Spatial-economic-ecological model for the assessment of sustainability policies of the Russian Federation

Project 213091

Final Publishable Summary Report

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Table of contents

1. Executive Summary

The objective of the project was to develop and implement for the Russian Federation an integrated spatial-economic-ecological modelling approach, which can be used to assist policy makers in their choice of medium and long-term sustainability policies. This implies the following interrelated aims:

- develop modelling approach, which represents the state-of-the-art in impact assessment modelling;
- build consistent database for Russian economy;
- construct the spatial-economic-ecological model for Russia;
- develop a set of sustainability indicators associated with the model;
- use the model to assess the effects of a set of important sustainability policy measures in order to demonstrate the operation ability and reliability of the developed modelling approach.

In pursuing this objective the following assumptions and methodological guidelines were adopted:

- Quantitative approach: existing European and international models such as GEM-E3, PACE, RAEM, EPPA and MIRAGE provide adequate references for the methodological basis of the project.
- Focus on three major dimensions – economic, environmental and social.
- Sensitivity tests and validation of results: taking into account the degree of uncertainty of any study focused on social and environmental issues, the SUST-RUS project will provide robustness check of the main parameters.

The main result of the first reporting period was a calibrated database, the core of the economic module and the assessment framework. In addition to an analytical formulation of the model we constructed economic model with the SUST-RUS database as of 2006 benchmark year. We completed an implementation of the model in the modeling language (General Algebraic Modeling System – GAMS). As a result, by the end of the first reporting period we had a first full operational version of SUST-RUS.

During the second reporting period the development of the model was continued and new modules were integrated within the core economic model: the environmental, international and social dimensions. All modules and the framework developed in the first reporting period were integrated in the main economic module.

The sensitivity of the model's output to exogenous parameters was tested in a local and a global sensitivity and uncertainty analysis. Three policy relevant simulations were performed and the results were reported in a working paper and on the final conference of the SUST-RUS project.

The SUST-RUS modelling tool provides Russian scientific community and policy makers with the sound scientific support for formulating sustainability policies, which are characterized by a balanced integration between social, economic and environmental policy objectives. The use of this approach will assist implementation of the strategy for sustainable development as well as efficient incorporation of the sustainability goals into the existing Russian policy tools at regional and federal levels. The SUST-RUS modelling approach represents the state-of-the-art in many different areas of knowledge and, hence, is superior to other policy assessment models available for Russia.

Summing up, the SUST-RUS project is useful in the sense that:

- It helps to make consistent judgments about alternative sustainability policy options, both for priority setting and for making good judgments about their impacts on sustainability along three dimensions: economic, environmental and social.
- It allows the comparison (and selection) of the effectiveness of varied policy options.
- It also makes it possible to go beyond the present state-of-the-art in the assessment of sustainability policies by linking the three dimensions of sustainability in a unified framework.
- The developed assessment tool is suitable for the whole range of policies and available to the interested parties.

2. Description of main S & T results

2.1. Summary description of project context and objectives

SUST-RUS addresses one of the objectives of the FP7 priority "developing the tools for analyzing key elements of sustainable development policies at the macro- and meso-economic levels, with particular attention to the effects of cooperation and trade policies as well as to the impacts of the delocalization of EU activities": develop the sustainability assessment model for Russia linked with the rest of the world via flows of trade and capital, develop a set of the sustainability indicators coupled with the model in order to help the Russian policy makers in their assessment of the sustainability policy packages including policies with respect to international cooperation and trade.

Russian rich endowment in natural resources determines the important role Russia plays in the world-wide sustainable development: Russia has 30% of the world wild nature resources (8 mill. hectares of the Russian territory), the Baikal Lake contains 20% of world fresh water resources, Russia has 30% of world forest resources.

However the overall ecological situation in Russia is far from ideal. As it follows from "The State Report on Environmental Situation in Russia":

- 15 % of the total Russian territory is heavily polluted. The most polluted regions are the regions of petrochemical and chemical industries concentration. The further economic development of these regions requires substantial investment in ecological improvement.
- Only 3,5% of the Russian territory is declared as special protected natural areas including national parks, natural reserves etc.
- While economic depression of the 90-es led to decline in air pollution from industrial sources, the air pollution due to transportation substantially increased. As a result 40 million of the Russian population in 86 cities face dangerous air pollution when it exceeds "admissible limits" by 10 and more times.

15% of the Russian Federation territory, which accommodates 25-30 million of inhabitants, is considered to be unfavorable from the ecological point of view. 60 mill. of Russian population lives in the polluted air areas, more than 50 mill. drink polluted water. 15% of diseases of the urban population are provoked by bad ecological situation. The average life expectancy is 61 for males and 74 for females; every 4 adult and every 6 child are chronically sick. There is a natural decrease of the population due to the excess of death rate over birth rate. From beginning of 1990-ties the losses of Russia are several hundred thousand people a year.

Nevertheless some steps to sustainable development goals have been made. Russia recognized the importance of sustainable development and signed the 1992 Rio Declaration. In 1994 the President of Russia signed "The State Strategy of Nature Protection and Sustainable Development" which aimed at ensuring a gradual reproduction of the natural ecosystems to the level of the guaranteeing stability of environment and future provision of sustainable favorable environmental development.

According to this Strategy the federal and regional authorities are responsible for the preparation of sustainable development programs.

In 1996 "The State Concept on Nature Protection and Sustainable Development" was adopted and published. This Concept was a result of the wide discussion among experts, officials and politicians. This Concept became a basis for the Two year State Action Plan on nature protection and sustainable development adopted in 1994.

The Federal Concept of environmental protection and sustainable development is a primary tool to deal with the issues of sustainable development. It serves as a basis for the Federal Strategy of environmental protection and sustainable development. This strategy is the 10-year long term forecast of the socio-economical development and the nature protection. This strategy is divided into two 5-year periods.

The first long-term forecast was done for the period 1996-2005. Each year this forecast was revaluated, modified and prolonged. In the framework of this Federal Strategy the two-year Action Plans were processed and put into practice. Each of these two-year plans consisted of two parts: a list of environmental and sustainable development programs and corresponding normative legislative base.

Now there are about thirty Federal ecological programs. The next stage of environmental and sustainable development management implies the introduction of the ecological parameters in the system of macroeconomic indicators (GNP, GDP). The federal system of ecological management (including the system of ecological standards) is used as the basis for all Russian regions and sectors of the national economy. Regional and industrial authorities implement similar forms of environmental and sustainable development management: the design of the regional (sector's) concepts and strategies, action plans, etc.

Meantime there is no unified research capacity that Russia federal and regional policy makers can utilize in order to design the consistent multi-level policy aimed at sustainable development and ecological improvement.

The objective of the SUST-RUS project was to develop and implement for Russia an integrated spatial-economic-ecological modeling approach, representing the state-of-the-art in different areas of economic, transport, resource-use and environmental modeling; the approach that can be used to assist policy makers in their choice of medium and long-term sustainability policies.

The main aims of the SUST-RUS project were:

- To close the gap between Russian and the European and international state-of-the-art tools and practices in the assessment of the sustainability policies.
- To provide the Russian policy makers with the set of specific sustainability indicators linked either to the individual policy measures or to their packages. Each sustainability indicator belongs to either social, economic or environmental area and is calculated using the SUST-RUS modeling tool.

The sustainability is a complex notion and develops along the social, economic and environmental dimensions. The SUST-RUS research consortium worked at all three dimensions of sustainability and incorporated them into the modeling tool. The approach was to start from the standard general economic modeling framework and elaborate it further by including the environmental and social dimensions in accordance with the state-of-the-art European and international approaches.

Given the large geographic area of Russia and strong differences between the economic and social structure of its regions it was important to incorporate the regional dimension into the policy assessment framework. For that purpose the new economic geography methodology was chosen as a basis for the construction of the model. The present quality of the statistical data for the Russian Federation allowed the researchers to split the country into seven federal districts according to its administrative division.

Patterns of sustainable development depend upon the technological progress in general and upon the technological developments, related to energy use, in particular. Technological progress gives the economy the ability to sustain the same consumption levels without increase in the use of energy and/or emissions. The level of technology in a country is determined both by the R&D within the country itself and by the inflow of technological knowledge from the rest of the world. This inflow goes either via imports and foreign capital inflow to the county or via international knowledge spillovers. SUST-RUS model incorporates international trade and FDI channels to have an effect on the productivity of Russian economy.

