions (NDCs) or Intended Nationally Determined Contributions (INDCs) to achieve this global goal, reviewing them once every 5 years. The Agreement does not provide for a mechanism to compel countries to declare the NDCs, nor to be bound to achieve it.

Uzbekistan signed the Paris Agreement on April 19, 2017. The country's contribution implies a reduction in the negative impact on the climate in the form of a reduction in specific emissions per unit of GDP by 10% by 2030 compared to 2010.

In order to implement the Paris Agreement, a number of legal acts were adopted:

- The program of measures for the development of renewable Energy (RES) and energy efficiency improvement for 2017-2021,[7] as well as the decision of 2019,[8] provide for bringing the share of RES in the total volume of electricity generation to 25% by 2030.
- The 2030 Agenda for National Sustainable Development Goals and Targets.[9] The indicator "CO2 emissions per unit of value added" is indicator 9.4.1 from the list of indicators for the implementation of the National SDGs until 2030. Thus, progress in reducing emissions is mandatory for inclusion in Uzbekistan's Voluntary National Review of Progress on the SDGs.
- 2019-2030 Strategy to transition to a "green" economy. It envisages: a) reduction of specific emissions per unit of GDP by 10% from the level of 2010; b) twofold increase in energy efficiency and reduction of the carbon intensity of GDP; c) development of RES with bringing their share to 25% or more of the total electricity generation.[10]
- The Agricultural Development Strategy for 2020-2030[11] provides for: a) reduction of water use per 1 ha of irrigated area by 20% until 2030; b) reduction of agricultural greenhouse gas emissions by 50%."
- The Environmental Protection Concept 2030[12] contains numerous goals, including in the field of environmental protection: a) reducing emissions by 10%; b) switching 80% of pub-

[5] Resolution of the Cabinet of Ministers of the Republic of Uzbekistan "On approval of the Regulation on the procedure for the preparation and implementation of investment projects under the Clean Development Mechanism of the Kyoto Protocol" No. 9 of 10.01.2007.

[6] Resolution of the Cabinet of Ministers of the Republic of Uzbekistan "On improving the Hydrometeorological Service of the Republic of Uzbekistan" No. 183 of 14.04.2007.

[7] Resolution of the President of the Republic of Uzbekistan "On the Program of measures for the further development of renewable energy, improving energy efficiency in sectors and the social sphere for 2017-2021" No. 3012 of 26.05.2017.

[8] Resolution of the President of the Republic of Uzbekistan "On accelerated measures to improve the energy efficiency of economic and social sectors, the introduction of energy-saving technologies and the development of renewable energy sources" No. 422 of 22.08.2019.

[9] Resolution of the Cabinet of Ministers of the Republic of Uzbekistan "On measures to implement the national goals and objectives in the field of sustainable development for the period up to 2030" No. 841 of 20.10.2018.

[10] Resolution of the President of the Republic of Uzbekistan "On approval of the Strategy for the transition of the Republic of Uzbekistan to a "green" economy for the period 2019-2030. No. 4477 of 04.10.2019.

[11] Decree of the President of the Republic of Uzbekistan "On approval of the Strategy for the Development of Agriculture of the Republic of Uzbekistan for 2020-2030" No. 5853 dated 23.10.2019.

[12] Decree of the President of the Republic of Uzbekistan "On approval of the Concept of Environmental Protection of the Republic of Uzbekistan until 2030" No. 5863 dated 30.10.2019.

lic transport to gas-cylinder fuel and electric traction; c) increasing the forest fund to 4.5 million tons. ha; d) bringing the coverage of the population with services for the collection/export of solid waste to 100%; e) an increase in the volume of solid waste processing to 65%; f) an increase in the volume of processing of specific waste (packaging, batteries, mercury-containing waste, tires, used oils, etc.) to 30%.

Below is an estimate of the volume of emissions for the period of 1990-2017 prepared by Uzhydromet based on an inventory of emissions (Table 1). It includes:

- emissions of 4 direct greenhouse gases: carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O) and hydrofluorocarbons (HFCs). Estimates of CH4, N2O, and HFCs emissions are converted to CO2 equivalent units;
- emission estimates for the sectors with the highest emissions: energy (methane leakage sub-sector in the Natural Gas Processing category); industrial processes and production, including F-gases (Ammonia production. CO2 emissions", "Nitric acid production. N2O emissions", "Cement production"); agriculture, forestry and other land uses (category "Forest land remaining forested"); waste (category "Solid waste disposal in landfills»).

Uzbekistan is strongly committed to the Paris Climate Agreement to reduce greenhouse gas (GHG) emissions. The country is committed to reducing the specific emissions per unit of GDP by 10% by 2030 compared to 2010.

Emissions in 2017 totaled 177.8 million tons of CO2-eq. (excluding CO2 uptake in the "Land Use" sector) and 173.1 million tons of CO2-eq. taking into account the CO2 uptake in the "Land Use" sector. In 1990-2017, emissions decreased by 6.3%, and in 2010-2017-by 5.4%. Furthermore, taking into account the absorption capacity of forests, emissions decreased by 2.5% and 3.5%, respectively.

TABLE 1 GREENHOUSE GAS EMISSIONS IN UZBEKISTAN DURING 1990-2017, MILLION TONS OF CO2-EQ.

Year	Energy	Industrial processes	Agriculture	Wastes	Total emissions	Forestry and other land use	Net emissions
1990	165.2	8.4	14.1	1.9	189.6	-12.1	177.5
2000	200.9	5.8	14.7	2.4	223.8	3.7	227.5
2010	162.8	8.3	23.3	2.5	196.9	8.4	205.3
2013	128.6	8.1	26.6	2.6	165.9	5.2	171.1
2014	130.9	8.6	27.4	2.6	169.5	-2.6	166.9
2015	124.3	8.3	28.5	2.6	163.8	-4.1	159.6
2016	129.0	8.6	29.9	2.6	170.1	-4.7	165.4
2017	136.1	8.3	30,6	2.7	177.8	-4.7	173.1
Trend							
Δ(1990-2017)	-17,6%	-1.2%	117.7%	40.4%	-6.3%	61.4%	-2.5%
Δ(2013-2017)	5.8%	3.0%	15.2%	2.0%	7.1%	-190.2%	1.2%
Contribution							
1990%	87.1%	4.4%	7.4%	1.0%	100.0%		
2013%	77.5%	4.9%	16.0%	1.6%	100.0%		
2017%	76.6%	4.7%	17.2%	1.5%	100.0%		

Source: Hydrometeorological Service Center (Uzhydromet).

The largest share of emissions is accounted for by carbon dioxide (CO2), its contribution to the total emissions was 58% in 2017. Methane (CH4) accounted for 36%, nitrous oxide (N2O) for 6.7%, and hydrofluorocarbons (HFCs) for 0.2%.

The largest contribution to the volume of emissions is made by the energy sector – 76.6% and the Agriculture sector – 17.2%. The “PPIP” sector accounts for 4.7%, while the “Waste” sector accounts for 1.5%.

Since 1990, there has been a tendency to reduce the contribution of the energy sector to total emissions (from 87.1% to 76.6%) and to increase the contribution of the agriculture sector (from 7.4% to 17.2%) due to the growth of livestock and the use of nitrogen fertilizers. The contribution of the “PPIP” and “Waste” sectors remained almost unchanged. In the Forestry and Other Land-use (LLDW) sector, there were significant changes in CO2 uptake and emissions in 1990-2017, but overall, the contribution of this sector to total emissions is insignificant (about 2.5%).

Overall, the inventory showed an upward trend in non-energy emissions. During 1990-2017, their share in total emissions increased from 18% to 34%.[13]

The assessment showed that Uzbekistan fulfilled its year 2030 emissions reduction commitments already in 2017. It is necessary now to determine how much new volume of NDCs the country can take until 2030 and what should guide such determination. The new NDCs should be more ambitious, because the Paris Agreement implies “ambitiousness” in reviewing national NDCs. However, an ambitious NDC means a transition to an active climate policy, that is, a transition to a “green” development scenario (measures to prevent IR and adapt to IR). The transition will require huge investments (for example, the high cost of electricity based on renewable energy sources). The new NDCs should be such that the cost of achieving it does not exceed the cost of eliminating the negative socio-economic effects that may arise as it is achieved. Moreover, the costs (investments) increase as the ambition of the NDCs increases (i.e., as the strictness of the climate policy increases). This is important to take into account when determining the optimal size of Uzbekistan’s new emission reduction commitments.

[13] Source: Hydrometeorological Service Center (Uzhydromet) of the Republic of Uzbekistan.

2. Methodological aspects of assessing the impact of emissions reduction measures on the economic and social situation: A review of the literature and alternative hypotheses

In the world practice, there is no "approved" methodology that assesses the impact of measures to reduce emissions on the socio-economic situation in countries implementing the "green" development scenario. There are separate assessments on various aspects of this impact, including the example of individual countries. The United Nations Environment Programme (UNEP) is currently preparing the Global Assessments Synthesis Report[14] which aims to consolidate key global assessments and collaboration in modelling, communication strategies and information activities. This initiative is a collaboration between the International Panel on Climate Change (IPCC), the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES), the Global Environment Outlook (GEO-6), the Global Sustainable Development Report (GSDR), and the International Resources Group (IRG).

The analysis of modern works (29 sources) published during 2010-2020 allowed drawing a number of conclusions that were taken into account when developing a methodology for assessing the impact of measures to reduce emissions on the economic and social situation in Uzbekistan.

1. There is no single point of view on assessing the socio-economic effects of the transition to a "green" economy. On the one hand, the transition to the "green" format is accompanied by a loss in GDP (for example, the UK's losses in achieving carbon neutrality are estimated at 1-2% of GDP per year).[15] Another approach is that instead of fighting the CC (including reducing emissions), it is more appropriate to adapt to it. The cost of attaining these purposes is estimated at approximately 500 billion US dollars annually for the entire humanity.[16] There is also a fundamentally different view that the choice between climate action and economic growth is a false dichotomy. Countries can achieve their climate goals and at the same time increase their incomes.[17]

[14] Source: https://www.unep.org/resources/assessment/global-assessments-synthesis-report

[15] Source: the assessment was announced at the seminar "Russia, the United Kingdom and the world on the trajectories of low-carbon development", February 28, 2020, together with the forum "Oil and Gas Dialogue" of IMEMO RAS of Russia, Moscow.

[16] Assessment of the Director of the Institute of National Economic Forecasting of the Russian Academy of Sciences (B. Porfiriev) at the II All-Russian Conference " Analysis and Forecasting of the Development of the Russian Economy (March 2020, Novosibirsk).

[17] Source: A study by a group of scientists from China, " Self-preservation Strategy for Achieving Global Warming Goals in the Post-Paris Agreement Era "(April 2020). Experts represent the Center for Energy and Environmental Policy Research, the Beijing Institute of Technology, the School of Management and Economics, and the Beijing Key Laboratory for Energy Economics and Environmental Management. The article was published in Connection with Nature https://www.nature.com/articles/s41467-020-15453-z

2. Most studies in the field of climate policy assess the physical consequences of CC (deterioration of water and air quality, rising temperatures, loss of agricultural products, damage from increased extreme weather conditions, etc.). These risks are well studied and evaluated. The assessment of the impact of green policies on socio-economic indicators is reflected only in certain aspects (for example, the impact of investment growth in certain "green" areas on certain macro indicators-GDP, energy and carbon intensity of GDP). There is no methodology for assessing the impact of the "green" scenario on social indicators (human health, income, quality of life, migration, etc.). The lack of prioritization of social goals leads to their exclusion from the "green" scenario of socio-economic development and slow progress in the implementation of climate strategies.[18]

3. The choice of social and economic goals of the "green" scenario depends on the level of development of the country. The target indicators of different countries reflect different accents of the "green" scenario: in developed countries, competition and jobs are in the first place; in developing countries-sustainable development, solving poverty problems, issues of justice and citizen participation in decision-making; in BRICS countries-resource efficiency. For Uzbekistan, the most significant social indicators are employment and income of the population.

4. The effects of implementing climate policies for employment are mixed. In the short and medium term, the implementation of the "green" scenario will reduce employment in the sectors that will undergo liquidation/modernization. In the long term, the number of jobs should increase due to the emergence of labor-intensive green industries/sectors. This reinforces the importance of selecting the sectors of the "green" scenario for Uzbekistan, in which even short-term job losses can be very sensitive due to the difficult employment situation.

The situation in the field of employment also requires careful selection of technologies that are expected to implement the "green" scenario. World experience shows that the transition to "green" technologies leads to the disappearance of jobs in informal types of employment and routine technological processes.[19] The conclusion is relevant for Uzbekistan, where informal employment is high and has a primitive low-tech character.

5. Efforts to reduce emissions limit the demand for fossil fuels and reduce their price, which carries risks for energy exporters and, as a result, a decrease in the GDP growth rate and the well-being of the population in energy-exporting countries.[20] Thus, for Russia, the achievement of the Paris Agreement by 2030 will lead to a decrease in the annual GDP rate by 0.2-0.3 percentage points, and further tightening of the climate policy will lead to an additional annual decline in GDP by 0.5 percentage points.[21] Such a negative impact will occur due to a decrease in the volume of energy exports – the main factor of Russia's GDP growth in the current "brown" development model. This situation is also relevant for Uzbekistan (natural gas makes up a significant part of export revenue).

6. Many combinations of measures can be used to reduce the negative CC effects, but they all affect: 1) technology, 2) behavior, and 3) policy.[22] These areas can be considered as channels of influence for Uzbekistan's "green" development scenario.

7. Assessment of the amount of investment for the implementation of the "green" scenario on the basis of tools that enable prioritizing projects. This will make it possible to distinguish

[18] Work of the HSE Center for Environmental Economics and Natural Resources "Social consequences of climate change building climate friendly and resilient communities via transition from planned to market economies", 2019. The paper presents estimates of the impact of climate risks on the situation in 27 countries of Central and Eastern Europe (CEECCA).

[19] Source: Asian Development Outlook, 2018 "How technology affects jobs", ADB 2018.

[20] Source: Condon M., Ignaciuk A. Border carbon adjustment and international trade, OECD Working Paper, No.6, 2013.

[21] The study "The consequences of the Paris Climate Agreement for the Russian economy", I. A. Makarov, H. Chen, S. V. Paltsev, 2018. Published in the journal " Questions of Economics», 2018. № 4.

[22] Source: IPCC Climate Change Report, 2014 http://ecology.gov.kg/public/images/file_library/2017042415424212.pdf

between “climate” and “other” investments in investment programs, so that it becomes possible to correctly calculate the socio-economic effects of “green” investments. Currently, the issue is debatable for many countries, including Uzbekistan.

8. Limiters of the “green” scenario. The positive impact of the green scenario may face limitations that may reduce its effectiveness and scale. In particular, not always and not all “green” sectors and technologies are environmentally friendly and efficient, much depends on the specific technology, company, industry. While some entities gain three-fold (reducing emissions at the same time as production costs, creating new jobs, and increasing profits), others lose out: costs exceed revenues and losses occur instead of profits, and often production is closed and jobs are lost.

The analysis of the publications allowed developing a methodology for assessing the impact of measures to reduce emissions on socio-economic indicators in relation to Uzbekistan. In general, the approach consists in conducting model calculations at the macro and sector levels:

I. Assessment of the conditions necessary to achieve the emission reduction goal. Analysis of specific emissions by sectors with direct emissions (energy, chemicals (ammonia production), building materials (cement), transport, agriculture) and evaluation of different hypotheses about the impact of macroeconomic and institutional factors that shape the dynamics of emissions. For this purpose, an econometric analysis of the World Bank database (WDI) for more than 200 countries and data on the volume of emissions in Uzbekistan (data from Uzhydromet) was carried out.

II. Assessment of changes in social indicators under different scenarios of transition to “green” development at sector level. The transition to a green economy is impossible without knowing which sectors can be classified as environmentally efficient, and what their potential is to increase employment and income growth. This requires a sectoral analysis of the carbon intensity of the economy and its social orientation. To do this, the authors used the Input-Output method (I-O Table)[23] in the form of the Leontiev model, supplemented with a block of emissions and social indicators (number and income of employees). The method allows calculating emissions for all 78 sectors that form the economy of Uzbekistan (and not only for the main 5 sectors).

III. Assessment of the impact of emission reduction measures on economic and social indicators exemplified by the energy sector, taking into account the “brown” and “green” scenarios (the characteristics of both scenarios are given in Annex 2).

The “brown” scenario assumes the preservation of the current priorities of economic policy and factors/sources of economic growth. This includes:

- growth of income from the exports of metals, gas, agricultural products and processing of mineral resources with a low share of added value (mainly at large enterprises established in the Soviet period);
- expansion of the sector (small business and private enterprise) SBPE in traditional sectors (trade, catering, transport, agriculture);
- preservation of income from the export of labor resources (external labor migration);

[23] I-O tables give an idea of the flows of goods and services, representing each indicator in a 3-dimensional coordinate system: by aggregation levels (the first dimension is macroeconomic and sectoral); by use (the second dimension is goods/services for final consumption (including household consumption, government spending, investment, exports); for production purposes (intermediate consumption), by source of origin (the third dimension is local production or import). For each industry and for the economy as a whole, the basic balance sheet identities are fulfilled: a) production is equal to consumption; b) equality of GDP by any measurement method – the production method (the sum of value added for all sectors); the method of calculation by final consumption; the method of calculation by factor value. For a detailed description of the Model, see Annex 1.

- technological modernization of existing production facilities (mainly low-profit ones), focused on the import of technologies and professionals.

The “green scenario” focuses on the transition to a resource-saving, low-carbon development model. It has two alternatives (traditional and socially oriented scenarios):

- “Green” scenario 1 (traditional “green” low-carbon development):
- accelerated implementation of energy -, resource-and nature-saving technologies;
- traditional technological model (purchase of imported technologies, equipment, specialists, without attempts to develop their own domestic technological base and production facilities with a completed technological cycle);
- established sources of financing for green projects (public budget and external loans).

“Green” scenario 2 (socially oriented low-carbon “green” development):

- selective climate financing of projects with the best combination of emission reduction indicators and social indicators;
- a new model of technological modernization (strengthening the contribution of technology to solving social and environmental problems through the development of its own technological base and production facilities for processing local raw materials with a complete technological cycle).

3. Conditions that shape the emissions dynamics: Analysis of global experience and sectoral specific emissions in Uzbekistan

Sectoral trends in specific emissions. The analysis of specific emissions dynamics in transport (Figure 1) allows distinguishing three periods: 1997-2005-the period of reduction of specific emissions, 2006-2012-the period of relative stability, and 2013-2017-the period of rapid growth of specific emissions, which reached the level of 2000. The main reason for the increase in specific emissions is a moderate increase in freight traffic (by only 1.8%) during 2013-2017, with an increase in emissions of almost 12%, as well as an explosive increase in the number of cars.

Among other sectors (Figure 2), the greatest progress in reducing specific emissions has been made in the energy sector: from 1.027 tons/thousand kWh in 1990 to 0.952 tons/thousand kWh in 2000 and to 0.51 tons/thousand kWh in 2017, or twice in almost 30 years.

FIGURE 1 DYNAMICS OF SPECIFIC EMISSIONS IN THE «TRANSPORT» SECTOR (2000 = 100%)

Source: authors' calculations based on data from Uzhydromet and the State Statistics Committee

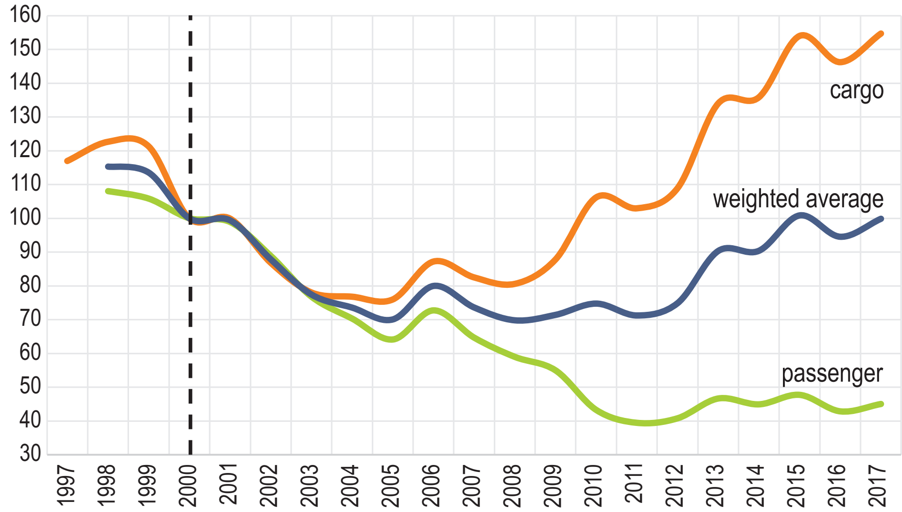
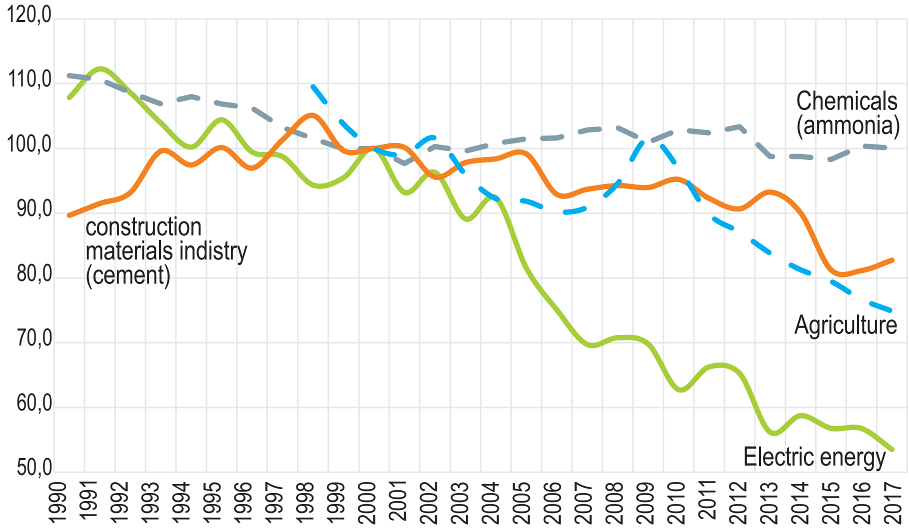


FIGURE 2 DYNAMICS OF SPECIFIC EMISSIONS BY SECTORS «CHEMICAL INDUSTRY» (AMMONIA), «CONSTRUCTION MATERIALS INDUSTRY» (CEMENT), «ENERGY», «AGRICULTURE» (LIVESTOCK FARMING) (2000 = 100%)

Source: authors' calculations based on data from Uzhydromet and the State Statistics Committee



INSET 1: ALGORITHM FOR ANALYZING SPECIFIC EMISSIONS BY SECTOR

Sources of information

- emission statistics – Uzhydromet;
- sector output in physical terms (million kWh, thousand tons of ammonia, cement, meat, milk, etc.) and investments – State Statistics Committee;
- macroeconomic, structural and institutional indicators (statistics of the World Bank and other international organizations).