Transition to sustainability is a process in time, when the economy is going from the equilibrium, with unstable production and consumption patterns, to the sustainable equilibrium. The importance of this transition process for the policy conclusions required its incorporation into the SUST-RUS modeling approach and called for the use of time dimension. The recursive dynamics approach was realized in the current version of SUST-RUS modeling tool.

Thus, the objective of the study was to develop and implement for Russia an integrated spatial-economic-ecological modelling approach, which represents the state-of-the-art in different areas of economic, health, social and environmental modelling, and which can be used to assist policy makers in their choice of medium and long-term sustainability policies.

This objective implied the following interrelated aims:

- develop modelling approach, which represents the state-of-the-art in impact assessment modeling and corresponds the complexity of the sustainability issue;
- build a consistent database necessary for the implementation of the developed approach for Russia;
- construct the spatial-economic-ecological model for Russia;
- develop a set of sustainability indicators associated with the model, which allows for quantification of social, economic and environmental effects of sustainability policies;
- use the model to assess the effects of a set of important sustainability policy measures in order to demonstrate the operation ability and reliability of the developed modelling approach.

The main goal of the SUST-RUS modelling project was to provide the Russian and international community with a sound scientific support for formulating sustainability policies, which is characterized by a balanced integration between social, economic and environmental policy objectives. The use of the SUST-RUS approach is able to assist the implementation of the EU strategy for sustainable development in Russia as well as an efficient incorporation of the sustainability goals into the existing Russian policy tools on regional and federal levels. The SUST-RUS modelling approach represents the state-of-the-art in many different areas of knowledge and, is hence superior to other models available for Russia.

During the study, all objectives were reached and form a part of the foreground of the project at this stage. More particularly, during the project, the following was realized:

- A literature review, preceding the mathematical formulation of the SUST-RUS model, was written as the first deliverable (*D1.1. Overview of the relevant literature*) of the project.

- Modelling methodology was worked out according to the state-of-the-art models reviewed. Structure of the core model was described in the second deliverable (*D1.2. Description of the modelling methodology*).

- A raw dataset containing all economic data to create a baseline for the model for 2006, balance the dataset on regional level and possibly update the database in the future, was generated as the second deliverable of the project (*D2.1. Description of the constructed database, data quality and data collection methods* and *D2.2. The spatial -economic-environmental database for the model*).

- The mathematical basis of the model with all relevant derivations necessary to implement the core economic module was reported in the third deliverable (*D3. Description of the general structure of the spatial-economic-ecological model for Russia*).

- A consistent system of output indicators, based on a literature review of sustainability indicators, reported in deliverable *D4. Description of a set of the sustainability indicators coupled with the constructed model*. The indicators are distinguished in four domains: economy, trade, social and environment. All indicators are calculated by the model endogenously and allow for a full analysis of model output for progress towards sustainability.

- The core model was augmented by environmental, social and international modules. The description of the data and the implementation of each separate module integrated into the main SUST-RUS framework were reported in deliverable *D5. Description of the environmental, international and social part of the model.*

- Interaction between model dimensions is reviewed in deliverable *D8. Description of the links between the three dimensions of sustainability within the model.* The SUST-RUS model highlights links between environmental damage and labour market throught the health module.

- Sensitivity analysis of the modeling results was presented in deliverable *D9.1. Assessment of the model reliability and sensitivity analysis*.
- A number of politically relevant policy simulations were generated and reported in deliverable *D9.2. Assessment of policy scenarios*.
- The SUST-RUS integrated model, programmed in the GAMS modeling code, was fully realized and is available as the deliverable (D9.3: The spatial-economic-ecological model for Russia coupled with the consistent database) of the project. The full dataset, containing balanced regional social accounting matrices classified according to an ISIC official disaggregation in 32 sectors, balanced trade flows in goods and services, energy consumption and supply, international trade and taxes, FDI and capital flows, social and household data, labour market data and emissions, is coupled to the model.

The SUST-RUS approach can be used to assist the implementation of the sustainable development policies in Russia as well as an efficient incorporation of the sustainability goals into the existing Russian policy tools on regional and federal levels.

2.2. Overview of the relevant literature (deliverable D1.1)

Deliverable *D1.1. Overview of the relevant literature* is reviewing the state-of-the art literature summarizing best practices of construction and use of spatial-economic-environmental models. Among the reviewed models are: GEM-E3, EPPA, MMRF-GREEN, GreenMod II, GTAP-E, ISEEM, TEQUILA, and DEAN. The deliverable pays special attention to Russian experience of construction and use of economic models that could be referred to the same class as SUST-RUS model.

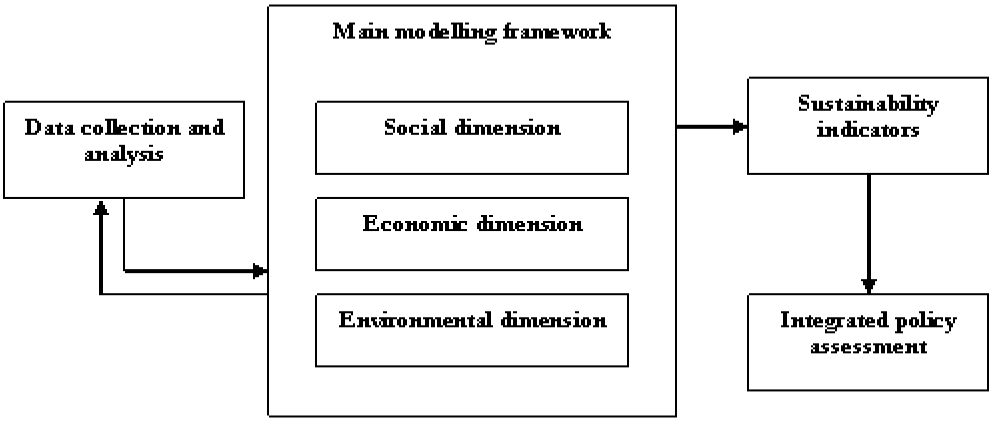
The SUST-RUS project has clear orientation for practical policy applications. Analysis of policy measures of appreciable magnitude and applicability, as evident in those concerning sustainable development, call for careful modelling of major policy trade-offs in the decisions involved. Accordingly, it seems natural that economic thinking should be the central point in this modelling exercise. Indeed, economics is considered the science of resource allocation, both in normative and positive senses, and as such, is heavily involved in analysing trade-offs, agent incentives and all the minutiae of actual-decision making by productive agents. The way people react to suggested policies is the single most important factor in transforming the nature of intended consequences of those policies, sometimes out of all recognition.

This review covers the class of models commonly referred to as computable general equilibrium (CGE), specifically set up to answer policy questions of sustainable development, especially in its environmental and energy aspects. The main reason for limiting the overview with this class of models is the decision of the SUST-RUS modelling crew to set up this kind of model for Russia. In defence of this decision we can mention that CGE modelling tradition consistently provides the single most effective and widely used policy assessment tool in economic matters in the world. Moreover, the comprehensive nature of the CGE class of models (their "general" flavour and highly detailed level of disaggregation in representing major economies) lends them naturally to studying environmental effects of economic activity.

2.3. The SUST-RUS Methodology (deliverable D1.2)

During our research the clear need for the spatial-economic-environmental model for Russia was revealed, since there is no comparable Russian model grounded on the same principles as the leading international models.

Figure 1: SUST-RUS methodology



The development of the SUST-RUS methodology was a logical continuation of the literature review. We suggested the methodology based on the best international and Russian practices of a spatial-economic-environmental modelling approaches, or in other words – multiregional computable general equilibrium (CGE) models. Given the complexity of the model, the proposed methodology describes in great details the following components of the model:

- Consumers
- Labour Market
- Producers
- Industrial structure
- Investment and capital
- Government

The complicated CGE is highly structural and substantially depends on the benchmark dataset. Along with the proposed methodology we suggested the most important steps of the database construction as well as risks associated with the data.

In order to use the model in policy discussion it is important to incorporate the ability to fine-tune the modelling tool for the essential policy issues. It is very important to decide on the range of potential policy scenarios on the stage of developing the model structure. At this stage, goals for policy simulations were set for future implementation in the SUST-RUS model.

The goals for policy simulations, which were set at this stage, were:

- Evaluation of the energy security of the Russian Federation (for example, given the amount of natural gas reserves).
- Evaluation of the dependence of the Russian economy on the exports of primary energy sources, such as natural gas, petrol, raw oil and coal.
- Impact of the accession of Russia to the ETS market for emission permits
- Effect of emission standards and environmental regulation on the Russian economy
- Effect of demographic transition on the Russian economy.
- Impact of liberalization of the Russian economy for international trade (for example, the accession to the WTO).
- Impact of pollution standards on health of Russian population and economy.
- Impact of taxation and redistribution initiatives of the Russian government on income inequality and poverty.
- Impact of structural investments in the transport and trade infrastructure in Russia.

- Impact of growth in importance of different trade partners of Russia (for example, China and Europe).

Description of the modelling methodology is presented in deliverable D1.2. The methodology is built on the basis of the best international and Russian practices of development of spatial-economic-environmental modelling tools for assessment of sustainable development policies. The methodology outlined takes into account special features and availability of Russian data. This report is expanding on methodology behind constructing Russian CGE model of economy, energy and environment, chosen by the SUST-RUS team. The report draws heavily on the work done in preparing literature review for the same project (see D1.1, CEFIR, 2009) and work on collecting and analysing available data. According to modelling philosophy, adopted by the SUST-RUS team, there were two steps in constructing a Russian CGE model. The first step was devoted to construction of the prototype model incorporating the most important features of the full-fledged model. During the second step of the model construction the final version of the model was built, augmenting the basic features of the prototype model with representation of the environmental and social blocks. The basic prototype model is static whereas the advanced model employ fully-rational (forward looking) dynamics, introduce monopolistic competition in some markets, and take account of labor migration. In the discussion of methodological issues, the authors describe the differences between the two models in more detail.

2.4. The database of the model (deliverables D2.1 and D2.2)

The raw database of the SUST-RUS model

The SUST-RUS model database at this stage consists of seven regional social accounting matrices. Each region, represented in the database, corresponds to the federal district of the Russian Federation. Balanced set of regional social accounting matrices constitute the core of the SUST-RUS model dataset.

The completion of this task involves the following work:

- Estimation of the 2006 country IO table
- Estimation of the 2006 regional IO tables
- Estimation of the 2006 interregional trade flows
- Construction of the 2006 regional social accounting matrices
- Balancing of 2006 regional SAMs with interregional trade data

Environmental data for the SUST-RUS model includes data on regional emission of SOx, NOx, VOC, and PM10, as well as CO2. All emissions are calculated on the basis of fuel use by region and by industry. The completion of this task involves substantial data work described in deliverable D5.

Cross-entropy procedure to balance matrices

Part of the foreground of the model is the cross-entropy procedure, which was used to derive balanced regional social accounting matrices from the original national social accounting matrix for Russia. This procedure was updated at several stages during the course of the SUST-RUS model work and forms an integral part of the work which has been done on the model.

The original unbalanced database contained a few problems, which had to be solved before any modeling could take place.

The original data on imports and exports contained re-export and re-import from other regions. Therefore, in some cases the amount of exports from a region was unrealistically high, in some cases even higher than the production. Similarly the amount of imports in a region could be too high to match the consumption of goods.

In the first version of the database the data on interregional trade in services was absent, and the Input-Output tables were balanced by increasing the international exports and imports of services. This lead to an overestimation of the exports and imports of services into Russia.

The interregional trade flows are not adjusted to the real demand of consumers in each region.

The savings rates were too high in some regions, while too low in other, due to an absence of interregional capital flows in the original data.

Some very small numbers in the original data created problems when they were implemented in the model.

The cross-entropy procedure couples several databases which have been used to generate the balanced database of the model. Among those data are: the exports and imports by region, the original regional input-output tables, national account data, transport margins, transport costs and regional trade flows and data on regional GDP and investment.

The cross-entropy maximization procedure is based on the minimization of the Kullback-Leibler divergence between the original data and the new 'balanced' dataset. In this way the procedure corrects several of the irregularities present in the original data, trying to maintain the integrity of the original data to the full extent possible.

Description of the constructed database, data quality and data collection methods is reported in the Deliverable D2.1. Detailed description of the data is essential to understanding modelling results. All implicit assumptions in the dataset construction are documented in this report. A computable general equilibrium model is a highly structured mathematical representation of an economy in question. However, all this complexity is ultimately fed with data coming from the benchmark database. Thus, a CGE model cannot provide results that are more accurate than the initial data. It is hard to overestimate the importance of the database construction for the computable general equilibrium analysis. Ensuring the quality and integrity of the benchmark data is one of the most important tasks in the modelling work. A complete dataset for a CGE model consists of several parts. First of all, there is a big set of statistical data, representing a snapshot of the economy for the base year. Usually statistical data is organized in the form of a social accounting matrix. Another part of the dataset consists of elasticities of substitution and transformation for CES and CET functions, as well as of other functional parameters that cannot be calibrated from the benchmark data. This work is documented in the deliverable *D3. Description of the general structure of the spatial-economic-ecological model for Russia*.

The spatial-economic-environmental database for the SUST-RUS model is presented in deliverable D2.2. The SUST-RUS model database consists of seven regional social accounting matrices. Each region in the database corresponds to a federal district of the Russian Federation in the base year of 2006. Balanced set of regional social accounting matrices constitute the core of the SUST-RUS model dataset. Usually the benchmark dataset is organized in a form of a social accounting matrix (SAM). The SAM format ensures that all material and financial flows are balanced. Deliverable 3.2 contains the benchmark dataset for the SUST-RUS project in the social accounting matrix format. Given spatial nature of the SUST-RUS project, the benchmark dataset is a multiregional social accounting matrix. All regional SAMs (RSAMs) are interconnected by trade and income flows. All RSAMs sum up to the country social accounting matrix, all RSAMs have structure implied by the SUST-RUS model.

2.5. Structure of the SUST-RUS model (deliverable D3)

Description of the general structure of the spatial-economic-ecological model for Russia is presented in deliverable D3. This report documents the SUST-RUS methodology in algebraic formulas; the model code and the database of model parameters, which cannot be calibrated from the SUST-RUS model database, are described in deliverable D2.1.

The SUST-RUS modelling approach provides Russian and international community with the sound scientific support for formulating sustainability policies for the Russian Federation. Sustainability means that the needs of the present generation should be met without compromising the ability of future generations to meet their own needs. The EU sets the following key objectives concerning sustainability:

- Environmental protection
- Social equity and cohesion
- Economic prosperity
- Meeting international responsibilities

The SUST-RUS modelling approach is characterized by a balanced integration of social, economic and environmental policy objectives. Therefore, this deliverable describes the appropriate modelling techniques along these dimensions. The report presents a full mathematical formulation of the model. The model is formulated as a system of simultaneous nonlinear equations, which represent the solutions to utility maximization and producer costs minimization problems as well as the market equilibrium conditions. The major problem of sustainable development is the rational use of spatially distributed natural resources such as minerals, water, land and ecosystem services. The use of most of these resources depends upon the allocation of production and consumption activities. By incorporating the representation of geographically distributed consumption and production patterns into the SUST-RUS modelling framework, the authors were able to account for the use of natural resources in the economy as well as to assess the effects of sustainability policies on different Russian regions.

The SUST-RUS model, among others, allows incorporating the following features:

- region-specific factor endowments of capital and labour
- regional production and consumption
- intermediate inputs of the sectors (total output is produced using not only capital and labour but also inputs of various services and goods)
- interregional trade
- representation of government finances (taxes, subsidies and transfers) and multi-level governance system
- emissions related to production and energy inputs of the sectors
- negative effect of emissions on the households' welfare
- investment decisions of households and firms
- representation of agglomeration mechanism in some sectors via Dixit-Stiglitz framework with monopolistic competition (optional)

Chapter 2 of the Deliverable 3 gives an overview of the model structure and discusses its main components and the underlying theory. In the subsequent chapters the model is introduced in mathematical details including a full set of model parameters and variables and a full description of all model equations and their economic interpretation. Most of the model equations are the results of utility maximization or costs minimization problems.