Calculation of specific emissions: specific emissions = emissions in thousand tons/output in physical terms (thousand tons).

The use of natural indicators allows evaluating the distorting influence of the price factor. In terms of output, such factors include: for the «chemical» industry – ammonia production indicator (thousand tons); for the energy sector – power generation (million kWh); for the «CMI» sector – cement production (thousand tons); for «agriculture» – the volume of meat and milk production (thousand tons). Indicator of production in transport is reflected in the weighted average estimate of passenger turnover indicators (billion passenger seats) and cargo turnover (billion tons km). The weights are selected based on the share of passenger and cargo turnover in the value of the total volume of transport services.

For comparability, the specific emissions for different sectors were recalculated as a percentage of the value of this indicator for the year 2000.

To account for all the factors that affect specific emissions dynamics, relative indicators and international indices are used, some of them are formed based on cost indicators. These include: investment in the sector as a percentage of the gross output of the sector (for example, INV_EN – investment in energy, see the list of indicators in Annex 3). It should also be borne in mind that investment in a sector may differ from investment in the type of production that is the source of emissions. For example, investment in agriculture may differ from investment in livestock, the main source of agricultural emissions. To fine-tune the indicators, one needs detailed statistics of sectoral investments in the context of types of products that are not publicly available.

In agriculture, until 2009, specific emissions (in terms of a ton of milk/meat) were volatile, and since 2010, the indicator began to decline as a result of increased milk and meat production. During 2000-2017, emissions increased by 2.1 times (from 14.1 to 29.3 million tons), meat production by 2.7 times, and milk production by 2.8 times.

Since 2000, there has been a moderate decline in specific emissions in cement production. If in 2000 the indicator was 0.451 tons of emissions per ton of cement, then by 2017 it decreased to 0.374 tons of emissions per ton of cement, or by 17%. In the chemical industry (production of ammonia) during 1990-2000, there was a moderate tendency to reduce specific emissions, after which this indicator remained until 2018.

In 2011, in transport and agriculture, the favorable trend of reducing specific emissions was replaced by an unfavorable one (an increase in specific emissions). The reasons are the rapid growth of the cattle population in the absence of proper processing of animal waste, as well as the slowdown in the freight turnover of railroad transport. This poses the risk of falling short of the country's commitments to reduce emissions compared to 2010.

Conditions that shape specific emissions dynamics. The most well-known is the technological hypothesis suggesting that specific emissions should decrease as the share of resource-saving technologies in the structure of fixed capital increases.[24] The authors were unable to obtain data on the share of new technologies in the sectors that are direct emitters of emissions. Therefore, to analyze the hypothesis, a close indicator of "investment in the sector" (in % of the sector's output) was used to determine the scale of technological modernization of any sector.

The analysis of the dynamics of sectoral specific emissions in 2000-2017 allowed identifying two categories of sectors. The first category includes sectors that have a stable tendency

[24] The third national communication sets the task of halving the energy intensity of the economy by 2030 (in 2013, the energy saving potential was estimated at 22.7 million tons of oil equivalent). This will reduce emissions by 53.1 million tons of CO2-eq. It also indicates priority energy – and resource-saving technologies in direct-emission sectors (p. 174).

to reduce specific emissions (energy and CMI). The second includes sectors with mixed dynamics of emissions (agriculture and transport) and without progress (chemical).

A comparison of the average (by year and by sector) estimates of specific emissions and investments for each category suggests that, in general, the technological hypothesis is confirmed. The average investment for the first category of sectors (23.4%), where specific emissions decreased (the average annual rate of emissions reduction was (-2.6%)), is almost 2 times higher than for the second category of sectors (13.8%) with mixed dynamics of specific emissions (the average annual rate of reduction of specific emissions is close to 0).

TABLE 2 AVERAGE ANNUAL ESTIMATES OF INVESTMENTS (IN% OF THE SECTOR›S OUTPUT) AND THE RATE OF CHANGE IN EMISSIONS (%) BY SECTORS AND CATEGORIES FOR 2005-2017.

Categories	Sectors	Investments	Specific emissions	Investments, average by category	Specific emissions, average by category
Category 1	Energy sector	35.7	-3.9	23.4	-2.6
	Construction materials industry	11.1	-1.3		
Category 2	Chemical industry	24.4	1.5	13.8	0
	Transport	13.1	0		
	Agriculture	3.8	-1.5		

Source: calculations based on the initial series of indicators given in Annex 4 (Table 1,2)

However, the pattern is broken among sectors within categories. For example, the average annual investment in transport was 13.1% compared to 3.8% for agriculture (both sectors in the second category). At the same time, the average annual rate of reduction of specific emissions in agriculture was (-1.5%), and in transport – about 0%. Therefore, a high level of investment does not guarantee a transition to "green" development and additional conditions are needed.

Additional conditions forming sectoral specific emissions were "searched" by the pairwise correlation method among a number of macroeconomic and institutional indicators (Tables 1, 3, Annex 4). The analysis showed that none of the three indicators of investment activity (FDI_gdp is the share of foreign direct investment in % of GDP, GDS_gdp is gross domestic savings in % of GDP, GFC_gdp is gross investment in fixed assets) have any relation to specific emissions (Table 3, Annex 3), except for transport (relation to FDI (R2=-0.57) and gross domestic savings (R2=-0.7)).

In the energy sector, there is a weak relationship with foreign direct investment (FDI_gdp) and gross fixed capital investment (GFC_gdp). The corresponding correlation coefficients for them are below the threshold values of -0.40 and -0.46 (the threshold value is 0.5).

For the chemical industry, a positive relationship was found with all indicators of investment activity (correlation coefficients +0.68, +0.61 and +0.73, respectively). This means that with the growth of investment in the sector, there is not a decrease, but, on the contrary, an increase in specific emissions, indicating the ineffectiveness of programs for the modernization of the chemical industry.

On the other hand, industrialization is a contributing factor to the green transition. Talking about this negative correlation coefficients between the share of employment in sector (led industrialization) and specific emissions in the energy sector, CMI and agriculture (-0.96, -0.78, -0.73, respectively, refer to the cells in the Table.3).

For the “transport” sector an important factor in the reduction of specific emissions is the overall export growth (indicator EXP_gdp, R2= of -0.76) and the complexity of the economy indicator (ECI, R2=-0,66).

The greatest impact on the reduction of specific emissions is the globalization of the national economy (the KOF Globalization index, which combines economic, political and social globalization). This is evidenced by the high negative correlation coefficients for 4 out of 5 analyzed sectors (from -0.54 to -0.88). Channels for the impact of globalization on emissions: a) more favorable conditions for the import of resource-saving technologies and b) improving the quality of human capital in the context of deepening social globalization.

In addition, it is impossible to move to a “green” economy without achieving the global average quality standards of state institutions. This is indicated by the high values of correlation coefficients (from (-0.52) to (-0.82)) for 3 out of 5 sectors in two of the three indicators of the development of institutions (RoL is the level of compliance with law, GEF is government effectiveness).

TABLE 3 ASSESSMENT OF THE LEVEL AND DIRECTION OF THE INFLUENCE OF MACROECONOMIC, STRUCTURAL AND INSTITUTIONAL FACTORS ON THE DYNAMICS OF SPECIFIC SECTORAL EMISSIONS

Factors	Impact on specific emissions	Specific manifestations
Investment factor (FDI_gdp, GDS_gdp, GFC_gdp) (growth in investment activity)	Mixed impact	Of the 5 analyzed sectors, only transport was found to have a negative relationship with emissions (for FDI_gdp -0.57 and GDS_gdp -0.70). For two sectors (chemical and CMI), a positive relationship was obtained (an increase in specific emissions with an increase in investment). No link found for other sectors.
The level of industrialization of the economy (EML_IND) (growth of the industrial sector)	Positive impact (reduces specific emissions)	High values of the coefficients of pairwise correlation between the industrialization indicator EML_IND and specific emissions for the "energy", "construction materials industry", and "agriculture" sectors (-0.96, -0.78, -0.73)
Foreign economic factor (EXP, EXP_gdp, KOF) (growth in the openness and globalization of the economy)	Overall positive impact, especially on the KOF globalization indicator	For the KOF index, significant negative correlation coefficients were obtained for 4 out of 5 sectors analyzed (from -0.54 to -0.88). For the EXP_gdp index, a negative correlation with specific emissions was obtained for two sectors (energy and transport), and only for one sector (chemical) it was positive.
Energy intensity and pressure on natural capital (ENI, NRS_GDP) (growth in energy intensity and use of natural capital)	Very negative impact (leading to increased specific emissions)	For the energy intensity indicator ENI with three out of five sectors, high (> 0.5) direct correlation coefficients were obtained (from +0.79 to +0.98, energy, CMI, agriculture). For the indicator of natural rent NRS_GDP, there is a direct relationship (growth in emissions) for the chemical, CMI, and agriculture sectors (from +0.48 to +0.62).
Institutional factors (RoL FoC GEF) (stronger government institutions)	Positive impact on emissions reduction	Negative correlation coefficients for three of the five sectors and for two of the three indicators (from -0.52 to -0.82, energy, CMI, agriculture, RoL, GEF).
Macroeconomic stability ((INF), DEV) (stronger stability)	Positive impact reinforcing stability in emissions reduction	Positive correlation between growth in (INF) inflation and growth in emissions (in four out of five sectors, from +0.47 to +0.74), as well as between an increase in DEV devaluation rates and emissions (in two out of five sectors).

Source: summary of data in Table 4 of Annex 3.

FIGURE 3. 15 DEVELOPING COUNTRIES WITH THE LOWEST EMISSIONS (KG CO2 PER $ 1 OF GDP)

Source: Calculations using the World Bank database (WDI).

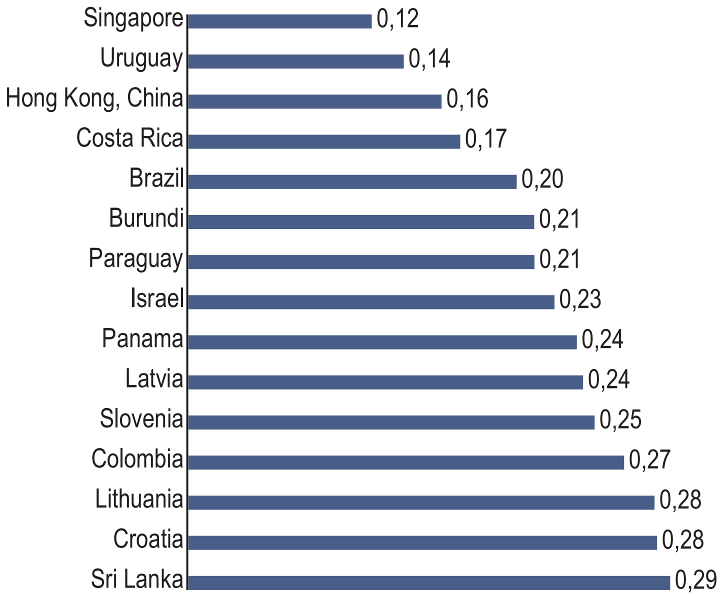
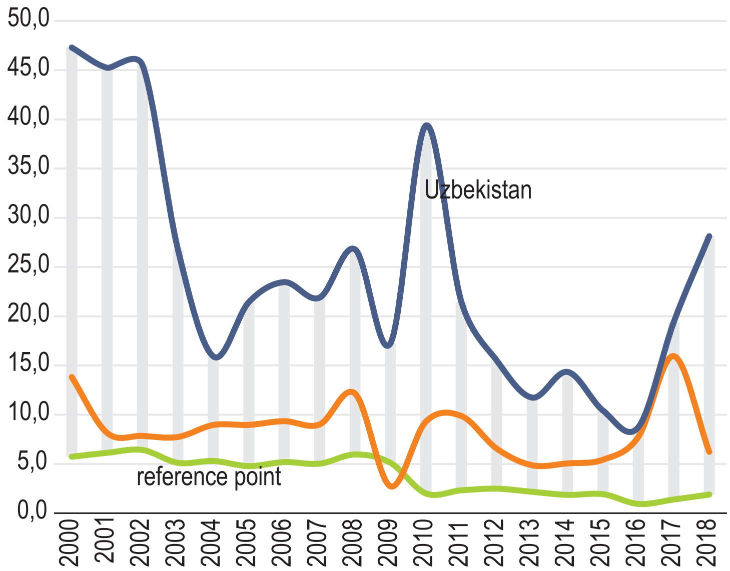


FIGURE 4 INFLATION IN UZBEKISTAN AND BENCHMARKS FOR «GREEN» DEVELOPMENT (BY GDP DEFLATOR, %)

Source: Calculations using the World Bank database (WDI).



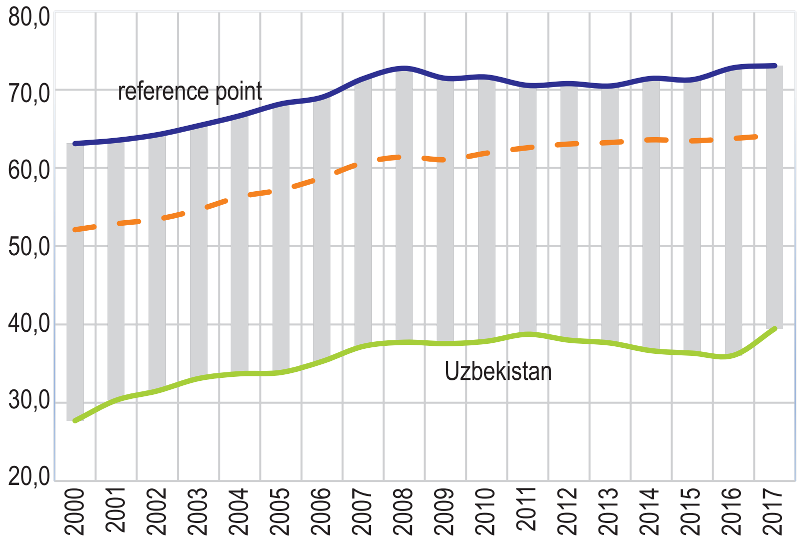
A negative impact on specific emissions is made by factors such as high energy intensity (ENI, from +0.79 to +0.98, Table.3); high load on natural capital (natural rent indicator NRS_gdp, from +0.48 to +0.62); high inflation ((INF), from +0.47 to +0.74), as well as a high rate of devaluation of the Uzbek soum (DEV, from +0.54 to +0.83). The conclusions remain relevant even with a time lag of one year (Table 5 in Annex 4), indicating their stability.

The results of the analysis (Table 3) suggest the main conclusion. Investment activity alone is not enough to reduce specific emissions and shift the economy to low-carbon development. Equally important are the degree of integration of the economy into the world economy, the reduction of the burden on natural capital, the quality of state institutions, the level of inflation and the rate of devaluation of the national currency.

Comparison with the world benchmarks of "green" development. As such, a sample of 75 developing countries was analyzed, among which the top 15 countries were selected (Figure 3); this showed the best results in the last 15-20 years in terms of CO2 emissions per 1 dollar of GDP.

FIGURE 4 GLOBALIZATION INDEX (KOF) IN UZBEKISTAN AND BENCHMARKS OF «GREEN DEVELOPMENT» (FROM 0 TO 100)

Source: Calculations using the World Bank database (WDI)



The average rating for the top 15 group can become a reference point when creating the necessary macroeconomic and institutional conditions for reducing emissions in Uzbekistan.[25]

According to one of the main indicators of macroeconomic stability – inflation – the gap between Uzbekistan and world benchmarks has been rapidly growing in recent years (Figure 4), reinforcing the need for more effective measures to limit inflation in the context of further liberalization of the national economy.

almost 40 units, reflecting the intensification of the country's integration into the world economy. However, the Index values also increased for other developing countries. As a result, the gap between Uzbekistan and the world benchmark has hardly narrowed, reflecting the lack of efforts to integrate Uzbekistan into the world economy that have been made over the past 15-20 years. Without such efforts, the country's transition to an effective "green" economy may significantly slow down.

[25] The rationale behind the choice criteria used by developing countries comparable to Uzbekistan can be found in the article by S.V. Chepel "Энергоемкость развития и предпосылки ее ограничения: эконометрический анализ с акцентом на страны СНГ" ("Energy intensity of development and the prerequisites for its limitations: an econometric analysis with a focus on the CIS countries")// Finance and Credit. – 2017. – Vol. 23, No. 40. – pp. 2420-2436. https://doi.org/10.24891/fc.23.40.2420

4. Socio-economic effects: Calculation of the full scale of emissions and the multipliers of the extended impact

To assess the scale of possible social and economic effects, it is important to have an estimate of emissions not only for the main 5 sectors with direct emissions, but also for the other 73 sectors of the economy that can also contribute to the total emissions. Such calculations have never been done before. Below is an attempt at such a calculation based on the Input-Output model using the multiplier technique.

Output multiplier by final product (GDP). An important advantage of the I-O method is the ability to obtain an estimate of the economy's response to changes in final consumption for any sector and for any value. This is achieved by using a matrix of direct cost coefficients, which reflects the relationship between the sectors for the production and consumption of intermediate products. For example, the position in the matrix " a5 33 = 0.145" means the amount of gas (sector 5) in UZS, spent for the production of 1 thousand UZS of electricity (sector 33), etc. This allows analyzing the cost structure of any sector, including intermediate costs, labor costs, transportation costs, capital costs, as well as the distribution of sector products for the needs of other sectors, as well as for the needs of end-use.

To identify the sectors that are most sensitive to changes in final consumption, the multiplier calculation technique is used. It shows how the value of the indicator for the economy as a whole will change when the final consumption of any sector changes by the same amount (usually by 1). For example, the output multiplier for the final product for the sector "agriculture" (sector 1) mult(X(1)) = 1.6 means an increase in output for the economy as a whole with an increase in the final consumption of the products in the "agriculture" sector (for example, for fruit and vegetable products) per unit (for example, by 1 million UZS).

The output multiplier for the final product is always greater than one. This is due to the fact that an increase in consumption, for example, for agricultural products per unit, will require an increase not only in output for agriculture (direct effect), but also for other related sectors, depending on the value of the direct cost coefficients (direct cost matrix: for agriculture itself-by 0.326, for wholesale and retail trade-by 0.0127, for fertilizers-by 0.011, for transport-by 0.0047, etc.) – an indirect effect resulting from waves of consumption growth initiated by an increase in the final consumption for agricultural products per unit.

In turn, an increase in the production of, for example, fertilizers (sector 19) in response to an increase in demand from agriculture will create additional consumption of electricity (a33 19 = 0.1272). This will increase the demand for gas and so on in all technological chains in all sectors, which will be reflected in the value of the mult(X(1)) = 1.6 multiplier, which will significantly (1.6 times) exceed the value of the initial growth in consumption in agriculture, equal to 1. That is, the full assessment of the economy's response to the growth of final consumption per unit is 1.6 times higher than the direct estimate.

Based on the specifics of intersectoral relationships, the growth of final consumption by the same amount (for example, by 1 million UZS) for different sectors has a different impact on the economy according to different indicators. Thus, the average value of the output multiplier for the final product mult(X(j)) for 2016 was 1.504. However, its value differs by sector: from 1.132 (healthcare) to 2.130 (tailoring), 2.117 (textiles and textile products), 2.086 (sports and entertainment services), etc. The higher the value of the multiplier, the higher the values of the direct cost coefficients of the sectors (the material intensity of the sector) and the wider the technological relationships of the analyzed sector with other sectors.

The multiplier of emissions for the final product. The multiplier technique opens up opportunities for finding sectors that meet different criteria, one of which is emissions. With the conventional approach, the assessment is possible only for a narrow range of sectors in which the fuel combustion process takes place, i.e. direct emissions.[26] In fact, any sector uses electricity, transport, agricultural products and other goods, the production of which is associated with emissions. The use of the multiplier technique allows estimating the contribution of any of the 78 sectors of the economy of Uzbekistan to the increase in emissions.