2.6. Framework of sustainability indicators (deliverable D4)

Our sustainability indicators are inspired by the common "three pillars methodology", where indicators are fitted to economic, environmental and social goals of sustainability. Our review of sustainability indicators, which has been performed in deliverable D4, and the uses and critiques on GDP and alternative indicators for 'progress' have led us to use the approach of using multiple indicators to capture sustainability. This means that we see sustainability as the crossing point between several interlinked goals, expressed in terms of social welfare, economic production and preservation of the environment.

When applying to the SUST-RUS model the framework developed in deliverable D4, some changes were made. We decided to separate the 'trade' dimension from the 'economic dimension'. The reason was to remain consistent with the original set-up of the SUST-RUS model (economic, social dimension, environmental and international dimension). Also it was found that in some of our simulations the 'trade' component was important and was better distinguished independently from the economic dimension. This separation improved our overview on the SUST-RUS results. *Table 1* below contains the sustainability indicators which are now endogenously calculated from the results of the model.

Table 1: Overview of sustainability indicators

ECONOMY	ENVIRONMENT	TRADE	SOCIAL
Real GDP per capita (billion rubles)	CO2 emission (Mtonnes/GDP)	Interregional trade value (by GDP)	Atkinson index (ε=3[1]) (alternate inequality index)
Herfindahl index (index of economic concentration)	Electricity consumption (monetary value as ratio of GDP)	Current account (by GDP)	Consumption budget (by GDP)
Investment (by GDP)	Fossil fuel consumption (monetary value as ratio of GDP)	Foreign investment (by GDP)	Gini coefficient (standard inequality index)
Price index (base price)	NOX emissions (ktonnes/GDP)	International trade openness (export + import / GDP)	Kakwani index (measure of progressivity of tax system)
Public savings (by GDP)	PM emissions (ktonnes/GDP)		Poverty intensity[2] (average distance of low income to poverty line)
Tax revenues (by GDP)	SOX emissions (ktonnes/GDP)		Unemployment rate (total and by skill level)

For the analysis of SUST-RUS results we suggest applying a hierarchical approach. The sustainability indicators are at the topmost level of analysis and have been constructed to take into account the overlapping elements of sustainability. Of course, it is often not enough to simply report the change in sustainability indicators. Therefore, the model reports the base case, simulated, relative change and change in absolute value of all variables used in the model on national, regional and sector level. The highest level of detail available is on the level of sector and region and by household group[3].

2.7. The different versions of the SUST-RUS model (deliverables D3 and D5)

The SUST-RUS model was developed in several stages, from a simple core-economic model with three regions and three active sectors, without international or interregional trade, towards a fully integrated modeling framework.

[1] ε is equal to the inequality avoidance parameter, inherent to the Atkinson index.
[2] Poverty intensity is defined as the ratio of the average income of low income households (QL) to the poverty line. The poverty line is equal to 60% of the average household income.
[3] Meaning low income (QL), middle income (QM) and high income (QH) households.

First versions of core economic model (D3)

Table 2, which also figures in deliverable D8, summarizes the development of the core-model in several stages and shows how new elements were added to the model at each stage. The earlier versions of SUST-RUS played a great role for educational purposes, as they provided a better understanding of the mechanisms behind the model and the 'logic' of simulations with a computable general equilibrium model. The earlier versions of the model also form part of the S&T background of SUST-RUS and can be of interest to researchers in Russia or in other countries who are interested in creating their own versions of the model, with less demand in terms of data and details than the fully integrated model. The first version of SUST-RUS already has many of the basic features of the later model, and this is with only a very limited demand on data.

Table 2: Development of the economic module

Model version	Features	Database
SUSTRUS 0.1	3 regions 3 active sectors No international trade No interregional trade	Preliminary database (baseline equal to 2001) supplied by CEFIR
SUSTRUS 0.2	3 regions 3 active sectors International trade No interregional trade	Preliminary database (baseline equal to 2001) supplied by CEFIR
SUSTRUS 0.3	7 regions 21 sectors (OKVED classification) International trade Interregional trade in goods	Preliminary database (baseline equal to 2001) supplied by CEFIR
SUSTRUS 0.4	7 regions 32 sectors (NACE classification) International trade Interregional trade in goods	Economic database supplied by CEFIR and calibrated in cooperation with TML
SUSTRUS 0.5	7 regions 32 sectors (NACE) International trade to EU and ROW Interregional trade in goods and services	Economic database supplied by CEFIR and calibrated in cooperation with TML Improved interregional trade data supplied by CEFIR

Later versions of the model and addition of new modules (D5)

Once the economic module was finalized and ready for testing, we added the new modules, developed in the course of WP5, WP6 and WP7. In *Table 3*, *Table 4* and *Table 5* we summarize the elements of each module and the main data sources for each aspect of the module. The most recently available socio-economic, trade data and environmental data were used to produce the final SUST-RUS dataset. The model is calibrated for 2006, which is the most recent year for which a full database could be constructed.

Table 3: Social module

SOCIAL	Features	Database
STANDARD	-Labour market with different skill levels -Unemployment with wage curve -Social indicators (Gini/Poverty) -Different household types	-Demand of skills/occupations at the level of economic sectors (ILO data) -Average wage by skill/occupation level (RLMS) -Labour / capital income by household type (RLMS) -Endowment of skills/occupation by household type (RLMS)
OPTIONAL	Health impact module (cfr. Environmental module)	-data for health impact module based on GEM-E-3

The social module of SUST-RUS uses the *representative agents* approach. The model divides all population into several groups which consist of households with different characteristics. Each household has an endowment of skills and capital, which is different among the representative groups. For example, the low income classes have more unskilled labour and very low capital incomes. In SUST-RUS we have chosen to model three income classes (low, medium and high income) and three skill levels of labour.

The labour market has a different demand for each skill level, depending on the particular labour demand of each sector. Each sector pays the market rate for per skill level. Unemployment is modelled via the wage-curve approach, introduced by Blanchflower and Oswald (2005), following estimated elasticities of Shilov & Mueller (2008). Following the literature on the wage curve, we apply values between -0.15 and -0.13 for the lower skilled workers, while higher skilled workers perceive elasticities from -0.09 to -0.06. This represents the tightness of the labour market for different skills.

Table 4: Environmental module

ENVIRONMENT	**Features**	**Database**
STANDARD	Integration with environmental module -Energy use -Emissions of main pollutants -Abatement cost curves -Emissions trading system, energy taxes	- Database on energy and emissions based on different sources including the IEA and Goskomstat databases (Ter-11 database) for Russia - Data on abatement curves/abatement costs and emissions coefficients based on IIASA GAINS-Europe model estimations -Additional data provided by ZEW based on GEM-E-3 model -Auxiliary data of World Energy Database of OECD Projections from International Energy Outlook
OPTIONAL	Health impact module (cfr. Social module)	- Data for health impact module based on GEM-E-3

The environmental module integrates many of the attractive features of the GEM-E-3 model or European General Equilibrium Model for Energy-Economy-Environment (GEM-E3), ZEW's Policy Analysis based on Computable Equilibrium Model (PACE) and the American Emissions Predictions and Policy Analysis (EPPA). The standard versions of GEM-E3 take into account both costs and benefits of environmental policy suggestions. The mathematics of the emissions module therefore stays close to their origins of PACE, EPPA and GEM-E-3, with only minor modifications.

An impact module on health based on the GEM-3 models that cover feedback effects related to the health impacts of air pollution are discussed in Mayeres and Van Regemorter (2003) and Paltsev et al. (2005). These papers integrate health effects into the models, allowing for inclusion of more routes through which air pollution affects the economic agents, and provide more encompassing endogenisation of these effects.

While the mathematical formulation of the model is close to GEM-E-3, the real difference arises in the integration of specific data for Russia in the model. The SUST-RUS consortium gained access to the detailed data on energy use at sectoral level, originating from the TER-11 questionnaires on sector level, performed by the Russian statistical institute. On the basis of the consistent energy use data, we were able to calculate emissions by region, type of pollution and sector, corresponding with the SUST-RUS NACE format.

The abatement cost curves were estimated from IIASA data, which were specific for Russia. Sector specific abatement costs were estimated and calibrated for each SUST-RUS sector, where data were available.

Table 5: International module

INTERNATIONAL	Features	Database
STANDARD	Integration with international module -FDI in recursive dynamic system -Extended Armington function -Export and import taxes -Trade balance and foreign reserve system -Trade margins on international trade	-Database on international trade based on GTAP 7 and World trade database -Improved EXIOPOL database and recalibration of model
OPTIONAL	-Monopolistic competition of domestic and foreign firms	Guriev S. and Rachinsky A. (2005), The role of oligarchs in Russian capitalism, NES, Journal of Economic perspectives Jensen, Rutherford T.,Tarr D. (2004), "The Impact of Liberalizing Barriers to Foreign Direct Investment in Services: The Case of Russian Accession to the WTO." *SSRN eLibrary* (August).

The international part of the model was focused on a good representation of the international trade, disaggregating regional exports and imports by country of origin and destination and integrating transport costs and margins with the interregional and international trade. During the construction of the international module, it was necessary to change some elements of the database to better represent some aspects of the Russian economy. This comes down to five elements, which are summed up below:

- A **representation of the Russian stabilization fund**, which captures the excess income from the export of primary energy inputs (mainly petrol export) and stores it into an investment fund which is strictly used for foreign investment.
- **Trade and transport margins on export**, which was necessary as in the original social accounting matrix a too high share of exports was associated with the trade and transport sector and not with the oil, gas and petrol export.
- **Extended Armington and CET functions** disaggregating the export and import on regional level by country of origin and destination
- **An optional module, representing monopolistic competition in a domestic and foreign part** based on Jensen, Rutherford T. ,Tarr D. (2004) and Guriev S. and Rachinsky A. (2005)
- **FDI flows** which were integrated in the recursive dynamic structure of the SUST-RUS model.

Table 6: Assumptions and closures of integrated model

International closure	Government	Households/labor market	Investment/Capital market
Current Account balance	**Budget balance**	**Labour supply**	**Investment balance**
Flexible exchange rate	Flexible savings	Fixed labor supply in each region	Fixed investment demand
Flexible foreign savings	Flexible consumption	Fixed price of labor	Fixed capital
Exchange rate as numeraire	Flexible foreign debt	Unemployment according to wage curve	Simulation with capital accumulation
	Redistribution via transfers/lump-sum taxes		
	Tax incentives		

Table 6 summarizes the set-up of the model and the alternative assumptions that are pre-programmed for policy analysis. The underlined items show the 'standard' assumptions that are used by the model. In each model run, several assumptions can be combined or extended, which has also been done in some simulations. When taxation is the core of the simulation, it can be interesting to look at alternative specification of the budget balance of the government. Long term simulation can require a new specification of the capital and investment sectors. The model offers researcher substantial liberty to make new assumptions and compare these with the normal set-up of the model.

2.8. Linking the three dimensions of sustainability (deliverable D8)

Description of the links between the three dimensions of sustainability within the model is presented in the deliverable *D8. Description of the links between the three dimensions of sustainability within the model.*

Sustainability is a difficult and complex concept and it should be analyzed at the level of an entire system, rather than its composing sub-systems, including the analysis of the trade-offs between different sustainability dimensions. Therefore, in many applications researchers measure sustainability along the lines of economic, environmental and social functioning of a system. This is often defined as people, planet, prosperity (3P) or economy, environment and equality (3E) in practical applications.

The SUST-RUS model is characterized by the objectives of the EU definition of sustainable development. The final integrated model incorporates a set of flexible modules built around each EU sustainable development theme, that enable the user to isolate the effects of several policy alternatives and make consistent counterfactual scenario or (in broader terms) policy analysis. The modelling framework used by the SUST-RUS model, is the general equilibrium methodology. General equilibrium, as a methodology, is a common denominator for a wide range of approaches in theoretical and applied economics, which explain the behaviour of supply, demand and prices in a whole economy with many interacting markets.

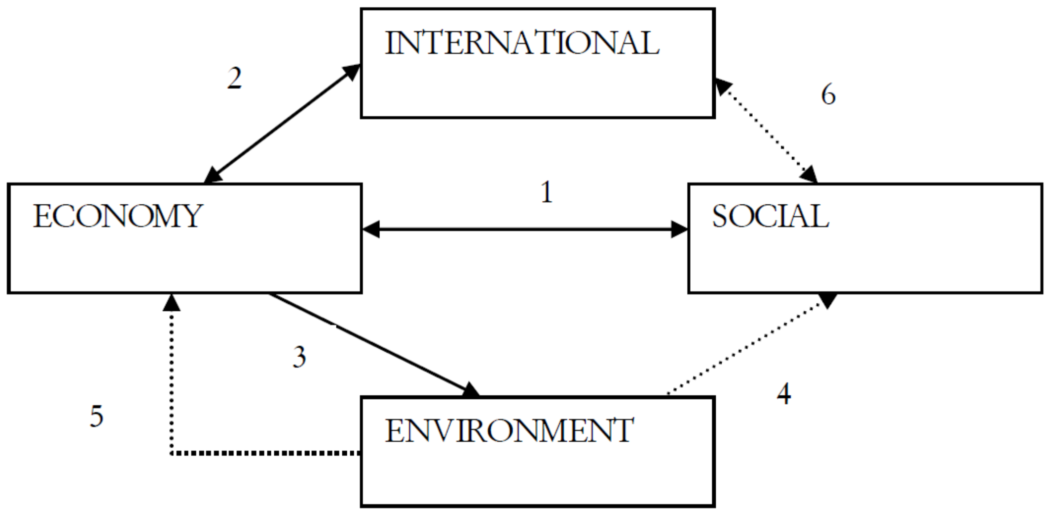
These markets evolve to a single overall equilibrium, with a price setting that supply equals demand, hence 'general equilibrium'. When applied, general equilibrium models are often implemented in special software packages (such as GAMS or MATLAB) to allow solving the often complex systems of equations they consist of. This explains the term 'computable' general equilibrium or CGE. The choice of the SUST-RUS project to use the general equilibrium methodology can be motivated from the objectives and concept of interrelatedness specific for the study of sustainability. General equilibrium methodology, as a holistic approach, is especially well suited for an integrated analysis of sustainability. During the development of the model, authors took this into account and made SUST-RUS into a flexible model, where the user has the choice to compare various assumptions related to the labour market, interregional or international trade balance and use of tax revenue. Also one is able to activate or deactivate parts of the model that are not of direct interest for some policy programs.

Our goal was to allow the researcher a large variety of methods within the model to study sustainability of Russia or if necessary to introduce updates or variations upon the basic model code.

The report D8 is structured to allow the reader to gain insight in the existing links between the SUST-RUS modules. In the first chapter authors explain how the integrated modelling framework of SUST-RUS was built up and how one can use the model to evaluate progress of sustainability in Russia. We show how the sustainability indicators, discussed in deliverable D4, are essential for understanding the interrelation between model elements.

Figure 2 represents interlinks between SUST-RUS modules in practical terms. We consider three main links (1, 2 and 3) and three optional links (4, 5, 6). Links 1 and 2 represent the functioning of the social, international and economic modules. Link 3 is the connection between economy and environmental functioning. Link 4 represents the impact of environment to health. Link 5 is an optional link from environment to economy. This link can be either driven by policy or by adverse health impacts to labor in a region. SUST-RUS contains a simple cap-and-trade scheme for emissions, which has been implemented based on the GEM-E-3 model. The SUST-RUS model does model a (limited) effect on labor, due to environmental damage, within the health module.

Figure 2: Interaction and links between modules



Regarding the links between the economic, international and social module (1 & 2), the Russian economy demands labor force of different skill levels, taxes are collected based on household income and capital income is transferred to capital owners. Goods and services are traded with several countries and firms can invest domestically or in the foreign market. In the same way, households have different preferences for consumption of goods on national and international level and supply their labor skills based on the perceived wage rate.