In this case, an increase in the final consumption for any sector j will lead to an increase in output not only for this sector, but also for all other technologically related sectors (almost all 78 sectors), including the above-mentioned 7 sectors with direct emissions. The amount of the increase in emissions for these 7 sectors caused by the increase in final consumption for sector j per unit[27] is the multiplier of the emissions of the j-th sector for the final product mult(EM(j)).

Calculations using this approach have shown that all sectors contribute to emissions regardless of fuel use. The average value of the emission multiplier for the final product was 754 kg of CO2 eq. by one million UZS of the growth of the final products of the sector (in 2016 prices) with a wide range of sector estimates – from 69 kg (for financial services) to 11,268 kg for the electric power sector. The multiplier value is higher for commodity-producing sectors (890 kg) and lower for the service sector (650 kg). From this point of view, the sectoral emissions multiplier mult(EM(j)) can be considered as the carbon footprint of the sector's products, since it enables ranking sectors by the criterion of their contribution to emissions under equal conditions with respect to the growth of final consumption for their products.

The largest amount of emissions does not only come from sectors that use fuel in their activities (electricity, metallurgy, etc.), but also a number of services sectors (Table 4). This is due to the fact that the structure of their costs is dominated by products that use hydrocarbons (electricity, metals, chemicals, etc.). Thus, the high value of emissions in the sector "Services of sewer systems; sewage sludge" – 2,549 kg – is due to the use of energy-intensive equipment. This is expressed in the fact that out of 0.308 UZS of intermediate product costs per 1 USZ of sector output, 0.2145 UZS accounted for electricity costs, 0.0247-costs of chemical products, 0.0122-metallurgical products, 0.0247-costs of rubber and plastic products (I-O Table).

A number of service sectors are characterized by high unit costs not only for energy, but also for transport services. So, in the sector 76 "Services to member organizations", the value of

[26] Agriculture – 245 kg/million soums of output; chemicals-644 kg; mineral products (mainly cement) – 459 kg; metals (steel) – 137 kg; electricity, etc. items – 10,611 kg; waste disposal services-7125 kg; transport services – 375 kg/million soums of output.

[27] The technique for calculating the emission multiplier is similar to calculating the output multiplier for the final product, for which the formula is used: *mult (X(j)) = ∑idij*, where dij is coefficients of total production costs (in this case, interpreted as an additional volume of output of the industry i, required to increase the final consumption for the industry j per unit). When switching to the emission multiplier, each additional volume of output dij is multiplied by the value of specific emissions per unit of output of the industry *i emi /xi* , whose values are not equal to zero only for the 7 sectors with emissions listed above. The calculations also take into account the absorption of emissions by forests *i =2*, where this coefficient has a minus sign. The calculation formula has the form: *mult(EM(j)) = ∑idij * (emi /xi).*

TABLE 4 UZBEKISTAN'S TOP 15 SECTORS WITH THE HIGHEST VALUES OF EMISSION MULTIPLIER

Sectors and areas of activity	Direct emissions in tons per 1 million UZS of output	Total emissions with an increase in the final product by 1 million UZS (multiplier)	Excess of total GHGs (multiplier) over direct GHGs (specific GHG emissions per 1 million UZS of output)
Electricity, gas, air conditioning	10.61	11.268	1.062
Waste collection, treatment and removal services; waste disposal services	7.13	8.714	1.222
Sewer systems services ; sewage sludge	-	2.549	-
Natural water; water treatment and water supply services	-	2.523	-
Chemical products	0.64	2.446	3.822
Services provided by affiliates	-	1.757	-
Paper and paper products	-	1.711	-
Other non-metallic mineral products	0.46	1.262	2.74
Metallic ores	-	1.148	-
Sports. entertainment and recreation services	-	1.064	-
Other individual services	-	0.895	-
Bituminous coal and brown coal (lignite)	-	0.888	-
Transport services		0.875	2.303
Basic metals	0.38	0.829	5.921
Public administration and defense services; social security services	-	0.714	-

Source: Calculations based on Uzhydromet's data (on emissions), also see I-O Tables..

transport services is 0.04 (the second place after the cost of electricity is 0.1351 UZS per 1 UZS of services).

Of great importance is the excess of total emissions (direct emissions + indirect emissions) over direct emissions (third column, Table 4). The greater the excess, the higher the indirect emissions. Indirect emissions can be estimated only on the basis of model calculations, allowing to identify sectors in which the introduction of resource-saving technologies (all other things being equal) will bring the maximum effect in terms of reducing emissions in the economy as a whole, accelerating the transition to a "green" economy.[28] The calculation showed that such sectors include chemicals (production of mineral fertilizers and ammonia – 3.82); mineral industrial materials (cement production – 2.74); transport – 2.3; metallurgy – 5.92.

[28] Obtaining more accurate calculations requires additional research, taking into account the indicators of investment costs for a typical resource-saving project for each of these sectors, the period and conditions of their payback.

A similar approach is used to identify the sectors that make the greatest contribution to solving social problems. For this purpose, the employment multiplier for final product and the income from employment multiplier for final product were calculated.

The employment multiplier for the final product. If, in the formula for calculating the final product emission multiplier (see footnote 21), the sector's GHG emission per unit of output emi/xi is replaced by the employment per unit of output Labi/xi, the employment multiplier for the final product mult(Lab(j)) can be calculated. It shows how employment will increase in the economy as a whole with an increase in the final consumption for the products of sector j per unit.

The calculation of the employment multiplier indicates that the sectoral structure of the economy is poorly connected with solving the problem of low employment. Growth of the final product (GDP) by 1 billion UZS. The amount leads to an increase in new jobs by only 31 units on average per sector. Moreover, different sectors have different potential for creating new employment with GDP growth of 1 billion UZS: from several units (mainly for commodity-producing sectors: oil and gas production; production of cars and components; oil refining – 7 units each, metallurgy – 8 units, rubber and plastic products – 9 units. etc.) up to 100 units. and more (mainly, services: veterinary – 99 units, postal and courier-108 units, social – 142 units).

The main barrier to higher employment levels in the services sectors is the specifics of the products. Services are "non-tradable goods", they cannot be sold on the foreign market (except for tourism and some transport services), i.e. almost all services are focused on the domestic market, which has a limited capacity in conditions of low income of the population. This significantly hinders the growth of the service sector and the creation of new jobs in it.

Multipliers enable outlining the sectors for which a moderate rate of increase in emissions with an increase in consumption for products is combined with the greatest contribution to employment growth. Such economic growth can be considered a socially oriented "green" economic growth.

To determine these sectors, it is necessary to first identify the sectors where the emission multiplier is lower than the sector average estimate. Then, among the sectors identified, one needs to select the sectors for which the employment multiplier is higher than the sector average estimate. When moving from the original scale of multiplier estimates to the normalized scale,[29] this means choosing industries with estimates of 1.3 times or more for the employment multiplier and from 0.7 or less for the emissions multiplier. In graphical form, this condition means a pool of industries located in the second quadrant (Figure 5). According to the criterion of emissions and employment, the socially oriented environmentally efficient segment of the economy (quadrant II) includes only service industries-health (0.162 for emissions and 2.038 for employment), education (0.22; 1.93), employment services (0.135; 1.28), a total of 14 industries. They are the most promising objects of state support, as their development leads to both lower emissions and increased employment. These industries account for only 10.2% of GDP, but 36% of all employment and 31% of the income from employment.

However, as already mentioned, the prospects for the development of service industries are limited by the small capacity of the domestic market. In addition, in quite many of them there is an increased risk of job losses as the process of digitalization of the economy deepens. In addition, the service sector is the most vulnerable sector when quarantine restrictions are imposed, as shown by COVID-19. Most industries are in the third quadrant. With a moderate increase in emissions, this pool of industries does not make a significant contribution to

[29] For example, for the industry j=58 (research and development) the initial estimate of the employment multiplier is equal to mult(Lab(58)) =56, and the normalized estimate is 56 (industry multiplier)/31 (industry average multiplier for the economy as a whole) = 1.83.

FIGURE 5 DISTRIBUTION OF SECTORS BY ZONES (QUADRANTS) WITH HIGH (>> 1) AND LOW (<< 1) GROWTH RATES OF GHG EMISSIONS AND EMPLOYMENT

Source: Calculations of relevant multipliers based on the I-O Tables for 2016

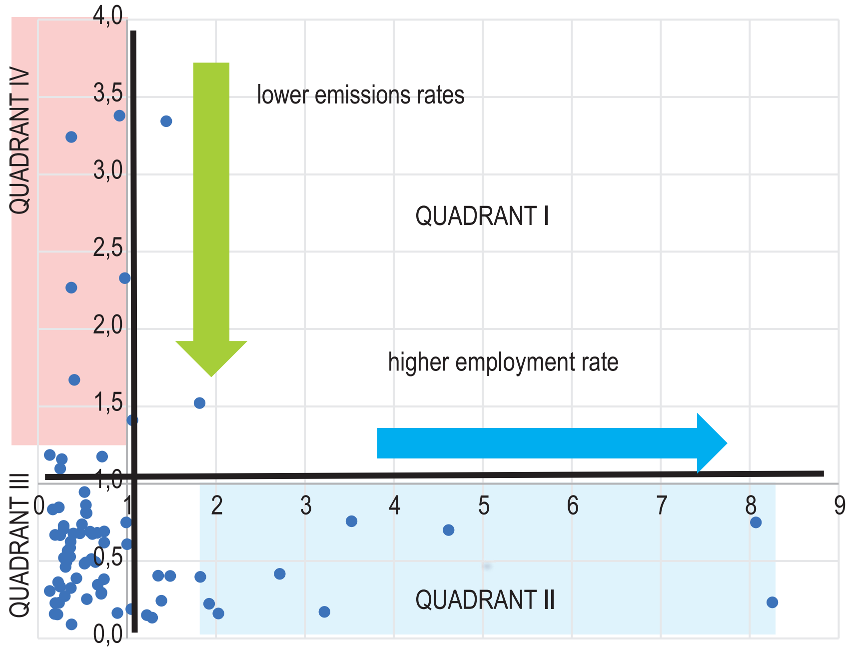
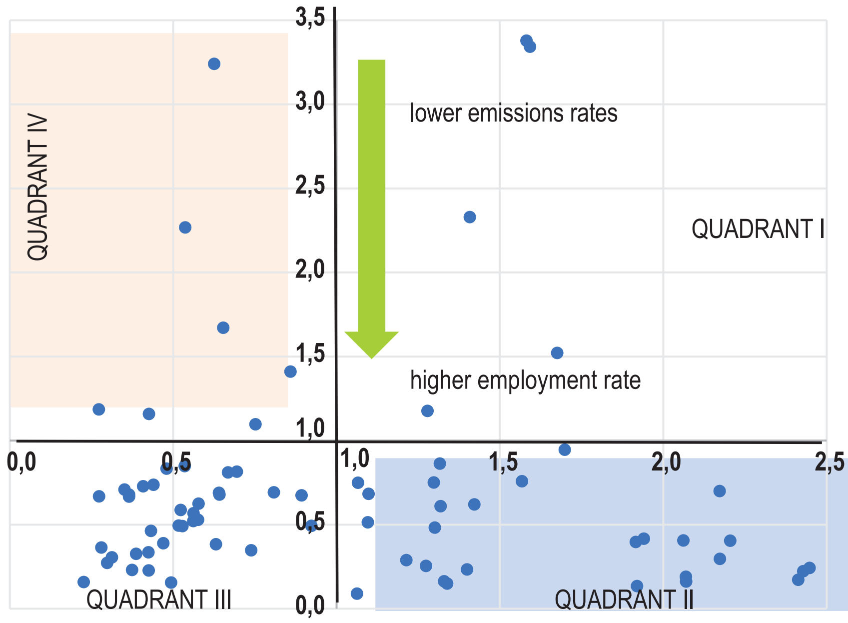


FIGURE 6 DISTRIBUTION OF SECTORS BY ZONES (QUADRANTS) WITH HIGH (>> 1) AND LOW (<< 1) GROWTH RATES OF GHG EMISSIONS AND EMPLOYMENT INCOME

Source: Calculations of relevant multipliers based on the I-O Tables for 2016



higher employment levels, since the normalized employment multiplier for them is significantly less than 1. This result is another argument in favor of the conclusion about the weak social orientation of the current structure of the economy and indicates the need for its transformation in the direction of industries and sectors with the greatest employment potential.

The income from employment multiplier by the final product. The average value of the multiplier was 0.367 (with an increase in final consumption of 1 billion UZS the income from employment in the economy as a whole increases by 367 million UZS). The multiplier values vary by sector. For example, for education -2.53 times, for social services -2.44 times, for building maintenance and landscaping -2.3 times, etc. Stimulating the consumption in these areas will maximize revenues and, consequently, restore demand in the economy, which is especially important at the stage of its post-crisis recovery.

An analysis of the estimates of the normalized income multiplier relative to the emissions multiplier (Figure 6) shows that the transition to a “green” economy is better consistent with the growth of household income than with the growth of employment, since the number of industries that fall into the second quadrant (21 industries) is significantly higher than for the employment multiplier (Figure 6). However, services (education, health, employment, veterinary services, consulting, etc.) also predominate among them. The exception is only one sector for the production of goods (other vehicles and equipment), which has the opportunity to bring its products to the foreign market, thereby expanding employment and income of the population.

Integral multiplier. The obtained multipliers can be used to assess the degree of social orientation of the structural shifts resulting from "green" development. To do this, it is enough to measure the social effect per unit of emissions. If the effect increases over several years with a decrease in emissions or their growth rate, then one can talk about socially oriented "green" development. If the social impact is reduced, there is a traditional "green" development focused on reducing emissions, regardless of the impact of such policies on employment and other social indicators.

A possible approach to the estimation of this indicator is to use multiples of employment and income, calculated on a unit multiplier emissions and averaged by sector taking into account the weight of sector in the structure of employment or income structure:

$$SGD(Lab) = \sum_j dlab(j)*(mult(Lab(j)) / mult(em(j)) / 78$$

$$SGD(Inc) = \sum_j dInc(j)*(mult(Inc(j)) / mult(em(j)) / 78$$

where:

dlab(j) is the share of sector j in the structure of employees (employment factor);

dInc (j) is the share of sector j in the total income from employment (the income from employment factor);

(em(j)) is the share of sector j emissions in total emissions (the emission factor).

The integral indicator of a green policy's social orientation may look as 0.7SGD(Lab) + 0.3SGD(Inc). The weight values of the factors (employment (Lab) and income (Inc)) can be changed as social goals are achieved (for example, if external labor migration is high, the employment indicator cane be increased, while if labor migration decreases, the share of the income indicator can be increased). The calculation showed that for Uzbekistan SGD(Lab) = 2.16, SGD(Inc) = 0.025, and the integral indicator is 1.52.

5. Assessment of the impact of emission control measures on social and economic indicators (exemplified by the Energy sector)

The sector that has the most complete information available to model the effects of resource conservation measures (emission control) is energy. A UNDP study showed in 2015[30] that the introduction of modern combined-cycle gas and gas turbine technologies (CCGT and GTU) would reduce specific fuel consumption to 175 g o.e./kWh. In this case, the total amount of fuel burned at the seven existing thermal power plants[31] would be reduced to 36% compared to the current volume, and resource savings would amount to 4.2 million tons of oil equivalent or 5.16 billion cubic meters of natural gas. Investments for the reconstruction and new construction of seven thermal power plants are estimated at $4 billion, and additional income from energy efficiency measures alone, as suggested by the most conservative estimate, will be at least $1.5 billion. The effects that should be expected in this case for the economy as a whole are modeled by changing the I-O model by the following positions:

1. Reduction of specific gas consumption per unit of electricity. The initial coefficient of direct gas costs (sector 5) per unit of electricity output (sector 33) a5 33 = 0.145 will decrease by:

$$36\% * 47{,}7/ 58{,}6 = 29{,}3\%,$$

where:

36% is a decrease in the total amount of fuel burned at the 7 TPPs;

47.7 / 58.6-the share of TPPs in the total amount of electricity generated in the country.

The new value of the direct cost ratio will be: a5 33, equal to 0.145*(1-0.293) = 0.103.

2. Reduction of emissions per unit of output of the electric power sector. The baseline level of emissions 10,611 tons per 1 billion UZS of electricity generation decreases by the amount of reduction in natural gas consumption (29.3%), adjusted for the fact that emissions from fuel combustion account for about 71% of emissions in the sector:[32] by 29.3*0.71 = 20.8%. The new value of specific emissions will be: 10,661*(1-0.208)=8,444 tons per 1 billion UZS of electricity generation.

3. It is expected that the reduction in electricity production costs will provide an equal increase in profits, which will be equally divided into: a) financing the development of production (including the repayment of loans taken for the modernization of equipment) and b) increasing the income from employment. Based on the I-O Table the value of cost reduction can be determined:

$$(0.145-0.103)\ 106.96 \text{ billion UZS} = 449 \text{ billion UZS},$$

[30] Towards sustainable energy: a strategy for low-carbon development in the Republic of Uzbekistan. UNDP, Tashkent 2015, p. 31.

[31] Syrdarya TPP, Novo-Angren TPP, Tashkent TPP, Navoi TPP, Takhiatash TPP, Angren TPP, Angren TPP, Talimarjan TPP

[32] Towards sustainable energy: a strategy for low-carbon development in the Republic of Uzbekistan. UNDP, Tashkent 2015, p.9.

where:

0.145 and 0.103 are the original and new (reduced) direct cost coefficients,

10696 billion UZS is gross output of the electric power sector (sector 33).

The amount of income from employment will increase by 449/2 = 225 billion UZS and will amount to 225 + 1675 = 1,900 billion UZS. New revenue of $ 1 billion UZS of output will increase to 1900/10696 = 0.178 against the initial estimate of 0.157 (before the transition to new electricity generation technologies).

4. The cost of technological renewal of the electric power sector for 7 TPPs in the amount of $ 4 billion can be used to compare possible macroeconomic effects and investment costs (for example, reducing emissions by $ 1 million of investments), and to justify the choice of those industries where positive macroeconomic effects per 1 million UZS of investments reach their maximum values.

The simulation indicates mixed economic and social consequences of measures to modernize the energy sector (decrease in the unit cost of gas per unit of electricity and emissions).

Increase in resource efficiency. Before modernization, the growth of final energy consumption by 1 billion UZS led to an increase in output for the economy as a whole by 1.632 billion UZS (output multiplier by final consumption mult X(33)). Decrease in unit gas consumption per unit of electricity generation by 29.3% will lead to an increase in output for the economy as a whole, not by 1.632 billion UZS but 1.573 billion UZS or by 59 million UZS less. This reflects the decrease in the economy's material intensity, hence the growth of its competitiveness. Output multipliers for energy-related industries are also decreasing: by 13 million UZS for the sectors “water supply” (including irrigation) and “sewerage services”; by 9 million UZS for “chemical products” and “paper and paper products”.

Emissions reduction. Reduction of emissions from the baseline level of 10611 tons per 1 million UZS of electricity up to 8,444 tons combined with a reduction in material consumption will lead to a reduction in the emission multiplier (Table 5) for most industries: 2,310 kg/1 million UZS for electric power sector, 515 kg/1 million UZS for sewerage services, 511 kg/1 million UZS for water supply, 20 kg/1 million UZS for agriculture, 19 kg/1 million UZS s for the automotive sector, 18 kg/1 million UZS for employment services, 13 kg/1 million UZS for financial services.

The sector-wide estimate of the emission multiplier during the modernization of the energy sector will significantly decrease: from 754 kg of emissions per 1 million UZS of the growth of final consumption up to 631 kg or 16% testifying to the importance of large-scale resource-saving measures in the energy sector during the transition to low-carbon development.

Of the 15 sectors with the largest reduction in the emission multiplier, the first 10 sectors include only 4 sectors with direct emissions (Table 5, electric power, waste management, chemicals, cement). Reduction of emissions for the remaining 6 sectors with an increase in final consumption for their products by 1 million UZS is due to technological links in terms of consumption and intermediate products with the electric power sector and other industries where fossil fuels are burnt, as well as a decrease in material consumption when implementing resource-saving technologies. This confirms the conclusion that it is important to introduce energy– and resource– saving technologies not only in sectors with direct emissions, but also in industries and services that have close technological relationships in the consumption of energy and water resources, products of the chemical, metallurgical, cement industries and transport services. Modeling allows identifying these sectors as well as assessing the effects of the introduction of resource-saving technologies not only for this sector but also for the economy as a whole.[33]

TABLE 5 15 SECTORS WITH THE LARGEST DECREASE IN THE EMISSION MULTIPLIER COMING WITH THE INTRODUCTION OF RESOURCE-SAVING TECHNOLOGIES IN THE ELECTRIC POWER SECTOR (T/MILLION UZS OF GROWTH IN SECTOR'S OUTPUT)

Sector #	Sector code	Sector of economy	emissions multiplier		
			before modernization of electric power sector	after modernization of electric power sector	reduction
1 (33)	D35	Electricity, gas and conditioned air	11.268	8.959	-2.310
2 (36)	E38	Waste collection, treatment and removal services; waste disposal services	8.714	8.552	-0.162
3 (19)	C20	Chemical products	2.446	2.100	-0.346
4 (35)	E37	Sewer system services; sewage sludge	2.549	2.034	-0.515
5 (34)	E36	Natural water; water treatment and water supply services	2.523	2.012	-0.511
6 (76)	S94	Services provided by affiliates	1.757	1.408	-0.349
7 (16)	C17	Paper and paper products	1.711	1.371	-0.340
8 (22)	C23	Other non-metallic mineral products	1.262	1.121	-0.141
9 (6)	B07	Metallic ores	1.148	0.917	-0.232
10 (75)	R93	Sports, entertainment and recreation services	1.064	0.860	-0.204
11 (40)	H49-51	Transport services	0.875	0.782	-0.093
12 (78)	S96	Other individual services	0.895	0.725	-0.170
13 (4)	B05	Bituminous coal and brown coal (lignite)	0.888	0.717	-0.171
14 (23)	C24	Basic metals	0.829	0.701	-0.127
15 (68)	O84	Public administration and defense services; compulsory social security services	0.714	0.585	-0.129

Source: Calculations based on the I-O Model.

Limited ability to combine measures for the modernization of the electric power sector with the solution of social problems. The calculation of multipliers (Figures 5, 6) showed that the second quadrant (the most promising in terms of the transition to socially oriented "green" development) includes the same 13 service industries as before the modernization of the sector (health, education, employment services, veterinary medicine, consulting, etc.). Among them, there are no commodity-producing industries that have the greatest prospects for expanding the market for products and creating new jobs. This indicates the need for a

[33] So, for the "water supply" sector, with the current cost of 366 thousand UZS per 1 million UZS s of the gross output of 262 thousand UZS accounted for the costs of the products of these sectors with direct emissions. For sewer systems services, respectively, 371 thousand UZS s and 266 thousand UZS, paper and products made from it – 370 thousand UZS and 164 thousand UZS, i.e. about half of all costs and more.

selective approach in the modernization policy, implementing it at the initial stage in those areas of production that will create the greatest opportunities for employment growth.

Negative impact on employment and income from employment. The increase in resource efficiency as a result of the introduction of energy-saving technologies in the energy sector reduces the demand for gas, transport services, chemical industry products, etc. (along the chain of technological relationships). The consequence is a decrease in output in many industries, hence a decrease in employment and income from employment. As the calculations showed (see stage b in Figure 7), with a constant volume of the final product of 255,150.7 billion UZS the volume of production required to achieve it in the conditions of the modernization scenario will be less than the initial estimate by almost 600 billion UZS.

Although in relative terms, this is a small amount for the entire economy (a decline of 0.15%), for individual industries, the decline in output will be significant. Thus, the demand for natural gas will decrease by 7.5% or 475 billion UZS. If the output of the sector decreases in the same proportion, this will mean the loss of 1,300 jobs (Table 6). In addition, a smaller but noticeable reduction in jobs is possible in the energy sector (160 jobs), manufacturing industries (191 jobs), transport (166 jobs) and services (about 500 jobs). In the economy as a whole, losses can reach 2,420 jobs, 2/3 of which are the most stable and highly profitable jobs (natural gas production, energy, manufacturing).

In addition to the job losses, the introduction of new technologies in the energy sector will reduce the incomes of those employed in the sector by almost 94 billion UZS and public budget revenues by 4.7 billion UZS.

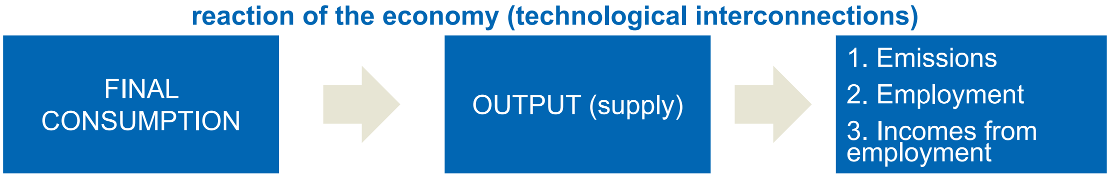
In relative terms, these losses for the entire economy are not so great: a decrease in output by 0.15%, employment by 0.06%, public budget revenues by 0.04%, income from employment by 0.16% (see stage b in Figure 7). However, these losses are associated with the modernization of the energy sector. The estimates obtained can significantly increase if modernization takes place in all sectors of the economy.

Opportunities to compensate for the negative consequences of the introduction of new technologies in the energy sector. According to calculations, the introduction of new resource-saving technologies in the energy sector will lead to a reduction in emissions by 281 thousand tons of CO_2 eq. (from 164.8 million tons to 164.5 million tons excluding the "forestry" sector or from 160.1 million tons to 159.8 million tons including this sector) with the same volume of final consumption. At the same time, the question arises: by what amount can final consumption be increased in the current structure of the economy in order to compensate for the negative social consequences of the introduction of resource-saving technologies in the energy sector without exceeding the limit on emissions (160.1 million tons)?

To ensure that emissions do not exceed this limit (compensation scenario, stage c in Figure 7), the marginal growth of final consumption in the current sector structure will be 0.176% of its base level. Even such a weak growth of the final product changes a slight decline in the economy as a whole (by output by 0.15%) to an economic growth of 0.03%, which is enough to compensate for the negative social effects on the economy as a whole. Thus, if the reduction in the number of employees in the compensation scenario for the gas production sector (1,280 jobs) does not differ much from the reduction in the number of peopled employed in the modernization scenario (1,300 jobs stage b, Table 6), then the growth of employment in other industries leads to an increase in employment in the economy as a whole by 4.7 thousand jobs (against their reduction by 2.4 thousand jobs in the previous calculation).

This is due to the fact that even with weak economic growth, the demand for skilled employment is growing. This, in turn, reflects on the growth of employment in education and health care (in 1764 jobs and 769 jobs, respectively), which accounted for more than half of the

FIGURE 7 REACTION OF THE ECONOMY AND SOCIAL INDICATORS TO THE TECHNOLOGICAL MODERNIZATION OF THE ENERGY SECTOR (MACRO LEVEL)



modeling scenarios (stages)

	Final consumption (billion UZS)	Output (billion UZS)	Emissions (thousand tons)	Employment (jobs)	Incomes (billion UZS)
a. BASELINE	255,151	398,771	160,144	4,071,604	57,306
b. MODERNIZATION OF THE ENERGY SECTOR	No change (255,151)	Decrease by 600 billion UZS to 398,171	Decrease by 281 thousand tons to 159 863	Decrease by 2,422 jobs to 4,069,181	Decrease by 94 billion UZS to 57,211
c. plus STIMULATING CONSUMPTION WHILE LIMITING EMISSIONS (compensation measures)	Increase by 499 billion UZS to 255,599	Increase vs stage (b) by 702 billion UZS To 398,873	Increase vs stage (b) by 281 thousand tons to baseline 160,144	Increase vs stage (b) by 4,739 jobs to 4,073,920	Increase vs stage (b) by 101 billion UZS to 57,312

Source: Authors' model calculations/simulations

total growth of employment in compensation scenarios compared to baseline assessments (stage a, see Table 6).

Similar results are obtained for incomes from employment (Figure 7).

TABLE 6 IMPACT OF ENERGY SECTOR MODERNIZATION AND COMPENSATION MEASURES ON EMPLOYMENT (JOBS)

Sector #	Sectors	Baseline (a)	After modernization (b)	Change in employment (b-a)	Increase of final consumption (c)	Change in employment (c-a)
1.	Agriculture, forestry and fisheries	564,790	564,773	-17	565,767	977
2.	Extraction of gas and oil	17,513	16,205	-1,308	16,233	-1,280
3.	Other extractive industries	58,306	58,267	-39	58,370	64
4.	Processing industry	584,735	584,544	-191	585,573	838
5.	Energy sector	69,349	69,189	-160	69,311	-38
6.	Water and irrigation	21,178	21,150	-28	21,187	9
7.	Transport	151,860	151,694	-166	151,961	101
8.	Building	201,427	201,425	-2	201,779	352

Sector #	Sectors	Baseline (a)	After modernization (b)	Change in employment (b-a)	Increase of final consumption (c)	Change in employment (c-a)
9.	Education	1,007,307	1,007,298	-9	1,00, 071	1,764
10.	Health care	440,362	440,356	-6	441,131	769
11	Other services	954,777	954,281	-496	955,970	1,193
	Total	**4,071,604**	**4,069,182**	**-2,422**	**4,076,343**	**4,739**

Source: Model calculations/simulations.

Thus, a resource-saving policy can be combined with an increase in employment and income of the population, if at the same time conditions are created for the growth of domestic and external demand,[34] while the growth of production and the associated dynamics of emissions remain smooth (stability or moderate emissions reduction). In other words, the transition to green development should ensure that the speed of technological modernization (the introduction of "green" technologies) and the efforts to build market capacity and competitiveness of the manufacturing industry are coordinated, without allowing the dominance of international obligations regarding emissions over national interests the most important of which are boosting employment and poverty reduction.

[34] There are many factors here: reducing the tax burden, foreign economic barriers, transaction costs, infrastructure development, limiting income inequality and the monopoly position of certain sectors, etc.

6. Consideration for national interests in transitioning to an active climate policy: recommendations

The analysis of international experience and calculations show that it is important to take into account a number of risks when forming new commitments of Uzbekistan to reduce emissions. Without taking them into account, the accelerated process of transition to a "green" economy can negatively affect the level of economic and social development leading to a decrease in employment and incomes from employment. Climate policy should be proactive, but selective.

6.1 FORMULATING THE COUNTRY'S NEW EMISSIONS REDUCTION COMMITMENTS

Uzbekistan has long fulfilled its commitment to reduce emissions which was planned to be achieved by 2030 (reducing specific emissions by 10% compared to 2010). Uzbekistan should review its 2030 emissions reduction commitments. The Table 7 shows dynamics of some emission reductions achieved through methane (natural gas) leak reduction in energy sector and indicates trends for decreasing carbon intensity of GDP. However, other sectors' potential should be unlocked to preserve the positive dynamics.

The new emissions reduction commitment as part of implementing the Paris Agreement may have a different wording. In particular, it could look not as a traditional commitment formulation (i.e., reducing emissions by ...% by a certain year), but as "maintaining the level of specific emissions at year 2017 level". In other words, the country will make efforts not to exceed the level of specific emissions by 2030 above the level achieved in 2017.

TABLE 7 SPECIFIC EMISSION DYNAMICS IN UZBEKISTAN, 2010-2017

	2010	2013	2015	2016	2017
GDP, $ (in 2010 prices)*	46 679 875 793,6	58 122 388 985,6	66 934 792 340,1	71 013 939 308,1	74 182 244 738,0
Emissions, million tons**:					
without forest absorption	200,1	190,3	185,3	182,8	189,2
with forest absorption	187,1	179,0	173,1	172,3	180,6
Emissions in kg per $1 of GDP (specific emissions):					
without forest absorption	4,22	2,85	2,45	2,40	2,40
with forest absorption	4,40	2,94	2,38	2,33	2,33
Dynamics of specific emissions: 2010 = 100%					
without forest absorption	100,0	67,7	58,0	56,8	56,8
with forest absorption	100,0	66,9	54,2	53,0	53,1

Source: Authors' calculations
*Notes: * Source: World Bank data*
*** Source: Uzhydromet, inventory results.*

This formulation would be more adequate to the features/challenges of the current stage of the country's development, given that:

- there is an increase in agricultural emissions (during 2010-2017, the sector's emissions increased by 30%) against the background of population growth and, accordingly, with an increase in livestock and fertilizer use;
- the process of deindustrialization of the economy, which is accompanied by a decrease in the volume of emissions from the "industry" sector, may reverse the trend;
- an increase in the amount of indirect emissions from the activities in the services sector. The services sector have a significant share among the sectors with the highest values of the emission multiplier (Table 4). If their development dynamics are high (which is what many of the adopted programs focus on) the volume of emissions will begin to increase.

6.2 DEVELOPING A METHODOLOGY TO EVALUATE INDIRECT EMISSIONS

The analysis showed that it is important to calculate the carbon footprint for all 78 sectors of the economy of Uzbekistan, and not just for a few industries with direct emissions, which are traditionally considered by Uzhydromet. This involves calculating not only direct emissions, but also indirect emissions, which together give an idea of total emissions. In this paper, such calculation is done through the effects of intersectoral relations relative to the supply and consumption of intermediate products. After calculating the total emissions, the authors found sectors that make a significant contribution to the volume of emissions but were never considered as emitter sectors.

Such calculations have never been performed before. It seems that more work is needed to assess indirect emissions. This will require:

- increasing the number of estimated categories and including all existing emission sources in the country in the inventory;
- developing data collection methodologies for each sector and large enterprises separately;
- updating the baseline (coefficients for calculating indirect emissions from electricity consumption);
- developing guidelines for estimating emissions from selected large enterprises and analyzing the costs and benefits of implementing emission reduction measures.

6.3 CONSIDERING THE CHANGES IN THE MACROECONOMIC AND INSTITUTIONAL ENVIRONMENT

All the emitter sectors have significant links with the indicators of the macroeconomic and institutional environment. This influence is strongest for the CMI (cement) and agriculture (livestock) sectors. For these sectors, the authors found the influence of structural, macroeconomic and institutional factors, such as the level of industrialization, the level of inflation, the level of globalization, the burden on natural capital (natural rent), the restriction of corruption, compliance with legislation, government effectiveness, etc. (almost half of the indicators reviewed, indicator classifier, Annex 4).

The coefficients with the factors allow estimating the influence of the factor on specific emissions dynamics. For example, if the average annual rate of inflation in 2012-2017 were only

TABLE 7 RESULTS OF ECONOMETRIC ANALYSIS OF THE INFLUENCE OF MACROECONOMIC, INSTITUTIONAL AND STRUCTURAL FACTORS ON SPECIFIC EMISSIONS DYNAMICS

Equation #	Factors with statistical significance	Factor coefficients	Probability of 0 hypothesis deviation %	Explained variance R2
Energy sector (electric energy)				
1	Inflation (INF)	0.24	89	0.41
	Freedom from corruption (FoC)	-0.66	98	
2	Investment in the sector (INV)	-0.16	84	0.25
3	Freedom from corruption (FoC)	-0.46	91	0.45
4	Export (in% of GDP, EXP_GDP(-2))	-0.33	91	0.51
Chemical sector (ammonia)				
1	Investment in the sector (INV(-3))	0.22	93	0.56
2	Investment in the sector (INV(-3))	0.11	99	0.97
	Gross domestic savings GDS_GDP(-1)	-0.09	88	
Construction materials (cement)				
1	Investment in the sector (INV(-2))	-0.71	90	0.55
	Direct foreign investment (FDI_GDP)	2.87	98	
2	Freedom from corruption (FoC(-2))	0.37	97	0.53
3	Natural rent (NRS_GDP)	0.19	89	0.56
4	Share of employment in the sector (EML_IND)	-3.14	95	0.73
5	Inflation (INF(-2))	0.19	93	0.49
6	Globalization Index (KOF)	1.79	93	0.33
7	Rule of law (RoL)	-10.5	95	0.87
Transport (automobile and railroad)				
1	Investment in the sector (INV(-2))	-0.62	95	0.38
2	Inflation (INF(-3))	0.49	95	0.80
3	Globalization Index (KOF(-2))	3.6	98	0.91
Agriculture (livestock farming)				
1	Investment in the sector (INV(-1))	-3.64	95	0.47
2	Globalization Index (KOF(-2))	-2.02	98	0.70
3	Investment in the sector (INV (-1))	-2.70	90	0.45
	Share of employment in the sector (EML_IND (-1))	-4.01	95	
4	Inflation (INF)(-1))	0.53	94	0.41
	Investment in the sector (INV(-1))	-6.33	95	
5	Investment in the sector (INV(-1))	-2.67	85	0.33
	Rule of law (RoL)	-17.9	90	
6	Government effectiveness (GEF(-2))	-14.1	0.91	0.68

Source: Authors' calculations.

1 percentage point lower (11.9% instead of 12.9%) specific emissions dynamics would improve:

- for the energy sector: from -3.33% (average annual rate of reduction of specific emissions for 2012-2017) to -3.57% (-3.33% – 0.24);[35]
- for the "CMI (cement)" sector: from -1.71% to -1.90% (coefficient 0.19);
- for transport: from an increase in specific emissions at 5.54% to 5.05% (0.49);
- for agriculture: from -3.0% to -3.53% (0.53).

[35] Here 0.24 is the coefficient before the "inflation" factor from equation #1 for the energy sector.

This shows that there is a significant reserve in reducing specific emissions associated with an improved macroeconomic environment, especially for transport and agriculture.

The impact of rising prices on the growth of the sector's specific emissions[36] occurs through different channels. The first, most likely, investment channel is based on an increase in the interest rate with an increase in inflation and a deterioration in investment conditions:

<rise in inflation> → <rise in interest rate> → <slowdown of financing for technological renewal + obsolescence of fixed capital> → <increase in specific emissions>

The other channel assumes the impact of inflation on demand-side emissions:

<rise in inflation> → <decrease in real incomes of the population> → <diminution in demand> → <decrease in product sales> → <increase in emissions per unit of product>

Significant reserves for reducing emissions are associated with the growth of the industrialization of the economy (the indicator "Share of employment in sector EML_IND"). In 2012-2017, the average annual estimate of this indicator was 23.9%. An increase in the share of employees in sector by 1 percentage point led to a decrease in specific emissions in the "CMI" sector by 3.14 percentage points while in agriculture by 4.0 percentage points.

The perspective of industrialization for the transition to low-carbon development is determined by the fact that if it occurs due to the accelerated development of the manufacturing sector, it means an acceleration of the process of economic diversification. This leads to an increase in the number of new sustainable jobs created, investments in human capital, an increase in the income of the population, i.e. socially oriented, inclusive "green" development.[37]

The importance of the institutional factor implies primarily the need to reduce the corruption level (according to the "freedom from corruption" indicator FoC) in order to reduce specific emissions in the energy sector (the value of the corresponding coefficient from -0.46 to -0.66); CMI (according to the "compliance with current legislation" indicator RoL, -10.5); in agriculture (according to the RoL index (-7.9), government effectiveness GEF (-14.1)).

The analysis also showed that the same factor can affect emissions differently for different sectors. Thus, the growth factor in economic openness contributes to limiting specific emissions in the energy sector and in agriculture while increasing emissions in the CMI sector. Perhaps this is due to the peculiarities of the sectors, their export potential, the level of freedom of management in decision-making, but the final conclusion can be drawn through additional research using more detailed data.

Increased investment is a factor in reducing emissions. Exceptions include investments in the chemical industry (INV_CH) and FDI for the CMI sector (FDI_gdp, coefficients with a "+" sign). However, the indicators of savings and investments (GFC_gdp, GDS_gdp) are almost unrelated to sectoral specific emissions, which indicates that only active investment policies are insufficient to achieve noticeable results in reducing emissions.

Coefficients (Table 7) allow quantifying the contribution of different factors to the change in specific emissions for different industries at different stages of their development. They provide an understanding of the importance of macroeconomic and institutional factors in creating conditions for the implementation of the "green" scenario. However, in most equations, the percentage of explained variance is about 50% or lower, which indicates a num-

[36] A direct link between prices and output, and therefore specific emissions, is excluded, since the calculation of specific emissions used outputs in non-price (in kind) terms (billion UZS). kWh, thousand tons, etc.)

[37] Source: Economic diversification in oil-exporting Arab countries. IMF. Annual Meeting of Arab Ministers of Finance, Manama, Bahrain.

ber of factors that are beyond the scope of econometric analysis. Obtaining more accurate estimates requires further research using more detailed (in the context of large enterprises and the main emitters of emissions) and up-to-date statistics (including emissions for 2018-2019).

Of course, it is impossible to achieve optimal/global average values of structural, macroeconomic and institutional factors within a short while. To begin with, it is possible to introduce separate macroeconomic and institutional indicators to the set of indicators that will be used annually to track changes in the macroeconomic and institutional environment in comparison with global trends. Together with monitoring of technological modernization (at least for the main "polluting" industries) and environmental indicators, this will allow for continuous monitoring and analysis of the effectiveness of climate investments.

6.4 CHANGING THE MODEL OF TECHNOLOGICAL MODERNIZATION: SOCIALLY ORIENTED "GREEN" TECHNOLOGIES

The analysis shows the limited capacity of the economy in terms of combining the goal of reducing carbon intensity and social goals. Among sectors with a moderate impact on emissions (63 sectors, Table 4) only a small number of sectors have both employment and income growth potential. Moreover, almost all of them belong to the services sector whose development is limited by the low incomes of the majority of the population.

The solution is to switch to a technological modernization model using double-dividend technologies (win-win technologies), which help combine traditional effects (economic and social) and climatic (environmental) ones. The search for these technologies that contribute to reducing emissions and at the same time address socio-economic challenges should become the basis of Uzbekistan's technology policy.

Global trends show that these technologies can be divided into two groups:

1. Socially responsible investments help achieve both financial and social effects combined. In the 1980s, socially responsible investment was recognized worldwide as an official financial mechanism. This is an important part of the interaction with UNEP FI – the UN's environmental division, in particular through its work with financial institutions.

2. ESG approach implies companies that meet specific performance criteria: E for ecology; S for social; and G for governance. The approach combines a comprehensive assessment of the impact of companies on the environment, their social responsibility (in relations with suppliers, employees and society), as well as transparency and efficiency of relations between owners, management and shareholders.

Investing in ESG assumes that along with the classic indicators (profitability, revenue, capitalization), additional criteria for selecting companies appear. For example, environmentally harmful sectors are excluded. Structurally, the ESG funds' stock indices are similar to the usual S&P 500 index, but "cleaned" of coal, gas and oil companies.