The link between the economic and the environmental part (3) is modeled in accordance with the state-of-the-art approach. The economy demands energy carriers, which produce damaging emissions when consumed by industry or by households. The main polluters of the Russian economy are the energy and heat producers and the basic metals sector.

New policy measures (for example, the introduction of energy taxes) cap on emissions, emissions trading or specific environmental taxation will have a direct effect on the economy (5). The link between environment, exposure to emissions and health (4) has been considered in the health impact module of the model and presented in deliverable D5.1.

2.9. Sensitivity and uncertainty analysis (deliverable D9.1)

In general the sensitivity and uncertainty analysis with computable general equilibrium models such as SUST-RUS is relatively limited. Often only a very limited set of parameters are analyzed and only within a relatively small range of variation. In the course of the SUST-RUS project we have tried to operate a more intensive and demanding approach to this analysis, by systematically running the model repeated times and checking the effect of changes in parameters on the main output of the model.

A systemic sensitivity analysis was performed in two stages, on two basic simulations and on a representative subset of parameters. The output indicators that were used in our analysis were the absolute change in social welfare indicator (measured in equivalent variation) and the absolute change in the gross domestic production indicator.

The stages of the sensitivity analysis were:

- **First stage:** Local method with small variations from point estimates on the level of sectors and regions
- **Second stage:** More detailed Morris screening method on the level of sectors

The simulations which were implemented in the model for sensitivity analysis were:

- The '**emission tax'** scenario, we introduce a tax on carbon dioxide emissions of 1 euro or 38 rubles per ton. The income from the tax is attributed to the savings of the government.
- The '**international energy price'** scenario is based on an exogenous reduction of the price of gasoline, gas, oil and coal on the international market with 1% of its initial value.

The representative subset of parameters is listed in *Table 7*. Each row in *Table 7* contains a parameter which should be specified by region and by sector. This means that each row represents 224 parameters. In total, 2240 parameters are handled by the systemic sensitivity analysis in a number of model runs.

Table 7: List of parameters with description

Parameter name	Description
Sigma KLE	Elasticity of substitution between capital-labour and energy bundle
Sigma KL	Elasticity of substitution between capital and labour
Sigma E	Elasticity of substitution between electricity and fuels
Sigma NE	Elasticity of substitution between gas/oil bundle and coal
Sigma OIL	Elasticity of substitution between gas and oil inputs
Sigma A	Armington elasticity of demand
Sigma T	CET elasticity of export demand
Sigma A1	Interregional trade elasticity (Armington)

The analysis uncovered that the sensitivity of our main output indicators (social welfare in terms of equivalent variation and gross domestic product) are strongly concentrated in some parameters and regions. In general a strong influence could be indicated for the trade sector in the Central region, the petrol and raw oil producing sectors in the Urals and Volga regions, the elasticity of capital-labour-energy bundle of the electricity and heating producing sectors and capital-labour elasticity of the gas sectors. The effect of parameters was dependent on the type of simulation.

The primary energy sectors and gas sectors had a high relevance in the emissions tax scenario. By far the most influential parameter is the elasticity of substitution between capital and labour of the gas sector in Urals. Secondly and thirdly follow the elasticity of the capital-labour-energy bundle in the electricity and gas generation sector and the capital-labour elasticity of the coal mining sector. The impact on the parameters of international trade is low when only local effects are considered, the Morris screening method revealed interaction effects of (mainly) the CET and Armington elasticities of the petrol and electricity sector on social welfare and GDP.

The effect of the CET and Armington trade elasticities was much more relevant in the 'energy price reduction scenario'. Increasing CET elasticities for export intensive sectors, increased the negative GDP and welfare effects of the energy price scenario. Larger Armington elasticities for import intensive sectors had a positive effect on both social welfare and GDP.

Even though the impact of some parameters on social welfare and GDP was potentially high, the final results of the model were remarkably robust, even within a range of -50% and +50% on the baseline value of each exogenous parameter. For the first scenario we found deviations in the social welfare indicator of +- 3% compared to the average and in the gross domestic product of +- 5%. In the second scenario we found deviations in the social welfare and gross domestic product between +- 8% of the averages. In general the effect on gross domestic product was somewhat less predictable and did not follow a 'normal' distribution.

Our reasoning is that, as each parameter set was a random draw within the variance allowed within the set, the effect of the parameters counteracted to some degree, limiting the uncertainty on the final result within reasonable margins. Also, we have considered only very aggregate indicators on country level. These will not be impacted to such a large degree as more disaggregate indicators (such as welfare) by region, production of particular sectors or labor demand by skill level. It was impossible, however, to take into account lower level indicators without losing ourselves in too much detail.

2.10. Assessment of policy scenarios (deliverable D9.2)

Within WP9 we have chosen to report the results of three different simulations, which can be used, after further modification for international publications in peer-reviewed journals.

In the first simulation, ***we increase the domestic price of natural gas***, which is currently underpriced as compared to the long-run marginal cost. We distinguish the impact on both industry and household. The economic, social and environmental effects of this policy are evaluated in detail.

The second simulation makes use of the opportunity offered by **the accession of the Russian Federation to the World Trade Organization (WTO)**. The policy modeled implies a limited change in import tariffs and a reduction in barriers for services (communication, financial sector, business, insurance and transport).

The third simulation concerns ***the dependency of Russia on the export of energy products to the rest of the world***. During the financial crisis in the end of 2008, the collapse of the world price of natural gas, petrol, raw oil and coal did have a noticeable effect on the Russian economy. This simulation makes a 'back cast' of the impact of the collapse of the energy prices and evaluates to which degree the model replicates the empirical results.

2.10.1 Policy scenario 1: effect of an increase in the domestic price of natural gas in Russia

In this simulation we started from the low domestic price of natural gas on the Russian domestic market and the low energy efficiency of the Russian economy. Russia is the biggest consumer of natural gas in the world, both in real and in relative terms: 56% of the domestic energy use can be directly attributed to natural gas. In the recent Worldbank and IEA report "Energy efficiency in Russia: untapped reserves", claims are made on the possibilities to reduce energy intensity in Russia. This document takes a clear standpoint on the current 'wasteful' practices and offers a number of good arguments why Russia should care about energy efficiency. Russia has (among a comparative study of 121 countries) the 12th highest energy use by GDP[4] (measured in kilograms of oil equivalent). Russian energy use by GDP is equal to 0.42 kgoe[5] / dollar, which is much higher than other 'cold' countries in Europe like Iceland (+- 0.32 kgoe/dollar), Canada (0.25 kgoe/dollar), Sweden (0.18 kgoe/dollar). It is also more than double the amount of the United States (around 0.2 kgoe/dollar) and almost triple the amount of average EU countries (0.1-0.15 kgoe/dollar). This led the authors to claim that there is a huge unused potential for energy savings. In fact, by realizing its energy efficiency potential, Russia could save over 240 billion cubic meters of natural gas (almost two thirds of the current domestic consumption), 340 billion kWh of electricity, 89 million tons of coal and 43 million tons of crude oils.

Increasing energy efficiency would be beneficial for economic development on the long term, taking into account the dwindeling resources of natural gas in Russia, as well as lead to an important decrease in pollution (mainly carbon dioxide) associated with combustion. To promote energy efficiency, however, it is also necessary to give the right incentives to consumers and firms alike. The price of natural gas on the domestic market however, is heavily regulated and set at a non-competitive level.

Russia produces about 550 billion cubic meters of gas each year. From the total production, 320 billion cubic meters are sold domestically at a discount price of 50[6] $ /tcm for households and 70 $/tcm for industrial producers. Losses on the domestic market are compensated by selling natural gas at much higher rates on the international market. A total of 160 billion cubic meters are exported to Europe and

[4] Corrected by Purchasing Power Parity (PPP)

[5] Kilograms of oil equivalent

[6] Prices are based on estimates at the time of writing and are only indicatory for the level of difference between the domestic market price of consumers, firms and the export price of natural gas.

70 billion cubic meters to CIS/Baltic countries. Exports price for CIS/Baltic countries[7] are around 100-120 $/tcm. The price for Europe is substantially higher and varies between 200 and 300 $/tcm at the present time.