There is another version of this strategy. The same S&P 500 index is taken and adjusted by reducing the share of companies with a low ESG rating and increasing the share of companies with a high ESG rating. As a result, eco-friendly companies push ESG funds higher, and sagging oil companies, aviation, auto sector, etc. do not have an impact on them, because there are almost no companies in these industries in the adjusted indices. The top traded ESG funds have higher returns compared to the market. Therefore, by investing in ESG shares with higher returns, investors unwittingly start a chain reaction, which leads to a greater focus of investors on the social and environmental factors of the companies ' activities.

6.5 DEVELOPING TOOLS TO PRIORITIZE “GREEN” PROJECTS

Not always and not all green sectors/technologies are socially oriented, environmentally friendly and efficient. Calculations for the energy sector have shown that the effects of “green” development in terms of job retention can be negative. Another challenge is that the creation of new jobs in “green” sectors may require investment in retraining of and extension services for the workforce.[38] In addition, green technologies may have negative environmental/health side effects that may not be immediately identified or may be underestimated.[39] As a result, significant investment in these technologies may not be justified.

The selection of projects should be regulated by the technological upgrading policy and “green” financing. Neither of them is in the country yet. The technological upgrading policy has never been officially announced, and “green” funding is mainly provided by donor grants. The exact number of “green” projects is unknown. By the end of 2020, the country is implementing 79 projects (in the amount of $286.2 million) that have climate change targets. The projects focus on 4 areas: a) RES; b) agriculture, water and forestry; c) individual energy sectors; d) SHW (solid household waste).[40] The selection of projects is not transparent. The single coordinator of grant projects is the Ministry of Investment and Foreign Trade, which has not published criteria for the selection of “green” projects.

What is needed is to create a national system of green financing. This would require the following:

1) Identify the target CC indicator, since the criteria for selecting projects may be different. For example, if the goal is to reduce emissions, then nuclear energy should be considered green, since its carbon footprint is certainly less than that of most other types of energy generation. However, other standards are focused not only on the climate, but also assess the risk of leaks and accidents. Therefore, they exclude nuclear energy from the “green” areas. In general, the logic should be as follows: for a project to be recognized as green, it should improve the situation in one direction and not worsen it in the rest.

2) Develop tools for prioritizing “green” investments. This will make it possible to distinguish between “climate” and “other” investments in investment programs, so that it becomes possible to correctly calculate the socio-economic effects of “green” investments. Currently, the issue is debatable for many countries, including Uzbekistan. Assessments by international experts have shown that the experience of Ghana can be used as an effective example of project prioritization.[41] In short, this approach boils down to the following:

- identify key areas for CC mitigation/adaptation. In particular, 5 areas were identified in Ghana: 1) agriculture and food security; 2) disaster preparedness and response; 3) natural resource management; 4) social development; 5) energy, sector and infrastructure development;
- create specific programs for each key area;
- identify emission reduction priorities for each area and program;

[38] Antal M. «Green goals and full employment: Are they compatible?»//Ecological Economics (2014) и Consoli D., Marin G., Marzucchi A., Vona F. «Do green jobs differ from non-green jobs in terms of skills and human capital?»//Research Policy (2016).

[39] Source: Frasier K. «New Research Reveals the Safety Hazards of Green Building» (2012); «It’s not easy building green! World Green Building Trends report 2016»; Cohen R. «Energy-efficient green buildings may emit hazardous chemicals», 2017.

[40] Source: Systematization of projects from relevant ministries and departments, as well as on official donor websites. The systematization was carried out by the national expert O. Nimatullayev.

[41] Report “Climate Change Project Prioritization Tool and Guideline”, under the auspices of the Government of the Republic of Ghana, 2017.

apply a set of technical tools for prioritizing projects: SWOT analysis; Multi-voting Technique; MCA4climate project priority tool; PEST analysis; OECD criteria-DAC criteria for evaluating development projects; Criteria-based matrix, etc.[42]

6.6 WELL-WEIGHED CHANGES TO THE SECTORAL STRUCTURE OF THE ECONOMY

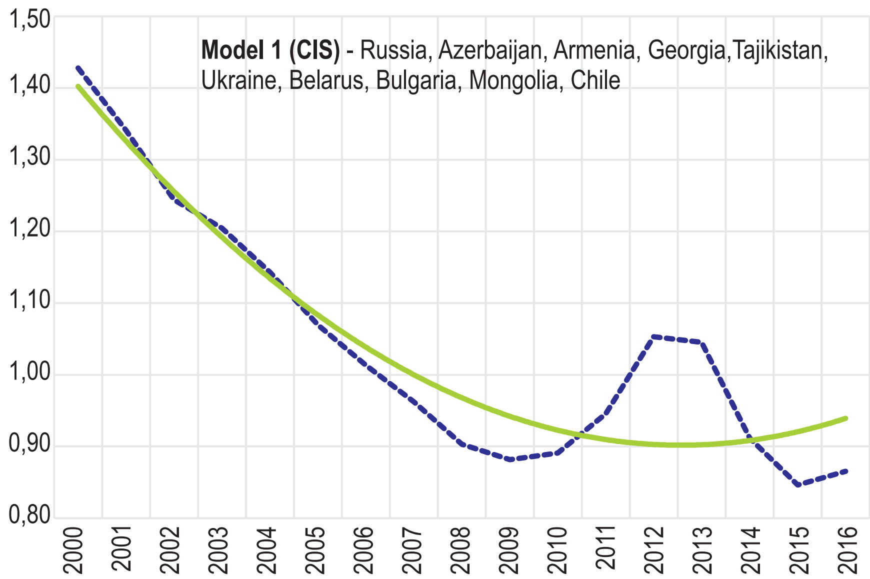
Developing nations tend to use two models for reducing specific emissions. Model 1 countries (most of the CIS countries and emerging markets – Bulgaria, Mongolia, Sri Lanka, Group A, annex 5) have seen their specific emissions decline rapidly since 2000s (Figure 8).[43] On the other hand, Model 2 countries (China, Malaysia, Costa Rica, Mexico, South Africa, etc., group B, annex 5), have seen fundamentally different emissions dynamics: an increase in emissions in early 2000s followed by accelerated decline by 2016 (Figure 9).

The advantages of the second model are obvious. Given the high cost of "green technologies", countries that were slow to introduce such technologies managed to significantly increase their level of development, including reducing poverty and solving other social problems, created a certain scientific and technological reserve in the field of resource and environmental conservation, and only then moved to an active, but selective policy of low-carbon development. The negative impact of accelerated emissions reduction on the solution of social problems is shown by the dynamics of a number of social indicators for groups of countries A and B (Annex 6).

Processing sector has the greatest potential for creating sustainable employment vis-a-vis other sectors. The share of the sector in the industry structure of the economy is an important indicator of the inclusiveness of economic growth.[44] In recent years, a global trend has been formed to reduce the share of the manufacturing sector against the background of an increase in the share of the service sector. But if for the countries in the first model (group

FIGURE 8 CO2 EMISSIONS (KG PER DOLLAR OF GDP IN 2010 PRICES), TYPICAL FOR THE CIS COUNTRIES AND A NUMBER OF ECONOMIES IN TRANSITION (MODEL 1)

Source: Calculations based on World Bank data https://databank.worldbank.org/source/world-development-indicators/Type/TABLE/preview/on#



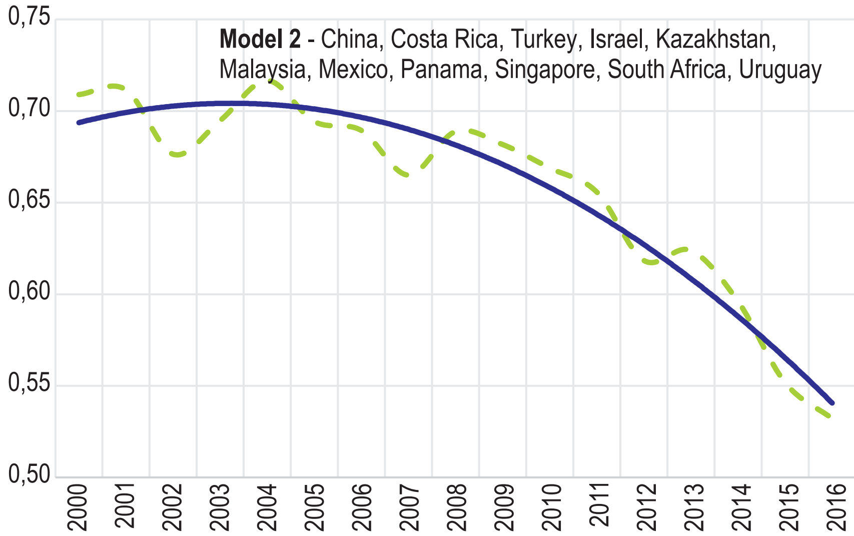
[42] The paper provides the steps for evaluating projects in accordance with each tool, as well as the pros and cons associated with the use of certain tools. This technical toolkit will be very useful for Uzbekistan in terms of selecting priority projects in the field of CC and their inclusion in investment programs.

[43] The reason for the rapid reduction of emissions in the CIS countries in the 2000s was not the transition to a "green" policy, but the de-industrialization of the economies. This is evidenced by the rapid decline in the share of the manufacturing industry in the structure of the economy. See also I. Makarov. The end of the era of romanticism in climate policy. Russia in global politics. №4 2011 https://globalaffairs.ru/articles/dvojnoj-dividend-vmesto-globalnogo-altruizma/

[44] See ESCAP, ECE, UN. How to promote inclusive and sustainable growth in the SPECA subregion? https://www.unece.org/fileadmin/DAM/SPECA/documents/ecf/2019/2019_SPECA_Economic_Forum_Background_Paper_Russian.pdf

FIGURE 9 CO2 EMISSIONS (KG PER DOLLAR OF GDP IN 2010 PRICES) TYPICAL FOR INDIVIDUAL SUCCESSFUL DEVELOPING COUNTRIES (MODEL 2)

Source: Calculations based on World Bank data https://databank.worldbank.org/source/world-development-indicators/Type/TABLE/preview/on#



A), the share of manufacturing in the structure of the economy decreased by 3.7 p.p. (from 19.3% to 12.6%), then for the countries in the second model, this decrease was significantly lower (by 2.5 p. p.). This means saving millions of jobs in the second model countries compared to the first model countries (see Annex 6).

If one uses the share of education expenditures indicator (in % of GDP), the negative impact of accelerated decarbonization on social development becomes even more obvious. In the Model 1 countries, the change in this indicator was insignificant, while in the Model 2 countries with a moderate decarbonization rate in the early 2000s, there was an increase in the indicator (by 1 percentage point).

6.7 CREATING CARBON REGULATION WITHIN THE COUNTRY IN RESPONSE TO EXTERNAL RISKS OF CARBON PROTECTIONISM

Governments of nations with active climate policies can apply special measures to products from countries without carbon regulation. The arsenal of such measures is wide and includes: a) actions to control emissions across the entire value chain at the company level; b) environmental standards and sector codes of conduct that all companies entering a country's market must comply with; c) carbon customs duties. The latter are actively covered in political discussions and literature which often refer to them as "carbon protectionism".

Carbon customs duties involve the introduction of a tax on imported goods with a high carbon footprint. In theory, the value of this tax should be calculated as the difference in the carbon footprint of the imported product and its national counterpart, multiplied by the unit price of emissions (determined, for example, in the framework of emissions trading). It is proposed to impose carbon customs duties on goods imported from countries where there is no carbon regulation. The European Union is an active promoter of the introduction of a carbon tax.

For Uzbekistan, such barriers may become an additional source of risk associated with the Paris Agreement. This is because, firstly, such a tax will be imposed not only on the export of carbon-intensive goods from 5 "polluting" industries (energy, natural gas production and transportation, ferrous and non-ferrous metals, fertilizers). Secondly, the tax will also affect other industries, since all 78 industries that form the economy of Uzbekistan have a carbon footprint. Another reason for the high carbon intensity of exports and other goods in Uzbekistan is its technological backwardness compared to many developed countries. Regardless of the reasons, the lack of carbon regulation at home will increase Uzbekistan's vulnerability to carbon barriers imposed abroad. The less efforts to reduce emissions are made at home and the closer the climate policy of the rest of the world is to the “2 0C” scenario, the higher the risks of barriers for national producers (both for exporters and for others). Therefore, the situation when other countries reduce emissions, while Uzbekistan does not make any efforts to reduce them, is hardly realistic.

The emission multipliers can be used to: a) create carbon regulation within the country and b) develop a mechanism to encourage enterprises to upgrade equipment. Emissions reduction can be stimulated by the introduction of a domestic emissions tax (carbon tax). To this end, all sectors can be classified into categories: high carbon footprint (category 1, more than 3 tons), relatively high carbon footprint (category 2, from 1 to 3 tons), medium carbon footprint (category 3, from 0.5 to 1 ton), moderate carbon footprint (category 4, from 0.2 to 0.5 tons), low carbon footprint (category 5, less than 0.2 tons).

Each category has its own tax rates, which increase moderately when moving to a higher category, for example, 0% for the 1st category, 1% for the 2nd, 1.5% for the 3rd, 2% for the 4th and 2.5% for the 5th. The overall increase in the tax burden will be insignificant, since more than half of the economic sectors (43 industries) fall into the 1st and 2nd groups with a zero and 1% rate on this scale, while only 2 industries (electric power sector, as well as waste collection, processing and disposal services) fall into the category with the highest tax rate of 2.5%.

In addition, the increased tax burden can be offset by a reduction in tax rates on labor, capital, or social contributions. As a result, the payments of enterprises may not be increased, but redistributed. This is called “tax-neutral” reform.[45] On the one hand, it creates an incentive for businesses to reduce emissions, and on the other, to invest more, including in green technologies, in order to reduce the tax burden.

6.8 BOOSTING THE EXPANSION OF GREEN AREAS

According to the results of the emission inventory, in recent years, the sector “Forestry and other land uses” has seen an increase in CO_2 uptake. For a long time before that, the sector only saw CO_2 emissions. The transition from emissions to acquisitions was the result of efforts to expand the forests, especially in the country’s desert areas, including in the Aral Sea region, as part of the national afforestation programs which are the most environmentally “green” and socially effective measures. Although the overall amount of CO_2 uptake is still small (about 2.5% of total emissions), it is important to take measures to strengthen it in the future.

The state of the desert grassland soils, which occupy vast areas, has a great influence on CO_2 uptake in this sector. To increase CO_2 uptake, it is necessary to strengthen measures to reduce the degradation of rangelands and improve their management. This requires, firstly, unconditional afforestation action as part of ongoing programs (measures to create protective forest stands on the drained bottom of the Aral Sea[46] and the Forestry Development Program for 2020-2024).[47] Secondly, it requires stronger measures to reduce the degradation of pasture lands. This will increase CO_2 uptake, reinforcing the country’s new emission reduction commitments. These efforts should target a 2-fold expansion of the forest area by 2030 compared to 2020.

[45] Source: Developing the raw material model of the economy, we import crises. https://tass.ru/ekonomika/6568815

[46] Resolution of the Cabinet of Ministers of the Republic of Uzbekistan “Strategy for the Conservation of Biological Diversity in the Republic of Uzbekistan for the period 2019-2028 No. 484 of June 11, 2019.

[47] Resolution of the President of the Republic of Uzbekistan “On additional measures to improve the efficiency of forest management in the Republic” No. 4424 of 23.08.2019.

Conclusion

In identifying new emissions reduction commitments, it is necessary to give consideration for a number of current national features of the country's climate policy.

1. The country already fulfilled by 2013 its emissions reduction commitments that were planned to be achieved by 2030 (a 10% reduction in specific emissions compared to 2010 levels). Overall, specific emissions decreased by 47% during 2010-2017. This resulted from: a) the deindustrialization of the economy in the 2000s; and b) the emissions reduction measures in the energy sector which is a key polluter (the sector's share in total emissions decreased from 87.1% to 76.6% during 2010-2017).

2. Investment activity alone is not enough to reduce specific emissions. Equally important are macroeconomic, institutional and structural factors, such as the degree of integration of the economy into the world economy, reduction of the burden on natural capital, quality of state institutions, and inflation and devaluation rates of the Uzbek soum.

3. The scale of total emissions is significantly higher than the scale of direct emissions from direct emitter sectors. The proposed approach for calculating indirect emissions (based on the Input-Output model using the multiplier technique) made it possible to estimate emissions for all 78 sectors, and not only for the «traditional» 5 sectors with direct emissions. The calculation showed that all sectors contribute to emissions regardless of fuel use. Moreover, the largest amount of emissions is not only featured by sectors that directly use fossil fuels in their activities (electricity, metallurgy, etc.), but also a number of services sectors. Thus, the top 15 sectors with the highest values of emission multiplier include 7 services sectors.

4. The limited capacity of the economy to combine the goal of reducing carbon intensity and social goals (expanding employment and increasing the income from employment). The multipliers of employment and income from employment by the final product allowed identifying sectors for which a moderate rate of increase in emissions with an increase in demand for products is combined with the greatest contribution to solving social problems (such economic growth can be considered socially oriented «green» economic growth). Among the sectors with a moderate impact on emissions (63 sectors), only a small number of sectors have both employment and income growth potential. Almost all of them belong to the service sector whose development is limited by the low income levels of the majority of the population. There are 14 such sectors, and they are the most promising targets for state support. These sectors account for only 10.2% of GDP, but 36% of the total employment in the country and 31% of the total income from employment.

5. The mixed impact of climate measures on socio-economic development. It is believed that the introduction of «green» policy measures – which constitute the basis for emissions reduction – lead to positive socio-economic effects. However, in the case of Uzbekistan, the situation is not so clear. Thus, the effects from introducing resource-saving technologies in the energy sector will be negative for the economy as a whole reducing employment and incomes from employment. Meanwhile, it is exactly employment boosting and poverty reduction which are the most serious challenges in Uzbekistan's current stage of development. Massive and rapid implementation of climate policy measures may hinder the country's progress in carrying out its National Sustainable Development Goals Program and Poverty Reduction Strategy 2030.

To get a complete picture of the social and economic effects, similar calculations should be done for all 78 sectors. This is a huge work that should be organized by relevant departments and can potentially become the basis for a number of UNDP's sector-specific projects.

6. The need for compensation to minimize the negative socio-economic consequences of the green scenario. Modeling of compensation (exemplified by the energy sector) based on measures to expand domestic and external demand for domestic products, allowed drawing an important conclusion. In the transition to «green» development, it is important to ensure that the speed of technological modernization (introduction of «green» technologies) is coordinated with the efforts to build the capacity of the domestic market and the competitiveness of the manufacturing/processing sector, without allowing the country's international obligations to dominate over national interests, the most important of which are employment boosting and poverty reduction.

The analysis of international experience and calculations suggest that a number of risks should be considered prior to committing Uzbekistan to new emissions reduction targets. Without such considerations, an accelerated transition to the «green» scenario may have negative effects leading to lower employment and lower incomes from employment. Climate policy should be active, but selective, taking into account national socio-economic development interests. The following recommendations can be proffered in this regard:

1. Formulating a new emissions reduction commitment. In the long term, it will be difficult to maintain the high rate of emissions reduction that was attained during 2010-2017 given that overall emissions may begin to increase as a result of: a) higher emissions from agriculture; b) higher industrialization of the economy; and c) higher indirect emissions from the dynamically developing services sector. Therefore, the wording of Uzbekistan's new emissions reduction commitments should be different: it should not use the traditional commitment statement (i.e., reducing emissions by ...% by a certain year), but it should read as «maintain the year 2017 level specific emissions». In other words, the country should make efforts not to exceed by 2030 the level of specific emissions attained in 2017.

2. Developing a methodology to assess indirect emissions. This will require: (a) larger numbers of estimated emission categories and incorporating all existing emission sources across the country for inventory purposes; (b) developing methods to collect data separately for each sector and large enterprises; (c) updating the baseline (coefficients for calculating indirect emissions); and (d) drafting guidelines to evaluate emissions from individual large enterprises and analyze the costs and benefits of emissions reduction measures.

3. Taking into account the changes in macroeconomic and institutional environment to ensure the reduction of specific sectoral emissions. It is impossible to achieve global average values of macroeconomic and institutional factors in a short while. To begin with, individual macroeconomic and institutional indicators should be introduced to the set of indicators that will help annually monitor changes in macroeconomic and institutional environment in comparison with global trends. Together with monitoring of technological modernization (at least for the main emitter sectors) and environmental indicators, this will enable continuous monitoring and analysis of the climate investment performance.

4. Modifying the technological modernization model: socially oriented «green» technologies. The solution is to switch to a technological modernization model using double-dividend technologies that combine the traditional effects (economic and social) and climatic (environmental) effects. The search for these technologies that contribute to reducing emissions and at the same time address socio-economic challenges should become the basis of Uzbekistan's technology policy.

5. Developing a toolkit to prioritize «green» socially oriented projects. Currently, it is difficult to say what the share of green projects in the total investment volume is. First of all, it is necessary to determine the «green» criteria and mandatory criteria that should be present in each new investment project. The experience of Ghana can be used as an example of project prioritization. The assessments of international experts showed that the climate projects in this country combined climate, social and economic criteria and were very effective, and the experience of Ghana in the process of selecting projects for climate investment can be used by other countries.

6. Well-targeted changes in the sectoral structure of the economy. Among the developing countries of the world, there are two models for reducing emissions. The first model is typical for most of the CIS countries. Since 2000, their specific emissions have declined rapidly. The countries of the second model (China, Malaysia, Costa Rica, Mexico, South Africa, etc.) were characterized by an increase in emissions in the early 2000s, and then their accelerated decline against the background of positive socio-economic effects. This became possible due to the fact that they: a) managed to create a technological reserve in the field of resource and environmental conservation and only then switched to an active «green» policy; b) maintained a high share of the manufacturing industry, not succumbing to the global trend of reducing the share of the sector in the sectoral structure of the economy, which has developed in recent years. These efforts have resulted in the retention of millions of jobs in the second model countries compared to the first model countries.

7. Formulation of carbon regulation within the country. Governments of countries with active climate policies apply barriers to the export of goods from countries without carbon regulation, including carbon customs duties (carbon tax). For Uzbekistan, such barriers may become an additional source of risk associated with the Paris Agreement. The formation of a system of carbon regulation within the country will reduce the vulnerability of Uzbekistan to carbon barriers imposed abroad. This can be done by: a) introducing an internal carbon tax on emissions (all industries can be classified according to the size of emissions); b) introducing a system of compensation for the increased tax burden of enterprises paying carbon tax by reducing tax rates on labor, capital or social contributions.

8. Boosting the expansion of green areas. Obvious and simple as this recommendation may seem, it is of special significance for Uzbekistan. This is due to the fact that in recent years, the sector «Forestry and other land uses» has seen an increase in CO_2 uptake. Before that, the sector had long seen only CO_2 emissions. Although the overall amount of CO_2 uptake is still small (about 2.5% of total emissions), measures should be taken to strengthen it in the future. This requires, firstly, unconditional afforestation action as part of ongoing programs; and secondly, stronger measures to reduce pastureland degradation. These efforts should target a 2-fold expansion of the forest area by 2030 compared to 2020

Annexes

ANNEX 1. BRIEF DESCRIPTION OF THE INPUT-OUTPUT MODEL

The Input-Output (I-O) method is one of the main methods of economic analysis and forecasting. It has been widely recognized since the second half of the XX century due to the fact that it enables analyzing the material and financial flows that have developed in the economy at the maximum achievable system level. Being the core of the system of national accounts, the I-O Table reveals GDP and other macroeconomic indicators in the sectoral context, linking the indicators of production and value added with their intermediate and final use (including household consumption, government spending, investment, exports, see Figure 1). At the same time, both for each sector and for the economy as a whole, the main balance sheet identities of the SNA (production equals consumption), as well as the calculation of GDP by production, consumption, and factor value are performed.

FIGURE 1 SIMPLIFIED INPUT-OUTPUT TABLE SCHEME

		Intermediate Uses				Final Uses						Gross Output
		Industry 1	Industry 2	...	Industry n	Households	NPISHs	Government	GFCF	CIIs	Export	
Domestic	1	Z_{11}	Z_{12}	…	Z_{1n}	f_{11}	f_{11}	f_{11}	f_{11}	f_{11}	e_1	x_1
	2	Z_{21}	Z_{22}	…	Z_{2n}	f_{21}	f_{21}	f_{21}	f_{21}	f_{21}	e_2	x_2
	…	…	…	…	…	…	…	…	…	…	…	…
	n	Zn_1	Zn_2	…	Z_{nn}	f_{n1}	f_{n2}	f_{n3}	f_{n4}	f_{nS}	e_n	x_n
Imports		Zm_1	Zm_2	…	Z_{mn}	f_{m1}	f_{m2}	f_{m3}	f_{m4}	f_{ms}		
Value-Addec		v_1	v_2	…	v_n							
Total Inputs		x_1	x_2	…	x_n							

Source: R. Miller P. Blair. (2009). Input–Output Analysis Foundations and Extensions. Second Edition, p.14..

Note: ZiJ is intersectoral flows of intermediate products (intermediate product of sector i, used in the production of products of sector j, first quadrant), fi is elements of the final product (consumption of households, population, etc., second quadrant), Zmi is intermediate and final imports, ei is exports, vi is value added, and xi is output (total costs).

One of the main advantages of the method is taking into account the technological factor in the form of relationships between all industries for the production and consumption of intermediate products, reflected in the technological coefficients of direct costs (for example, the amount of gas in soums spent on the production of 100 soums of electricity, the amount of electricity in soums spent on 100 soums of production of mineral fertilizers, etc., the first quadrant of the table in Figure 1). This allows analyzing the cost structure of any sector, including intermediate costs, labor costs, transportation costs, capital costs, etc., as well as the distribution of sector products for the production needs of other industries, depending on the level of their sector output, as well as for the needs of end-use.

The reflection of the supply and consumption flows of intermediate products in Tables A and B (first quadrant, Figure 1) allows for the most accurate and complete consideration for the impact of changes in final consumption on the changes in sector output required to meet it. To do this, the authors used linear algebra methods and algorithms that reflect the relationship between sector output (supply) and demand from the population, the state, the external sector, as well as from the economy itself (demand for intermediate products and capital goods).

In traditional terms the I-O model is described by a system of balance of linear equations in the form: $x_i = \sum_j a_{ij} \cdot x_j + f_i$ i = 1– n:

where: n is the number of industries and sectors of the economy, xi is gross output of the i sector, fi is final consumption of products of sector i, aij is technological factors of direct costs (or Leontief matrix is defined for the actual values of trade flows Zijo intersectoral and sectoral issues of xio in the reporting period as aij = Zijo / xjo).

Final fi consumption (or final demand[48]) is divided into internal fdi and external nei consumption, i.e. fi = fdi + nei. In turn, the domestic demand for fdi is determined by the demand (consumption) of hc households, gc state and gross accumulation of gs, i.e., fdi = hci + gci + gsi, i.e. external demand is determined by net exports nei =ei – mi.

All elements of the final consumption in forecasting can be used as input (set) indicators describing the future conditions of economic development (for example, the decline in demand from households by introducing the decline parameter-the lowering coefficient ki, obtaining a new value of hci= hci ˙ki).

In matrix form, within the framework of the traditional approach, the I-O model has the form: x = A ˙x + f , where x and f are the vectors of output and final consumption columns, respectively, and A is a square matrix of direct cost coefficients with dimension n n. At the same time, if the final consumption increased by the value of Δf, then the increase in output required to meet the increased final consumption is determined based on the algorithm: Δx = D ˙Δf, where D is the total cost matrix, determined on the basis of the direct cost matrix as the inverse of (I-A), where I is the unit matrix, i.e. D = (I-A)-1.

In addition to being used in calculations to determine the outputs of x, the elements of the total cost matrix D carry an important semantic load. They show how much sector output will increase if the value of the final product increases by one. This takes into account all the relationships that have developed in the economy on the flows of intermediate products, i.e. all direct and indirect effects. This is one of the main advantages of the I-O method.

Besides, if one sums up all the elements, for example, of the first column of the matrix D, the resulting value shows how much output will increase for the economy as a whole ∑iΔxi with an increase in the final consumption of the products of the first sector by one Δf1 = 1. This indicator mul(o)i is called the output multiplier for the final product and is calculated as: mul(o)j = ∑idij.

This basic model serves as a basis for constructing a wide range of different model constructions, which differ from it in a more detailed representation of those factors and aspects of the economy that are directly related to the analyzed problem, for finding solutions to which the model is built.

For most developing countries, including Uzbekistan, one of the most important factors is the external factor (export and import indicators). While exports are singled out as a separate element in the final product in most I-O models and tables, imports are included by default in the intermediate product flows, which creates significant difficulties in interpreting the results of calculations obtained on the basis of such models, given that imports for a number of commodity items can provide most of the needs of both the household sector and the productive sectors of the economy.[49]

Modern I-O tables enable a detailed representation in the model of commodity flows of foreign origin, since its first quadrant ZiJo, describing commodity flows between economic

[48] The I-O methodology proceeds from the premise that the economy is in a state of equilibrium at the time of the statistical survey, considering it as the equality of supply and demand, which are determined by the indicators of industry output, intermediate and final consumption.

[49] For Uzbekistan, these are such sectors as ferrous metallurgy, pharmaceuticals, wood production, computers and electronic equipment, mechanical engineering and a number of others.

sectors, is divided into two parts: the flows of intermediate domestic products ZDiJo and the flows of intermediate imports ZMiJo, where the a superscript character “0” means that the value of the corresponding indicator belongs to the reporting period (for example, 2016 or 2017).

This allows dividing the import for each sector item i into two components – the intermediate imi and the final fmi import, i.e. its total volume mi = imi + fmi.

In turn, for any sector i and any output vector x, the value of intermediate import imi (or intermediate demand for imported materials and components) is determined based on the technological coefficients of direct costs of imported materials and components amij as: imi = $\sum$jamij $\cdot$ xj, and the technological coefficients of direct costs of imported intermediate product themselves – based on the reporting I-O table: amijo = ZMiJo / xjo .

In the import-modified input-output model, the coefficients of direct costs aij can be represented as: aijo = adijo + amijo, where the coefficients of direct intermediate costs of domestic products adij are determined already by the matrix of intersectoral flows of domestic products ZDo < Zo according to the same formula: adijo = zdiJo / xjo

Taking into account these relations, the output volume x for a given final consumption vector f = fd + e (where fd is domestic demand or consumption of final products, including consumption by households, governments, fixed capital formation and changes in working capital, e is external demand or exports) in the import-detailed I-O model can be obtained by converting the extended basic SNA identity (resources= use) to the form: : imi + fmi + xi = $\sum$jaijo $\cdot$ xj + fdi + ei

or in matrix form: x + AMo $\cdot$ x + fm = (AMo+ADo) $\cdot$ x + fd + e

which, in its final form, allows bringing these relations to a system of linear equations with respect to the output vector x: x = ADo $\cdot$ x + fd + e – fm, the solution of which with respect to the output vector x is associated with obtaining the inverse of the matrix (I-ADo) matrix of the coefficients of the total costs of domestic intermediate products DDo = (I-ADo)-1. Then, for any vector of final consumption fd + e – fm, a new vector of sector outputs x, providing final needs (internal and external), is defined as the result of multiplying the matrix DDo by the vector of final consumption: x = DDo $\cdot$ (fd + e – fm), and the new import vector m = AMo $\cdot$ x + fm (the sum of the new intermediate and the given final import).

For the import-modified I-O model, the algorithms for calculating multipliers are updated accordingly: mult(o)j = $\sum$iddij0 – the output multiplier for the final product, mult(o)j = $\sum$iddij0 – the multiplier of the added value for the final product, where vio is the value of the added value of sector i per unit of output of this sector, i.e. vio = veio / xjo.

Other multipliers are determined similarly – the employment multiplier for final consumption, the income from employment multiplier, the state income multiplier, and a number of others. This expands the analytical capabilities of the model, allows justifying those areas of government support measures, the implementation of which will have the greatest effect in terms of restoring consumer demand, the labor market, provides guidelines for adjusting the current economic model, taking into account the expected global changes in the world economy caused by the impact of the pandemic crisis.

The model is implemented in the Excel environment and makes it easy to introduce new conditions regarding domestic and external demand, obtaining new estimates of economic activity, the situation with the incomes from employment and the state, labor market indicators, etc.

ANNEX 2. CHARACTERISTICS OF UZBEKISTAN’S “BROWN” AND “GREEN” DEVELOPMENT SCENARIOS UNTIL 2030 AND 2050

The analysis of the world literature, global trends in the development of industries, and models of technological policy allowed forming a wide list of green scenario indicators. Based on this list, expert forecasts were made for indicators that characterize the brown and green scenarios in relation to Uzbekistan.

ASSESSMENT OF THE PROSPECTS FOR UZBEKISTAN’S LONG-TERM DEVELOPMENT THROUGH BROWN (B) AND GREEN (G) SCENARIOS, 2025-2050

Indicators	2018 (report)	2020 (expected)	Scenario	2025 (forecast)	2030 (forecast)	2040 (forecast)	2050 (forecast)
Growth indicators							
GDP growth rate (%)	5.1	0.5	Brown (B)	3-4	2-3	-	-
			Green (G)	4.0-5.0	4.5-5.5	5.0-6.0	4.0-5.0
Export,% of GDP	31.3	25.0	B	31.7	25.0	-	-
			G	41.4	60.4	65-70	75-80
Emissions and the environment							
CO2 emissions (kg) per USD of GDP (2010 prices)	1.25	1.23	B	1.15	1.08	-	-
			G	1.1	0.8	0.5	0.4
GHG emissions total (million t. CO2 eq.)	180	190	B	210	228-230	-	-
			G	195-200	180-190	175-180	160-170
Forest and pasture areas (thousand hectares)			B				
			G				
Domestic solid waste processing capacity, in% of the total volume of domestic solid waste	10.0	10.0	B	10.0	10.0	10.0	10.0
			G	30.0	50.0	100.0	100.0
Buildings/houses with energy-efficient technologies,% of the total housing capacity	0.2	0.2	B	1.0	1.5	2.0	2.5
			G	3.0	6.0	12.0	24.0
Share of electric vehicles and hybrids in the total fleet,%	0.00.0	0.00.0	B	0.1	0.5	2.0	4.0
			G	0.5	3.0	6.0	12.0
Resource efficiency and resource consumption/demand							
Return on capital (USZ of GDP per 1 UZS of investment)	3.3	2.5	B	2.5	2.7	-	-
			G	2.9	4.0	5.2	6.0-6.5
Investment in fixed assets, % of GDP	32.5	40.4	B	40-41	36-37	-	-
			G	34.2	26.9	25.0	23-24
Energy intensity (kg o.e. per $ 1000 GDP)	176	170	B	160	155		
			G	145	105	82	68
Deficit (-)/surplus (+) energy resources (million toe)	-1.4	-1.6	B	-2.5	-7.0	-	-
			G	-1.6	-1.4	-0.5	0.2
Water yield (GDP in dollars per 1 cubic meter of consumed water resources)	0.8	1.0	B	1.2	1.35	-	-
			G	1.8	2.2	2.8	3.5

Indicators	2018 (report)	2020 (expected)	Scenario	2025 (forecast)	2030 (forecast)	2040 (forecast)	2050 (forecast)
Water scarcity (billion cubic meters)	-6.2	-7.5	K	-12.0	-18.0	-	-
			G	-5.2	-4.5	-3.2	-2.5
Indicators of economic balance and sustainability							
Foreign trade balance (% of GDP)	-5.6	-6.1	B	-5.5	-4.5	-	-
			G	-1.5	+3.2	+1.5	+0.8
Total external debt (% of GDP)	17.3	27.6	B	35-40	50-60	-	-
			G	25	22	18	15
Share of carbon tax payments in state budget revenues,%	0.0	0.0	B	..	..	..	..
			G	..	..	..	..
Economic diversification indicators							
Share of finished goods in export%	16.0	16.5	B	21.0	28.0	-	-
			G	24.0	34.0	55	65
Share of processing industry % of GDP	16.3	15.0	B	14.2	12.0	-	-
			G	16.5	18.0	17-18	15-16
Social indicators							
Growth of sustainable employment per year, in% of the number of employed	2.0	2.5	B	2.5	2.5	2.5	2.5
			G	3.0	5.0	7.0	10.0
External labor migration (% of migrants in labor resources)	30	25	B	27	30	-	-
			G	20	14	10	8
Extreme poverty rate (% of total population)			B				
			G				
For reference: average score for 75 developing countries CO2 emissions (kg/USD) export (% of GDP)	0,61 52,3	0,60 53		0,57 55	0,54 58	0,50 62	0,45 65

Source: Authors' estimates. Some estimates are not final and will be revised as data is received from the Ministry of Economic Development and Poverty Reduction.

The forecast estimates for the brown scenario are based on the following assumptions:

1) The post-pandemic recovery of the SBPE sector may take 2-3 years (it accounts for three-quarters of all those employed and more than half of GDP, domestic and external demand). Additional risks may arise due to the deterioration of the creditworthiness of enterprises and the population, which will negatively affect the financial stability of the banking sector, limiting the availability of credit resources. An additional risk may be the introduction of measures restricting the activities of the SBPE sector. As a result, the real GDP growth rate in the first five years of the forecast period (3-4%) is likely to be lower than the average rate for 2017-2019 (5.2%);

2) The high capital intensity of economic growth (or low capital return), reflecting the raw material orientation of the economy, will become a factor of deceleration. If during 2000-2005 one soum of investments (in the current year and in the two years preceding the current period with weights of 0.7, 0.2 and 0.1, respectively) accounted for more than 7 UZS of GDP

(in 2010 prices), then by 2010 this indicator had dropped to 4 UZS. The rapid growth of investments in 2018-2020 further reduced the capital return (to 3.4 UZS in 2018 and 2.5 UZS in 2020, estimate). Thus, the return on investment has fallen almost 3 (three) times since the early 2000s.

There is a limit for investment growth, exceeding which can destabilize the economic situation. In 2011-2016, investments were at the level of long-term values (21-23%of GDP), and external debt grew slightly (7.5% – 14.6% of GDP). Investment Boom 2017-2020 (investment to GDP increased in 2017 – 26% and to 42% in 2019 and 40.4% in 2020, forecast) led to a rapid increase in external debt to 27% of GDP (by mid-2020), due to an increase in external borrowing for construction and other capital-intensive industries, poorly related to both resource conservation and green development.

The same situation is typical for foreign trade. Exceeding the threshold estimate for the level of investment (21-23%of GDP) in 2017-2020 changed the ratio between exports and imports. If in 2011-2016 the foreign trade balance was active (the average estimate is + 1.6% of GDP), then in the last 4 years it became deficient and increased to -6.4% in 2019.

As the calculations show, maintaining the capital return at the level of 2.5 UZS s of GDP /1 UZS of investment will aggravate the macroeconomic situation. Maintaining economic growth even at the level of 3-4% per year in 2021-2025 in conditions of low capital return will require investment (40-41% of GDP), significantly higher than the threshold (21-23% of GDP). In this case, the dynamics of external debt will increase and by 2025 it may reach 35-40% with a growing impact on the growth of the state budget deficit due to increasing interest payments on debt servicing.

The situation will be similar in terms of the foreign trade balance deficit, which may amount to 5-6% of GDP by 2025, which will lead to the depletion of gold and foreign exchange reserves, accelerated devaluation of the Uzbek soum and destabilization of the financial situation as a whole.

3) The risk of a slowdown in the economy due to high capital intensity will be increased by additional factors. Already in the next 3-5 years, the depletion of traditional growth factors,[50] energy and water intensity, and the growing shortage of water, energy and land resources will increase.[51]

In general, the GDP growth rate under the inertial scenario will decrease from the current 5% (2020) to 4% by 2025 and to 2-3% by 2030, even without taking into account the limited water and energy resources, but only due to the unfavorable growth trend in the capital intensity of GDP, which indicates poor prospects for the brown scenario in the medium term.

The green scenario projections are based on a synthesis of global experience, including the experience of developing countries and countries with economies in transition that have made significant progress in reducing emissions while maintaining industrial potential.

In terms of resource efficiency, important benchmarks include:

- in terms of capital return: growth from 2.5 UZS of GDP per 1UZS of investment to 2.9 UZS in 2025 and 4.0 UZS in 2030 and 6.0-6.5 UZS s in 2050. In this case, the growth of demand for investments will not be explosive, and their value to GDP will be in the range of 25-27%, which was typical of many successfully developing countries of the world (China, Korea, Czech Republic);

[50] The growth of income from the export of metals, gas, agriculture and products of processing of mineral resources with a low share of added value (mainly at large enterprises established in the Soviet period), the expansion of the SBPE sector in traditional areas and sectors of the economy (trade, public catering, transport, agriculture), the preservation of income from the export of labor resources.

[51] Calculations of the primary energy resources deficit in the conditions of the inertia scenario by 2030 are from 10% and higher.

- in terms of energy efficiency, the indicator will increase by 1.2 times in 2025 and 1.6 times in 2030 (compared to 2000) and 2.5 times by 2050. This will ensure that by 2040 Uzbekistan will reach the global average level for this indicator;
- in terms of water efficiency: growth of the indicator by 1.8 times by 2025, by 2-2. 3 times in 2030, and by 3.5-3.6 times by 2050. In the context of rapid population and economic growth, this will reduce the water deficit, keeping it within 2.5-5 billion cubic meters (compared to 7.5 billion cubic meters in 2020).

The share of the manufacturing sector in GDP should increase from the current 15% to 16-17% in 2025 (due to the industrialization of small businesses) and to 18-19% in 2030 (due to the creation of its own technological base of resource-saving and green technologies), with a moderate decline to 15-16% by 2050 (global trend). Such dynamics will ensure the sustainability of the creation of new jobs, limit the vulnerability of the economy to external shocks, and increase its export potential. To do this, it is necessary to change the priority of investment policy with a focus on the development of non-resource sectors (reducing the share of investments in extractive industries and the primary processing of mineral resources from the current 75-80% to 60-65% by 2025 and 40-45% by 2030). This will also ensure a significant increase in the return on investment in the economy as a whole.

Emissions in the first 5 years should remain at the level of 2020 or slightly increase (to 195-200 million tons of CO2 eq.) against 190 million tons expected in 2020, with a subsequent exit on a downward trajectory (summary of the development of the most successful developing countries).

Alternative green development scenarios. The green scenario, in turn, can have two alternatives (traditional and socially oriented).