The issue of underpricing of natural gas remains a hot topic, as Russian government proposes to loosen the control of the natural gas price regulation on the domestic market. The current proposal is to index prices of all energy source to the level of inflation, but allow Gazprom to increase domestic gas prices at about 15% each year (about double of the current inflation rate). Gazprom controls 85% of all gas production in Russia with only a very fragmented share of independent producers.

To analyze the effect of changes in the domestic price on natural gas, a dynamic simulation was performed with the SUST-RUS model. In this simulation, the current proposal of the Russian government was replicated, and prices of natural gas on the domestic market were increased annually with 10%, starting in 2012 until 2020. To simulate the impact of such a change in prices, we assume that the government systematically increases taxes on final and intermediate consumption of natural gas. This is not a self-evident assumption. The domestic market of natural gas is tightly government controlled and only little information is available on taxation, production cost of natural gas and competition with independent producers. In fact, the Russian government mainly applies price regulation and production subsidies to retain low domestic gas prices.

The direct taxation approach was a necessary abstraction for two important reasons. First, there is too little information available on the real production cost of natural gas in Russia. Secondly, the direct taxation approach leads to the least distortion with other markets, which allows us to focus on the effect of the price change only and not with the wider economic impacts.

We compare three situations:

1. ***Only the consumers*** experience a rise in the domestic price of gas
2. ***Only the firms*** face the increase in taxes
3. ***Both consumers and firms*** face an increase in the price level of gas.

Our simulation will run from 2012 to 2020. In each year the price of gas goes up with 10%, compared to the last year. This means that by 2020 the price of gas will have doubled, compared to the base year. The chosen closure of the model is via the adjustment of foreign savings. The government balances its budget by increasing or decreasing public savings.

Our simulations show that increasing the price of natural gas for consumers alone, would not be effective in reducing emissions in the Russian Federation. The reason is that emissions would shift from the residential sector to the industries. A tax on industry only would be more effective to decrease pollution from natural gas, but would also lead to some 'leakage' to the residential sector on longer term. The government would best consider a mixed scheme, where both consumers and industry share in the burden of increased price of natural gas.

[7] In 2006, Russia decided to bring the CIS price and the European price closer together, effectively doubling the price of natural gas exports to CIS countries. This is at the origin of the Ukraine – Russia conflict, however is not a subject of the present simulation.

Table 8: Economy-wide and regional energy efficiency improvements (% change from BaU) [8]

	2015			2020		
	Scen_H	Scen_F	Scen_HF	Scen_H	Scen_F	Scen_HF
RF	0.0	-3.4	-3.8	-0.2	-5.4	-6.3
Central	0.2	-3.0	-3.2	0.1	-4.8	-5.4
North West	0.2	-4.6	-4.8	0.3	-7.9	-8.4
South	0.1	-1.9	-1.9	0.0	-3.0	-3.2
Volga	0.0	-2.5	-2.8	-0.3	-3.8	-4.6
Urals	-0.3	-4.7	-5.7	-0.9	-7.1	-8.9
Siberia	0.1	-3.6	-4.1	-0.2	-5.8	-6.8
Far East	0.0	-4.9	-5.3	-0.3	-8.5	-9.5

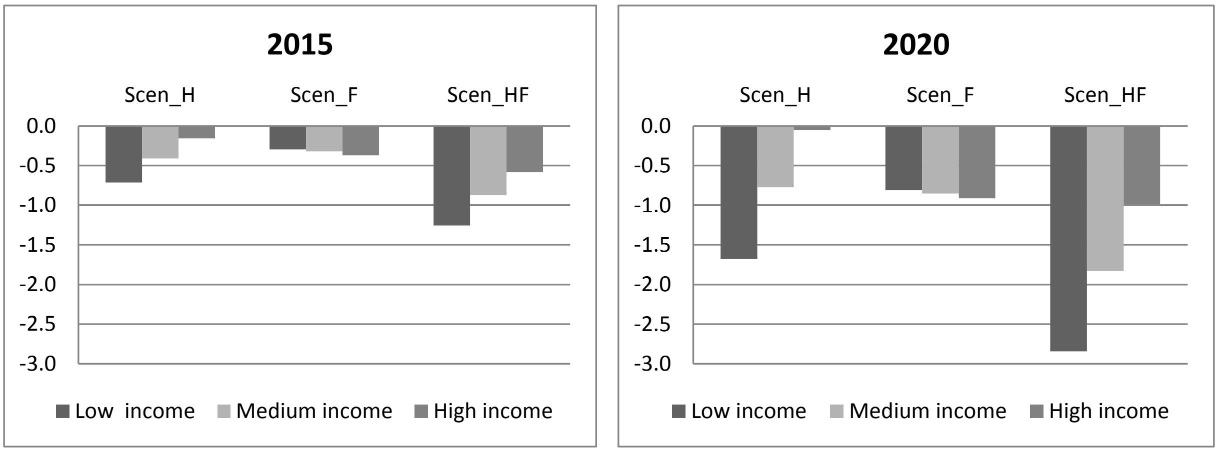
The potential environmental benefits of higher gas prices for both consumers and firms are substantial and could lead to a decrease in emissions over the entire period to around 1700 Mt or 1 year of comparable CO2 emissions of 2006 in the scenarios Scen_F and Scen_HF. Oppositely, however, a tax on natural gas would lead to higher consumption of coal, which (at longer term) would lead to substantially higher SOx (+4.48%) and PM emissions (+1.37%) under ceteris-paribus conditions in Scen_HF. Therefore, while increasing the price of natural gas would be beneficial for the environment, it would also be important to consider the negative environmental impact of a shift to coal or petrol (*Table 9*).

Table 9: NOX, PM and SOX emissions

Dimension	Indicators	Scen_H	Scen_F	Scen_HF
	NOX emissions	0.95	-31.25	-32.03
	PM emissions	-0.69	2.08	1.37
	SOX emissions	-0.43	4.84	4.48

On the social side, the model indicates that taxation of natural gas for consumers is regressive and lead to an increase in inequality. This is shown in *Figure 2*. This could best be considered, as the impact on welfare of the lowest income classes is 2 to 3 times higher than on the highest income classes. A fair tax scheme would take this into account and could involve cuts or exemptions for the lowest income classes. This would not really decrease the effectiveness of the tax scheme, as the industry remains the biggest consumer of natural gas in the Russian economy.

Figure 3: Welfare impacts for different types of households (% change from BaU)



[8] RF = Russian Federation

2.10.2 Policy scenario 2: accession to the WTO

In June 1993 a request was made for the accession of the Russian Federation to the World Trade Organization (WTO). Now, after more than 17 years of negotiations, Russia is finally close to become a full member of the WTO.

"*On 10 November 2011, the Working Party on Russia's accession, chaired by Ambassador Stefán Jóhannesson (Iceland), agreed, ad referendum, on the terms of the country's membership to the WTO by adopting the package containing reforms to Russia's trade regime, and the commitments that Russia undertook to implement as part of its WTO accession. From the date of accession, the Russian Federation has committed to fully apply all WTO provisions, with recourse to very few transitional periods.*"

The package of reforms Russia will undertake implies a set of reduction in import tariffs, reducing the overall tariff rate to 7.8 %, compared to an average rate of 10% in 2011. Additionally, besides the change in tariff lines, Russia has made an agreement to improve the access of foreign investors to the market. Special agreements were made to improve the access of financial service providers, insurance and telecommunication. On transport services, the Russian Federation made commitments in maritime and road transport services, including the actual transportation of freight and passengers. On distribution services, Russia would allow 100% foreign-owned companies to engage in wholesale, retail and franchise sectors upon accession to the WTO. The transparency of duties, taxes and regulations will be increased or adapted to international standards.

We performed a simulation with the SUST-RUS model from 2012 to 2015. The full shock in import tariffs takes place in 2012, after which we follow the adjustments of the Russian economy until 2015. The effects of the service reform imply a change in investments and capital flows, which are only taking effect after a few years. We consider the changes in 2012 as an impact effect which in reality might take about one-two years to be realized. The effects of policy changes, evaluated by 2015, corresponds to medium term effects which might require up to five years to become effective.

To distinguish the impact of the reform in services, we did two simulations: one with and one without the reform in services. The 'no service reform' simulation is performed for benchmarking only.