Traditional “green” low-carbon development to achieve the country’s commitments to reduce greenhouse gas emissions in the next 10 years:

- accelerated implementation of energy-, resource– and environment-saving technologies (primarily RES), especially in the basic sectors-metallurgy, transport, cement and food sector, fertilizer production, irrigation, energy-saving buildings, SHW) without priorities in terms of payback and creation of new jobs;
- traditional technological model (focus on the acquisition of imported technologies and equipment, the use of foreign specialists for its maintenance, without attempts to create and implement plans for the development of the domestic technological base and production facilities with completed technological cycles);
- established sources of financing for green projects (the state budget and external borrowing).

Socially oriented inclusive low-carbon green development:

- selective climate financing of projects that have the best combination of emission reduction indicators and social indicators (growth of employment and income of vulnerable populations, reduction of income inequality, etc.);
- a new model of technological modernization, which provides for strengthening the contribution of technology to solving social and environmental problems, including the expansion of sustainable employment through the gradual development of its own technological base and modern production facilities for processing local raw materials with a complete technological cycle (emphasis on double-dividend technology).

The table below provides an expert assessment of the development prospects of Uzbekistan on alternative options for the «green» development scenario until 2050.

TABLE 2 ASSESSMENT OF THE PROSPECTS FOR UZBEKISTAN'S LONG-TERM ECONOMIC DEVELOPMENT THROUGH TRADITIONAL (G-T) AND SOCIALLY ORIENTED (G-S) GREEN SCENARIO OPTIONS

Indicators	2018 (report)	2020 (expected)	Scenario	2025 (forecast)	2030 (forecast)	2040 (forecast)	2050 (forecast)
Growth indicators							
GDP growth rate (%)	5.1	0.5	G-T	4.0-5.0	4.0-5.5	5.0-6.0	4.0-5.0
			G-S				
Export,% of GDP (competitiveness indicator)	31.3	25.0	G-T	41.4	60.4	65-70	75-80
			G-S				
Emissions and the environment							
CO2 emissions (kg) per USD of GDP (2010 prices)	1.25	1.23	G-T	1.1	0.8	0.5	0.4
			G-S				
GHG emissions total (million t. CO2 eq.)	180	190	G-T				
			G-S				
Forest and pasture areas (thousand hectares)			G-T				
			G-S				
Resource efficiency at macro level							
Return on capital (UZS of GDP per 1 UZS of investment)	2.2	1.5	G-T	..	..	..	..
			G-S	..	..	..	..
Investment in fixed assets, % of GDP	29.8	32.0	G-T	32	35		
			G-S	..	..	..	..
Energy intensity (kg o.e. per $ 1000 GDP)	176	170	G-T	145	130		
			G-S	..	..	..	..
Economic diversification indicators							
Share of finished goods in export%	16.0	16.5	G-T	24.0	34.0	55	65
			G-S				
Share of processing industry % of GDP	16.3	15.0	G-T	16.5	18.0	17-18	15-16
			G-S				
Social indicators							
Growth of sustainable employment per year, in% of the number of employed			G-T				
			G-S				
External labor migration (% of migrants in labor resources)	30	25	G-T	20	14	10	8
			G-S				
Extreme poverty rate (% of total population)			G-T				
			G-S				

Source: Authours' expert estimates

ANNEX 3. RESULTS OF THE CORRELATION ANALYSIS OF FACTORS INFLUENCING THE DYNAMICS OF SECTORAL SPECIFIC EMISSIONS

TABLE 1 BASELINE SPECIFIC EMISSIONS BY SECTORS, 1990-2017

	EM_EN (tons/ thousand KWh)	EM_CH (t/t)	EM_CM (t/t)	EM_TR (t/million pass. th.km)	EM_AGR (t/t)
1990	1.027	2.299	0.40		3.28
1991	1.069	2.287	0.41		3.36
1992	1.034	2.245	0.42		3.28
1993	0.990	2.209	0.45		3.35
1994	0.954	2.232	0.44		3.24
1995	0.994	2.208	0.45		3.30
1996	0.947	2.195	0.44		3.66
1997	0.940	2.133	0.46		3.69
1998	0.898	2.099	0.47	177.6	3.47
1999	0.909	2.065	0.45	174.6	3.29
2000	0.952	2,067	0.45	156.7	3.17
2001	0.888	2.019	0.45	155.6	3.14
2002	0.917	2.073	0.43	138.1	3.22
2003	0.849	2.058	0.44	121.1	3.04
2004	0.879	2.083	0.44	113.9	2.92
2005	0.776	2.098	0.45	107.2	2.91
2006	0.715	2.100	0.42	122.2	2.86
2007	0.664	2.126	0.42	111.5	2.88
2008	0.674	2.133	0.43	104.7	3.00
2009	0.665	2.086	0.42	104.8	3.22
2010	0,598	2.127	0.43	103.5	3.07
2011	0.631	2.117	0.42	97.9	2.85
2012	0.621	2.136	0,41	102.6	2.76
2013	0.535	2.041	0.42	122.6	2.66
2014	0.559	2.041	0.41	121.9	2.57
2015	0,541	2.032	0.37	135.0	2.52
2016	0.541	2.075	0.37	125.7	2.43
2017	0.510	2.068	0.37	132.7	2.37

Source: Calculations based on data on emissions (Uzhydromet) and sectoral outputs in physical terms (State Statistics Committee)

TABLE 2. BASELINE SECTORAL INVESTMENTS (% OF SECTOR'S OUTPUT), 2005-2017

	INV_EN	INV_CH	INV_CM	INV_TR	INV_AGR
2005	27.5	10.6	7.3	22.4	1.6
2006	38.8	11.9	8,7	24,9	2,3
2007	65.0	7.5	7.3	27.1	2.0
2008	57.6	13.8	8.5	31.9	2.5
2009	70.8	17.5	15.8	47.0	3.1
2010	21.9	6.1	14.6	33.6	5.4
2011	20.0	3.9	8.1	21.0	5.5
2012	18.8	11.1	9.0	20.5	4.9
2013	22.1	11.2	6.8	21.2	4.7
2014	23.7	9.7	11.2	17.7	4.7
2015	25.0	14.4	11.3	13.9	4.5
2016	25.9	37.9	14.3	18.9	4.1
2017	46.9	14.5	21.4	17.6	4.1
Average for 2011-2017	26.1	13.1	11.7	18.7	4.7

Source: Calculations based on data on sectoral outputs and investments (in value terms) from the State Statistics Committee

TABLE 3. BASELINE MACROECONOMIC AND INSTITUTIONAL INDICATORS. 2005-2017

	INV_EN	INV_CH	INV_CM	INV_TR	INV_AGR
2005	27.5	10.6	7.3	22.4	1.6
2006	38.8	11.9	8.7	24.9	2.3
2007	65.0	7.5	7.3	27.1	2.0
2008	57.6	13.8	8.5	31.9	2.5
2009	70.8	17.5	15.8	47.0	3.1
2010	21.9	6.1	14.6	33.6	5.4
2011	20.0	3.9	8.1	21.0	5.5
2012	18.8	11.1	9.0	20.5	4.9
2013	22.1	11.2	6.8	21.2	4.7
2014	23.7	9.7	11.2	17.7	4.7
2015	25.0	14.4	11.3	13.9	4.5
2016	25.9	37.9	14.3	18.9	4.1
2017	46.9	14.5	21.4	17.6	4.1
Average for 2011-2017	26.1	13.1	11.7	18.7	4.7

Source: Calculations based on data on sectoral outputs and investments (in value terms) from the State Statistics Committee

	EMPL_IND	EXP_R	EXP_gdp	ECI	FDI_gdp	GDS_gdp	GFC_gdp	ENI
2000	20.6	9.2	24.7	-0.621	0.543	24.9	22.9	774
2001	20.4	-5.4	22.4	-0.820	0.726	23.7	26.8	747
2002	20.1	-6.7	20.1	-0.702	0.674	24.1	20.5	748
2003	20.4	26.5	24.4	-0.463	0.815	26.8	20.1	695
2004	21.2	28.1	29.1	-0.453	1.468	31.5	21.4	636
2005	20.9	12.0	30.4	-0.433	1.339	34.1	19.9	551
2006	21.8	16.8	33.1	-0.430	1.003	35.2	21.6	524
2007	22.7	39.9	42.3	-0.495	3.161	33.1	23.5	474
2008	22.6	37.4	53.3	-0.382	2.407	34.6	26.8	453
2009	23.2	-5.1	46.8	-0.464	2.499	30.6	28.4	372
2010	23.0	7.9	46.9	-0.440	3.506	29.6	27.0	335
2011	23.2	12.2	48.9	-0.556	2.893	31.2	25.7	339
2012	23.2	-5.9	42.8	-0.532	0.885	29.2	25.7	320
2013	23.8	11.1	44.2	-0.651	0.920	25.9	26.7	263
2014	24.2	-7.5	38.2	-0.766	0.988	26.0	23.4	248
2015	23.8	2.3	32.8	-0.874	0.081	24.3	23.3	205
2016	23.9	11.1	29.9	-0.896	2.033	22.1	22.8	183
2017	23.9	1.3	32.9	-0.847	3.038	26.9	25.6	176

	NRS_GDP	INF	DEV	KOF	RoL	FoC	GEF
2000	16.4	47.3	90.5	27.71	-1.2	25	-0.98
2001	27.0	45.2	78.8	30.32	-1.5	26	-1.19
2002	24.9	45.5	81.3	31.52	-1.3	25	-1.10
2003	27.6	26.8	26.4	33.10	-1.3	26	-1.03
2004	24.6	15.9	4.9	33.71	-1.5	24	-1.21
2005	23.3	21.4	9.2	33.87	-1.4	24	-1.16
2006	33.5	23.5	9.5	35.28	-1.2	26	-1.11
2007	29.6	21.9	3.7	37.21	-1.2	26	-0.87
2008	33.6	26.8	4.4	37.73	-1.3	26	-0.63
2009	24.6	17.3	11.1	37.56	-1.4	26	-0.71

	NRS_GDP	INF	DEV	KOF	RoL	FoC	GEF
2010	21.1	39.4	8.2	37.87	-1.4	27	-0.69
2011	26.5	21.5	8.1	38.76	-1.3	19	-0.91
2012	25.1	15.5	10.2	38.01	-1.2	36	-0.91
2013	22.3	11.7	10.9	37.64	-1.1	35	-0.63
2014	15.8	14.3	10.3	36.66	-1.1	13	-0.67
2015	10.7	10.4	11.1	36.34	-1.1	17	-0.58
2016	8.8	8.7	15.2	36.06	-1.1	18	-0.56
2017	14.7	19.4	69.0	39.47	-1.1		

Source: Data from the World Bank (WDI) and the International Energy Agency

TABLE 4 PAIRWISE CORRELATION COEFFICIENT MATRIX (BASELINE DATA. COINCIDING PERIODS)

Sectors and indicators	Sectors with direct emissions				
	EM_EN	EM_CH	EM_CM	EM_TR	EM_AGR
EM_EN	1				
EM_CH	-0.11	1.00			
EM_CM	0.80	0.10	1.00		
EM_TR	0.40	-0.75	0.03	1.00	
EM_AGR	0.77	0.19	0.84	0.03	1.00
EML_IND	-0.96	0.09	-0.78	-0.38	-0.73
EXP_r	0.12	0.42	0.21	-0.32	0.07
EXP_gdp	-0.62	0.59	-0.17	-0.76	-0.11
ECI	0.23	0.68	0.61	-0.66	0.53
FDI_gdp	-0.40	0.61	-0.14	-0.57	-0.04
GDS_gdp	0.00	0.73	0.31	-0.70	0.22
GFC_gdp	-0.46	0.13	-0.14	-0.20	0.01
ENI	0.98	-0.08	0.83	0.39	0.79
NRS_GDP	0.38	0.48	0.62	-0.36	0.59
(INF)	0.70	-0.01	0.63	0.47	0.74
DEV	0.52	-0.45	0.20	0.83	0.28
KOF	-0.88	0.42	-0.59	-0.71	-0.54
RoL	-0.60	-0.20	-0.75	0.20	-0.77
FoC	0.13	0.30	0.40	-0.14	0.34
GEF	-0.82	0.01	-0.71	-0.22	-0.52

TABLE 5 PAIRWISE CORRELATION COEFFICIENT MATRIX (WITH INDICATORS LAGGING ONE YEAR)

	EM_EN	EM_CH	EM_CM	EM_TR	EM_AGR
EM_EN	1.00				
EM_CH	-0.15	1.00			
EM_CM	0.77	0.07	1.00		
EM_TR	0.49	-0.74	0.11	1.00	
EM_AGR	0.74	0.16	0.81	0.13	1.00
EML_IND	-0.98	0.23	-0.75	-0.54	-0.72
EXP_r	0.17	0.27	0.05	-0.15	0.12
EXP_gdp	-0.59	0.77	-0.19	-0.82	-0.09
ECI	0.31	0.64	0.54	-0.57	0.56
FDI_gdp	-0.33	0.38	-0.33	-0.34	0.01

	EM_EN	EM_CH	EM_CM	EM_TR	EM_AGR
GDS_gdp	0.15	0.60	0.37	-0.60	0.24
GFC_gdp	-0.45	0.60	-0.25	-0.39	-0.05
ENI	0.97	-0.16	0.81	0.52	0.77
NRS_GDP	0.57	0.55	0.70	-0.15	0.65
(INF)	0.64	-0.15	0.57	0.50	0.71
DEV	0.36	-0.44	0.05	0.77	0.10
KOF	-0.85	0.54	-0.62	-0.76	-0.50
RoL	-0.71	-0.14	-0.71	-0.07	-0.83
FoC	0.28	0.58	0.18	-0.30	0.33
GEF	-0.86	0.14	-0.81	-0.35	-0.62

Source: Baseline data on sectoral emissions and macroeconomic indicators

Indicator/factor classifier

a. Sectoral indicators

a1. EN. CH. CM. TR. AGR – sector classifier (energy sector. chemicals. building materials. transport. agriculture).

a2. EM_EN. EM_CH. ……. – specific greenhouse gas emissions by sector (EN – for the energy sector. CH – for chemicals. etc.).

a3. INV_ EN. INV_CH.…. – investments in the sector (EN – in the energy sector. CH – in chemicals. etc.).

b. Structural indicators and resource efficiency (for the economy as a whole)

FDI_gdp – foreign direct investment (% of GDP);

GDS_gdp – gross domestic savings (% of GDP);

GFC_gdp – investments in fixed assets (% of GDP);

EML_IND – share of people employed in the sector (% of the total number of employed people – indicator of the level of industrialization of the economy);

ECI – Economic Complexity Index. diversification and complexity of exports;

NRS_GDP – natural resource rent (% of GDP);

EXP_gdp – export (% of GDP);

EXP_r – export growth rate (% of previous year);

KOF – globalization index (economic. political. social. from 0 to 100);

ENI – energy intensity of the economy (kg o.e. share of GDP);

(INF) – inflation (GDP deflator. %);

DEV – devaluation of the national currency (%).

c. Institutional development indicators

RoL – level of compliance with current legislation (from -2.5 to +2.5);

GEF – government effectiveness (from -2.5 to +2.5);

FoC – freedom from corruption (from 0 to 100).

ANNEX 4. RESULTS OF ECONOMETRIC ANALYSIS OF EMISSIONS REDUCTION CONDITIONS

1. ENERGY SECTOR

Dependent Variable: EM_EN (№1)
Method: Least Squares (Gauss-Newton / Marquardt steps)
Date: 12/15/20 **Time:** 15:44
Sample (adjusted): 2002 2016
Included observations: 15 after adjustments
EM_EN=C(1)+C(2)*(0.5*INF(-2)+0.5*INF(-1))+C(3)*FOC

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	7.050062	6.007479	1.173548	0.2633
C(2)	0.240526	0.139324	1.726383	0.1099
C(3)	-0.657508	0.242410	-2.712384	0.0189
R-squared	0.405280	Mean dependent var		-3.058789
Adjusted R-squared	0.306160	S.D. dependent var		6.297546
S.E. of regression	5.245672	Akaike info criterion		6.329540
Sum squared resid	330.2049	Schwarz criterion		6.471150
Log likelihood	-44.47155	Hannan-Quinn criter.		6.328032
Durbin-Watson stat	2.482122			

Dependent Variable: EM_EN (№2)
Method: Least Squares
Date: 12/17/20 **Time:** 16:54
Sample (adjusted): 2007 2017
Included observations: 11 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INV_EN1(-1)	-0.162824	0.104779	-1.553969	0.1588
0.2*FDI_GDP+0.8*FDI_GDP(-2)	-2.362082	2.114870	-1.116892	0.2965
C	1.461952	4.254386	0.343634	0.7400
R-squared	0.258218	Mean dependent var		-2.857434
Adjusted R-squared	0.072772	S.D. dependent var		5.983343
S.E. of regression	5.761521	Akaike info criterion		6.567281
Sum squared resid	265.5610	Schwarz criterion		6.675798
Log likelihood	-33.12005	Hannan-Quinn criter.		6.498876
F-statistic	1.392418	Durbin-Watson stat		2.808466
Prob(F-statistic)	0.302765			

Dependent Variable: EM_EN (№3)
Method: Least Squares
Date: 12/22/20 **Time:** 16:01
Sample (adjusted): 2007 2016
Included observations: 10 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INV_EN1(-1)	-0.086469	0.090511	-0.955339	0.3712
FOC	-0.466209	0.234053	-1.991895	0.0866
C	8.732675	5.926506	1.473495	0.1841
R-squared	0.453604	Mean dependent var		-2.574103
Adjusted R-squared	0.297490	S.D. dependent var		6.228729
S.E. of regression	5.220662	Akaike info criterion		6.386450
Sum squared resid	190.7872	Schwarz criterion		6.477226
Log likelihood	-28.93225	Hannan-Quinn criter.		6.286870
F-statistic	2.905606	Durbin-Watson stat		2.767455
Prob(F-statistic)	0.120581			

Dependent Variable: EM_EN (№4)
Method: ARMA Maximum Likelihood (OPG – BHHH)
Date: 12/23/20 **Time:** 09:47
Sample: 2007 2017
Included observations: 11
Convergence achieved after 7 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INV_EN1(-1)	-0.186497	0.152486	-1.223044	0.2672
EXP_GDP(-2)	-0.334780	0.168202	-1.990352	0.0937
C	11.53949	7.060198	1.634443	0.1533
AR(1)	-0.631498	0.438049	-1.441613	0.1995
SIGMASQ	15.76507	13.54848	1.163605	0.2888
R-squared	0.515604	Mean dependent var		-2.857434
Adjusted R-squared	0.192673	S.D. dependent var		5.983343
S.E. of regression	5.376117	Akaike info criterion		6.551020
Sum squared resid	173.4158	Schwarz criterion		6.731882
Log likelihood	-31.03061	Hannan-Quinn criter.		6.437012
F-statistic	1.596639	Durbin-Watson stat		2.099049
Prob(F-statistic)	0.289467			
Inverted AR Roots	-.63			

2. CHEMICALS (AMMONIA)

Dependent Variable: EM_CH (№1)
Method: ARMA Maximum Likelihood (OPG – BHHH)
Date: 12/24/20 **Time:** 10:25
Sample: 2009 2017
Included observations: 9
Convergence achieved after 7 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INV_CH1(-3)	0.224461	0.090418	2.482491	0.0680
ROL	-0.736738	3.025253	-0.243529	0.8196
C	-1.096516	3.657555	-0.299795	0.7793
AR(1)	-0.713242	0.298474	-2.389632	0.0752
SIGMASQ	1.601191	1.760819	0.909344	0.4146
R-squared	0.567080	Mean dependent var		-0.323167
Adjusted R-squared	0.134159	S.D. dependent var		2.039829
S.E. of regression	1.898072	Akaike info criterion		4.498706
Sum squared resid	14.41072	Schwarz criterion		4.608275
Log likelihood	-15.24418	Hannan-Quinn criter.		4.262256
F-statistic	1.309893	Durbin-Watson stat		1.339807
Prob(F-statistic)	0.399984			
Inverted AR Roots	-.71			

Dependent Variable: EM_CH (№2)
Method: ARMA Maximum Likelihood (OPG – BHHH)
Date: 12/24/20 **Time:** 10:20
Sample: 2009 2017
Included observations: 9
Convergence achieved after 10 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INV_CH1(-3)	**0.109276**	0.017589	6.212622	0.0034
GDS_GDP(-1)	**-0.087871**	0.045815	-1.917952	0.1276
C	2.054382	1.284826	1.598958	0.1851
AR(3)	-0.986331	0.019490	-50.60633	0.0000
SIGMASQ	0.078503	0.100156	0.783809	0.4770
R-squared	0.978775	Mean dependent var		-0.323167
Adjusted R-squared	0.957549	S.D. dependent var		2.039829
S.E. of regression	0.420277	Akaike info criterion		2.606478
Sum squared resid	0.706531	Schwarz criterion		2.716047
Log likelihood	-6.729151	Hannan-Quinn criter.		2.370028
F-statistic	46.11361	Durbin-Watson stat		3.025385
Prob(F-statistic)	0.001332			
Inverted AR Roots	.50+.86i	.50-.86i	-1.00	

3. CONSTRUCTION MATERIALS INDUSTRY (CEMENT)

Dependent Variable: EM_CM (№1)
Method: Least Squares
Date: 12/22/20 **Time:** 16:11
Sample (adjusted): 2008 2017
Included observations: 10 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
0.2*INV_CM1+0.8*INV_CM1(-2)	-0.706346	0.382784	-1.845288	0.1075
FDI_GDP	2.873958	0.983370	2.922559	0.0223
C	-6.277917	1.979349	-3.171708	0.0157
R-squared	0.551425	Mean dependent var		-1.172558
Adjusted R-squared	0.423261	S.D. dependent var		3.657073
S.E. of regression	2.777304	Akaike info criterion		5.124163
Sum squared resid	53.99391	Schwarz criterion		5.214939
Log likelihood	-22.62082	Hannan-Quinn criter.		5.024583
F-statistic	4.302487	Durbin-Watson stat		2.393498
Prob(F-statistic)	0.060454			

Dependent Variable: EM_CM (№2)
Method: Least Squares
Date: 12/22/20 **Time:** 16:17
Sample (adjusted): 2008 2017
Included observations: 10 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
0.2*INV_CM1+0.8*INV_CM1(-2)	-0.191134	0.326117	-0.586090	0.5762
FOC(-2)	-0.369530	0.131320	-2.813978	0.0260
C	8.218234	3.444458	2.385930	0.0485
R-squared	0.532696	Mean dependent var		-1.172558
Adjusted R-squared	0.399181	S.D. dependent var		3.657073
S.E. of regression	2.834690	Akaike info criterion		5.165067
Sum squared resid	56.24828	Schwarz criterion		5.255843
Log likelihood	-22.82534	Hannan-Quinn criter.		5.065487
F-statistic	3.989771	Durbin-Watson stat		1.618757
Prob(F-statistic)	0.069759			

Dependent Variable: EM_CM (№3)
Method: ARMA Maximum Likelihood (OPG – BHHH)
Date: 12/22/20 **Time:** 16:25
Sample: 2008 2017
Included observations: 10
Failure to improve objective (non-zero gradients) after 26 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
0.2*INV_CM1+0.8*INV_CM1(-2)	0.133154	0.433523	0.307144	0.7711
NRS_GDP	0.189906	0.097170	1.954370	0.1081
C	-5.403641	2.042426	-2.645697	0.0457
MA(1)	-0.999999	49259.61	-2.03E-05	1.0000
SIGMASQ	5.280028	6890.235	0.000766	0.9994
R-squared	0.561342	Mean dependent var		-1.172558
Adjusted R-squared	0.210415	S.D. dependent var		3.657073
S.E. of regression	3.249624	Akaike info criterion		5.741597
Sum squared resid	52.80028	Schwarz criterion		5.892890
Log likelihood	-23.70799	Hannan-Quinn criter.		5.575630
F-statistic	1.599598	Durbin-Watson stat		2.048874
Prob(F-statistic)	0.306291			
Inverted MA Roots	1.00			

Dependent Variable: EM_CM (№4)
Method: ARMA Maximum Likelihood (OPG – BHHH)
Date: 12/23/20 **Time:** 09:35
Sample: 2007 2017
Included observations: 11
Convergence achieved after 13 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
EML_IND	-3.137408	1.311673	-2.391913	0.0539
INV_CM1(-1)	-0.111064	0.189452	-0.586235	0.5791
C	72.24708	30.86125	2.341029	0.0578
AR(2)	-0.834878	0.334996	-2.492201	0.0470
SIGMASQ	3.000351	3.548069	0.845629	0.4302
R-squared	0.733983	Mean dependent var		-0.989178
Adjusted R-squared	0.556638	S.D. dependent var		3.522311
S.E. of regression	2.345345	Akaike info criterion		5.062805
Sum squared resid	33.00386	Schwarz criterion		5.243666
Log likelihood	-22.84543	Hannan-Quinn criter.		4.948797
F-statistic	4.138739	Durbin-Watson stat		2.722285
Prob(F-statistic)	0.060276			
Inverted AR Roots	-.00+.91i	-.00-.91i		

Dependent Variable: EM_CM (№5)
Method: ARMA Maximum Likelihood (OPG – BHHH)
Date: 12/23/20 **Time:** 21:53
Sample: 2008 2017
Included observations: 10
Failure to improve objective (non-zero gradients) after 18 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
0.2*INV_CM1+0.8*INV_CM1(-2)	0.304800	0.371841	0.819705	0.4497
INF(-2)	0.189891	0.080773	2.350913	0.0655
C	-5.629556	1.808609	-3.112643	0.0265
MA(1)	-0.999999	43964.33	-2.27E-05	1.0000
SIGMASQ	6.081380	6670.017	0.000912	0.9993
R-squared	0.494766	Mean dependent var		-1.172558
Adjusted R-squared	0.090579	S.D. dependent var		3.657073
S.E. of regression	3.487515	Akaike info criterion		5.882898
Sum squared resid	60.81380	Schwarz criterion		6.034190
Log likelihood	-24.41449	Hannan-Quinn criter.		5.716930
F-statistic	1.224102	Durbin-Watson stat		1.956931
Prob(F-statistic)	0.405864			
Inverted MA Roots	1.00			

Dependent Variable: EM_CM (№6)
Method: Least Squares
Date: 12/23/20 **Time:** 22:25
Sample (adjusted): 2006 2017
Included observations: 12 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
0.2*INV_CM1+0.8*INV_CM1	0.131942	0.256829	0.513736	0.6198
KOF	1.791842	0.868041	2.064236	0.0690
C	-68.56885	32.48316	-2.110905	0.0640
R-squared	0.329004	Mean dependent var		-1.430939
Adjusted R-squared	0.179894	S.D. dependent var		3.690613
S.E. of regression	3.342209	Akaike info criterion		5.463459
Sum squared resid	100.5333	Schwarz criterion		5.584686
Log likelihood	-29.78075	Hannan-Quinn criter.		5.418577
F-statistic	2.206447	Durbin-Watson stat		2.584549
Prob(F-statistic)	0.166050			

Dependent Variable: EM_CM (№7)
Method: ARMA Maximum Likelihood (OPG – BHHH)
Date: 12/24/20 **Time:** 09:45
Sample: 2008 2017
Included observations: 10
Failure to improve objective (non-zero gradients) after 109 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
0.2*INV_CM1+0.8*INV_CM1(-2)	-0.002434	0.351217	-0.006930	0.9948
ROL	-10.50086	3.911693	-2.684479	0.0550
C	-14.37509	4.886171	-2.941995	0.0423
AR(2)	-0.832009	0.393881	-2.112335	0.1022
MA(1)	-0.999982	28133.95	-3.55E-05	1.0000
SIGMASQ	1.453733	4377.918	0.000332	0.9998
R-squared	0.879226	Mean dependent var		-1.172558
Adjusted R-squared	0.728258	S.D. dependent var		3.657073
S.E. of regression	1.906393	Akaike info criterion		4.990503
Sum squared resid	14.53733	Schwarz criterion		5.172054
Log likelihood	-18.95251	Hannan-Quinn criter.		4.791342
F-statistic	5.823918	Durbin-Watson stat		2.387902
Prob(F-statistic)	0.056286			
Inverted AR Roots	-.00+.91i	-.00-.91i		
Inverted MA Roots	1.00			

4. TRANSPORT (AUTOMOBILE AND RAILROAD)

Dependent Variable: EM_TR (№1)
Method: Least Squares
Date: 12/22/20 **Time:** 17:32
Sample (adjusted): 2008 2017
Included observations: 10 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INV_TR1(-2)	-0.622011	0.278650	-2.232229	0.0561
C	1.530301	2.207885	0.693107	0.5079
R-squared	0.383802	Mean dependent var		2.054818
Adjusted R-squared	0.306778	S.D. dependent var		8.338091
S.E. of regression	6.942293	Akaike info criterion		6.889998
Sum squared resid	385.5634	Schwarz criterion		6.950515
Log likelihood	-32.44999	Hannan-Quinn criter.		6.823611
F-statistic	4.982847	Durbin-Watson stat		3.094128
Prob(F-statistic)	0.056102			

Dependent Variable: EM_TR (№2)
Method: Least Squares
Date: 12/22/20 **Time:** 22:42
Sample (adjusted): 2008 2017
Included observations: 10 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INV_TR1(-2)	-0.557157	0.267224	-2.084979	0.0755
EXP_R(-1)	-0.186738	0.133138	-1.402585	0.2035
C	3.517035	2.520984	1.395104	0.2056
R-squared	0.518985	Mean dependent var		2.054818
Adjusted R-squared	0.381552	S.D. dependent var		8.338091
S.E. of regression	6.557199	Akaike info criterion		6.842329
Sum squared resid	300.9781	Schwarz criterion		6.933105
Log likelihood	-31.21165	Hannan-Quinn criter.		6.742749
F-statistic	3.776273	Durbin-Watson stat		3.217405
Prob(F-statistic)	0.077189			

Dependent Variable: EM_TR (№3)
Method: ARMA Maximum Likelihood (OPG – BHHH)
Date: 12/23/20 **Time:** 22:00
Sample: 2008 2017
Included observations: 10
Failure to improve objective (non-zero gradients) after 17 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INV_TR1(-2)	-0.382828	0.144916	-2.641717	0.0459
INF(-3)	0.490462	0.194013	2.527984	0.0527
C	-9.406154	4.591650	-2.048535	0.0958
MA(2)	0.999999	13764.36	7.27E-05	0.9999
SIGMASQ	12.35480	85798.63	0.000144	0.9999
R-squared	0.802549	Mean dependent var		2.054818
Adjusted R-squared	0.644588	S.D. dependent var		8.338091
S.E. of regression	4.970875	Akaike info criterion		6.710272
Sum squared resid	123.5480	Schwarz criterion		6.861565
Log likelihood	-28.55136	Hannan-Quinn criter.		6.544305
F-statistic	5.080675	Durbin-Watson stat		2.531216
Prob(F-statistic)	0.052083			

Dependent Variable: EM_TR (№4)
Method: ARMA Maximum Likelihood (OPG – BHHH)
Date: 12/23/20 **Time:** 22:29
Sample: 2008 2017
Included observations: 10
Convergence achieved after 8 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INV_TR1(-2)	-0.579937	0.365059	-1.588614	0.1730
KOF(-2)	3.586758	1.053481	3.404673	0.0192
C	-132.5682	39.62491	-3.345577	0.0204
AR(1)	-0.872710	0.319297	-2.733221	0.0411
SIGMASQ	5.450771	3.376726	1.614218	0.1674
R-squared	0.912887	Mean dependent var		2.054818
Adjusted R-squared	0.843197	S.D. dependent var		8.338091
S.E. of regression	3.301748	Akaike info criterion		5.677024
Sum squared resid	54.50771	Schwarz criterion		5.828317
Log likelihood	-23.38512	Hannan-Quinn criter.		5.511057
F-statistic	13.09921	Durbin-Watson stat		2.018320
Prob(F-statistic)	0.007351			
Inverted AR Roots	-.87			

5. AGRICULTURE (LIVESTOCK FARMING)

Dependent Variable: EM_AGR (№1)
Method: ARMA Maximum Likelihood (OPG – BHHH)
Date: 12/22/20 **Time:** 22:56
Sample: 2007 2017
Included observations: 11
Failure to improve objective (non-zero gradients) after 10 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INV_AGR1(-1)	-3.637568	1.502001	-2.421815	0.0517
FOC(-2)	0.077782	0.209021	0.372126	0.7226
C	-2.505758	5.460557	-0.458883	0.6625
MA(2)	0.999989	13793.64	7.25E-05	0.9999
SIGMASQ	8.383215	62029.06	0.000135	0.9999
R-squared	0.467887	Mean dependent var		-1.600009
Adjusted R-squared	0.113144	S.D. dependent var		4.162934
S.E. of regression	3.920361	Akaike info criterion		6.212977
Sum squared resid	92.21537	Schwarz criterion		6.393838
Log likelihood	-29.17137	Hannan-Quinn criter.		6.098969
F-statistic	1.318948	Durbin-Watson stat		1.457426
Prob(F-statistic)	0.362148			

Dependent Variable: EM_AGR (№2)
Method: ARMA Maximum Likelihood (OPG – BHHH)
Date: 12/22/20 **Time:** 22:53
Sample: 2007 2017
Included observations: 11
Failure to improve objective (non-zero gradients) after 28 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INV_AGR1(-1)	0.657820	1.502883	0.437706	0.6769
KOF(-2)	-2.027372	0.614778	-3.297731	0.0165
C	73.42255	22.78947	3.221776	0.0181
MA(2)	-0.999998	10336.89	-9.67E-05	0.9999
SIGMASQ	4.755287	25024.36	0.000190	0.9999
R-squared	0.698165	Mean dependent var		-1.600009
Adjusted R-squared	0.496941	S.D. dependent var		4.162934
S.E. of regression	2.952630	Akaike info criterion		5.646011
Sum squared resid	52.30816	Schwarz criterion		5.826873
Log likelihood	-26.05306	Hannan-Quinn criter.		5.532003
F-statistic	3.469594	Durbin-Watson stat		1.724502
Prob(F-statistic)	0.085094			

Dependent Variable: EM_AGR (№3)
Method: Least Squares
Date: 12/23/20 **Time:** 09:41
Sample (adjusted): 2007 2017
Included observations: 11 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
EML_IND(-1)	-4.014961	1.694641	-2.369211	0.0453
INV_AGR1(-1)	-2.705307	1.458209	-1.855226	0.1007
C	92.24534	39.49005	2.335913	0.0477
R-squared	0.454676	Mean dependent var		-1.600009
Adjusted R-squared	0.318346	S.D. dependent var		4.162934
S.E. of regression	3.437017	Akaike info criterion		5.534086
Sum squared resid	94.50468	Schwarz criterion		5.642603
Log likelihood	-27.43747	Hannan-Quinn criter.		5.465681
F-statistic	3.335095	Durbin-Watson stat		1.834581
Prob(F-statistic)	0.088434			

Dependent Variable: EM_AGR (№4)
Method: Least Squares
Date: 12/23/20 **Time:** 22:04
Sample (adjusted): 2007 2017
Included observations: 11 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INV_AGR1(-1)	-6.331829	2.685575	-2.357718	0.0461
INF(-1)	0.529671	0.245556	2.157025	0.0631
C	-10.29790	4.328852	-2.378898	0.0446
R-squared	0.413284	Mean dependent var		-1.600009
Adjusted R-squared	0.266605	S.D. dependent var		4.162934
S.E. of regression	3.565074	Akaike info criterion		5.607248
Sum squared resid	101.6780	Schwarz criterion		5.715764
Log likelihood	-27.83986	Hannan-Quinn criter.		5.538843
F-statistic	2.817608	Durbin-Watson stat		1.144773
Prob(F-statistic)	0.118498			

Dependent Variable: EM_AGR (№5)
Method: Least Squares
Date: 12/24/20 **Time:** 09:50
Sample (adjusted): 2007 2017
Included observations: 11 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INV_AGR1(-1)	-2.676150	1.661913	-1.610282	0.1460
ROL	-17.89290	10.15103	-1.762669	0.1160
C	-22.77122	12.25126	-1.858683	0.1001
R-squared	0.331631	Mean dependent var		-1.600009
Adjusted R-squared	0.164539	S.D. dependent var		4.162934
S.E. of regression	3.805071	Akaike info criterion		5.737547
Sum squared resid	115.8285	Schwarz criterion		5.846064
Log likelihood	-28.55651	Hannan-Quinn criter.		5.669142
F-statistic	1.984717	Durbin-Watson stat		1.727758
Prob(F-statistic)	0.199556			

Dependent Variable: EM_AGR (№6)
Method: ARMA Maximum Likelihood (OPG – BHHH)
Date: 12/24/20 **Time:** 10:07
Sample: 2007 2017
Included observations: 11
Convergence achieved after 33 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INV_AGR1(-1)	0.143521	2.364039	0.060710	0.9536
GEF(-2)	-14.41119	7.255884	-1.986139	0.0942
C	-13.43286	5.382049	-2.495864	0.0468
MA(2)	-0.999996	11673.52	-8.57E-05	0.9999
SIGMASQ	5.102969	30326.99	0.000168	0.9999
R-squared	0.676096	Mean dependent var		-1.600009
Adjusted R-squared	0.460160	S.D. dependent var		4.162934
S.E. of regression	3.058667	Akaike info criterion		5.716575
Sum squared resid	56.13266	Schwarz criterion		5.897437
Log likelihood	-26.44116	Hannan-Quinn criter.		5.602567
F-statistic	3.131000	Durbin-Watson stat		1.557047
Prob(F-statistic)	0.102907			
Inverted MA Roots	1.00	-1.00		

ANNEX 5. DEVELOPING COUNTRIES WITH DIFFERENT CO_2 EMISSION TRAJECTORIES DURING 2000-2016

Country	Sub-periods with dramatically different CO_2 emissions reduction rates		Reduction (-) or growth (+) in CO_2 emissions in average for sub-period (%)		
	Initial period	Final period	Initial period	Final period	Total for 2000-2016
Group A: countries with high CO_2 emissions reduction rates at the initial stage of the reporting period followed by a sharp decrease					
Armenia	2001-2006	2007-2016	-7.0	-0.8	-3.2
Azerbaijan	2001-2010	2011-2016	-11.8	+2.4	-6.5
Belarus	2001-2012	2013-2016	-5.1	-1.0	-4.0
Bulgaria	2001-2009	2010-2016	-4.8	-1.9	-3.5
Chile	2001-2009	2010-2016	-2.4	-0.1	-1.4
Georgia	2001-2007	2009-2016	-4.3	+4.8	+0.2
Mongolia	2001-2008	2009-2016	-1.0	+5.8	+2.4
Russia	2001-2008	2010-2016	-4.5	-0.5	-2.8
Sri Lanka	2001-2012	2014-2016	-2.4	+10.8	+0.1
Tajikistan	2001-2011	2012-2016	-6.3	+11.8	-0.7
Ukraine	2001-2008	2010-2016	-6.3	-2.5	-4.6
Group averages			-5.1	+2.6	-2.2
Group B: countries with low CO_2 emissions reduction rates at the initial stage of the reporting period followed by a sharp increase					
China	2001-2011	2012-2016	-0.3	-6.6	-2.2
Costa Rica	2001-2007	2008-2016	+0.9	-3.4	-1.5
Israel	2001-2008	2009-2016	-1.1	-3.7	-2.4
Kazakhstan	2001-2008	2009-2016	-0.3	-3.0	-1.6
Malaysia	2001-2005	2006-2016	+3.1	-1.9	-0.3
Mexico	2001-2009	2010-2016	+1.0	-2.8	-0.7
Panama	2001-2010	2011-2016	-0.3	-4.2	-1.8
Singapore	2001-2009	2010-2016	+3.6	-9.5	-2.2
South Africa	2001-2009	2010-2016	-0.1	-2.7	-1.2
Yemen	2001-2009	2010-2016	+2.0	-4.6	-0.8
Group averages			+0.9	-4.2	-1.5

Source: Processed World Bank data on CO_2 emissions

ANNEX 6. COMPARISON OF TWO GROUPS OF COUNTRIES WITH DIFFERENT CO_2 EMISSION TRAJECTORIES BASED ON THE SHARE OF PROCESSING INDUSTRIES AND HEALTH EXPENDITURE (IN % OF GDP)

Countries	Share of processing industries (% of GDP)				Share of health spending (public and private. % of GDP)			
	2000	By end of initial period	Change (in p.p.)	By end of reporting period	2000	By end of initial period	Change (in p.p.)	By end of reporting period
Group A: countries with high CO_2 emissions reduction rates at the initial stage of the reporting period followed by a sharp decrease								
Armenia	18.5	11.9	-6.6	10.3	6.3	4.2	-2.1	4.5
Azerbaijan	5.3	4.8	-0.5	4.9	4.7	5.7	+0.6	6.0
Belarus	27.0	24.8	-2.2	20.2	6.1	5.0	-1.1	5.7
Bulgaria	12.1	12.8	+0.7	14.5	6.2	7.2	+1.0	8.4
Chile	16.9	11.2	-5.7	11.0	7.7	7.7	0	7.8
Georgia	12.2	10.4	-1.8	10.4	6.9	8.2	+1.3	7.4
Mongolia	6.7	6.6	-0.1	7.3	4.7	5.8	+1.1	4.7
Russia	15.2	14.9	-0.3	12.0	5.4	5.1	-0.3	7.1
Sri Lanka	15.1	18.0	+2.9	16.4	3.7	3.2	-0.5	3.5
Tajikistan	33.7	9.7	-24.0	9.7	4.6	5.8	+1.2	6.9
Ukraine	16.3	13.8	-2.5	12.2	5.6	6.6	+1.0	7.1
Group averages	16.3	12.6	-3.7	11.7	5.6	5.8	+0.2	6.3
Group B: countries with low CO_2 emissions reduction rates at the initial stage of the reporting period followed by a sharp increase								
China	31.8	32.1	+0.3	29.0	4.6	5.2	+0.6	5.5
Costa Rica	18.4	14.0	-4.4	11.4	7.1	8.4	+1.3	9.3
Israel	16.8	15.3	-1.5	12.5	7.5	7.7	+0.2	7.8
Malaysia	30.9	27.5	-3.4	22.2	3.1	3.6	+0.5	4.2
Mexico	19.0	15.1	-3.9	17.0	5.1	6.4	+1.3	6.3
Panama	11.3	7.3	-4.0	6.2	7.8	8.8	+1.0	8.0
Singapore	25.9	20.3	-5.6	17.6	2.8	5.1	+2.3	4.9
South Africa	17.5	13.6	-3.9	12.0	8.3	8.7	+0.4	8.8
Yemen	5.7	9.4	+3.7	6.9	4.5	6.0	+1.5	5.6
Group averages	19.7	17.2	-2.5	15.0	5.6	6.6	+1.0	6.7

Source: Processed World Bank data on CO_2 emissions