The reforms implied by the WTO accession, lead to decline in average prices of wood, food, transport equipment, clothing, chemicals and pharmaceutical products between 1.5 - 2.5% on impact and up to 3% in the medium run. It implies an improvement in welfare between 0.4% and 0.8% in real consumer budget on impact and up to 1.5% of real consumer budget in the medium term. The reforms in the service sector are important and are realizing almost half of the real welfare effect in medium term, as financial, distribution and other b2b service centers are expected to grow and increase employment.

On the downside, real GDP and tax incomes are negatively affected; GDP decreases by 0.1 % on impact. Negative adjustments are expected mainly in the local foods, chemicals and pharmaceutical and textile sectors, which lose (in output) between 0.5% and 2%. The basic metals and machinery sectors would not be affected or even grow, due to cheaper intermediate inputs. A strong adjustment is expected at the level of the trade balance. A decrease in trade surplus of 10-15% s is predicted by the model.

In medium run GDP is expected to adjust, as the reform is shown to stimulate foreign investment in service sectors. Within five years after the adjustment GDP has fully recovered and is growing above the average growth rated, realizing 0.7-0.8% more production within five years than in the base scenario (with average growth of 3.5%). The trade balance effect diminishes over time, as the Russian economy becomes more competitive. The food production and textiles sectors are expected to adjust more slowly to the reform.

The effect on the welfare is positive and progressive on impact, as many primary products, such as: flood, clothes and electronic become less expensive. In medium term, taking into account the reform of services, the effect is more positive for rich households. This is due to the increased employment of skilled people in service sectors such as the financial sector). Manufacturing sector will lose some employment.

Figure 4: Direct impact (2012) of WTO (with service reform) on sectoral level, imports, exports and production in absolute value (bill. Rubles of 2006)

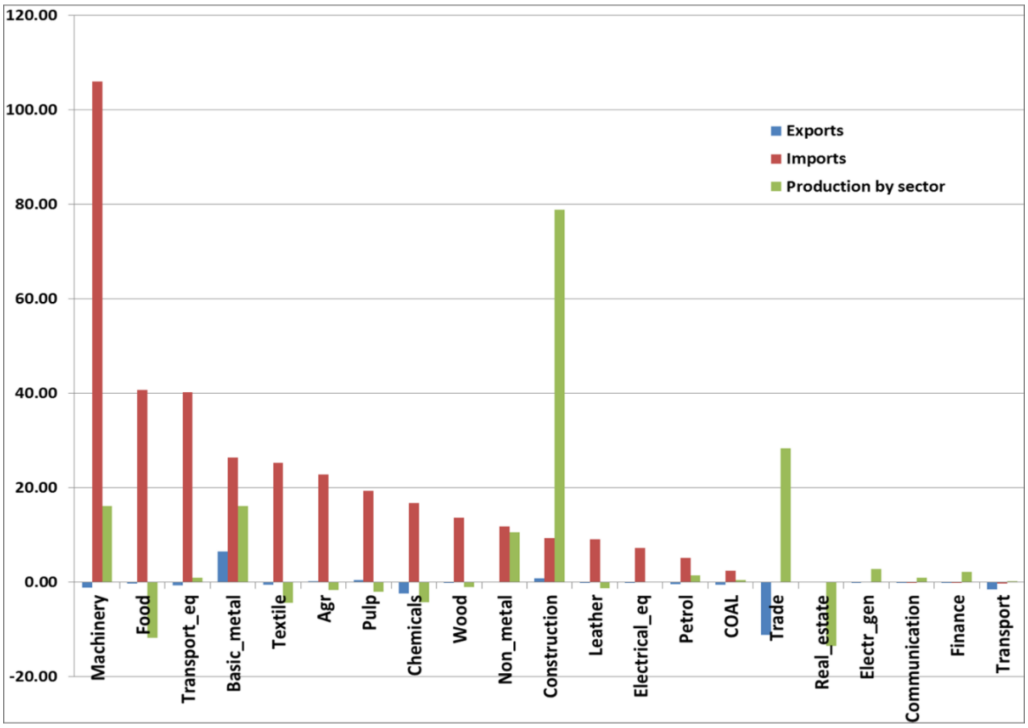
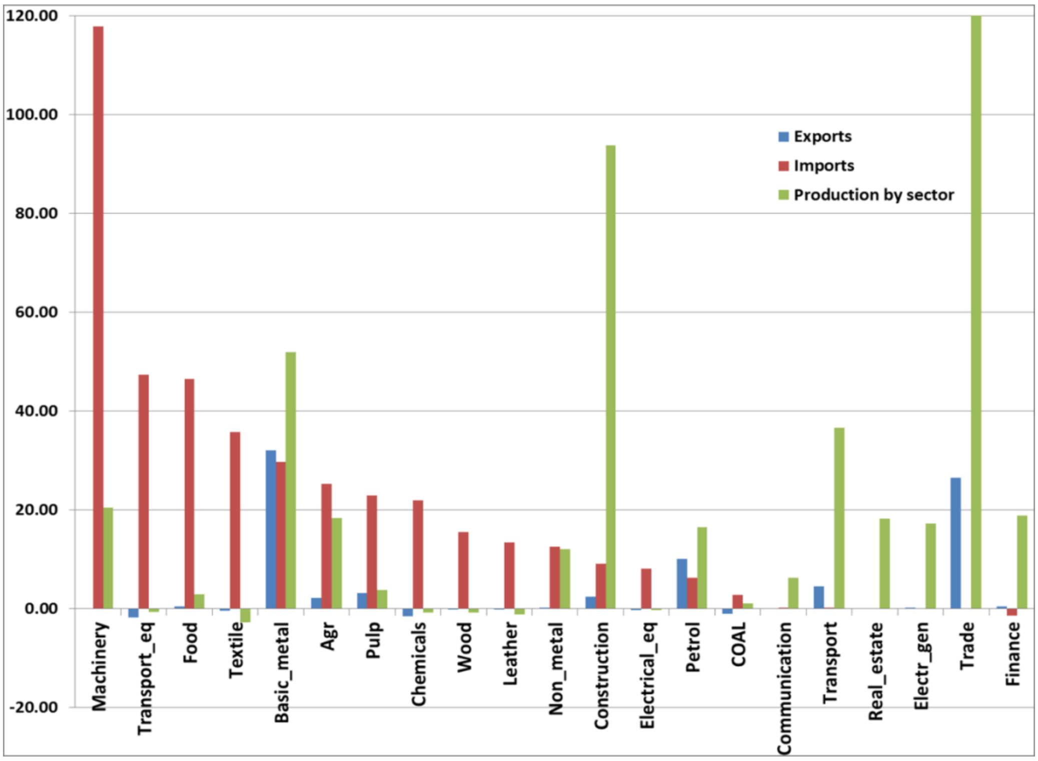


Figure 5: Medium term impact (2015) of WTO (with service reform) on sectoral level, imports, exports and production in absolute value (bill. Rubles of 2006)



2.10.3 Policy scenario 3: dependence of the Russian economy on shocks in international energy prices

In this simulation, we performed a simulation of the dependence of the Russian economy for shocks in international energy prices, inspired by a back-cast of the effects of the financial crisis. The period from 2006-2010 was chosen, as this coincides more or less with a pattern of growth[9] (2006-2008) – depression (2009) and recovery (2010).

During the crisis, the impact on the Russian economy was initially relatively low, until the demand for energy carriers plunged drastically from the high peak prices of 2008, halving and going under the nominal price of 2006. This sudden plunge in energy prices, reinforced by a decrease in foreign direct investments and return from foreign savings, is said to be the main culprit of the Russian economic downturn and the devaluation of the ruble. This has opened questions on the current export dependence of the Russian economy. While other European countries had a benefit from the lower energy prices during the financial crisis, the Russian economy went through a slow recovery. This economic recovery was not fully attained by 2011, even though the prices of energy are almost back at the level of 2008.

The export prices and volumes in *Table 10* were at the basis of a SUST-RUS dynamic simulation. This was performed to show how the SUSTRUS model could be used to simulate the export dependence of the Russian domestic economy and make predictions on energy use and changes in GDP. It was not our goal here to replicate the changes in macro-economic indicators from 2006-2010 to their full extent.

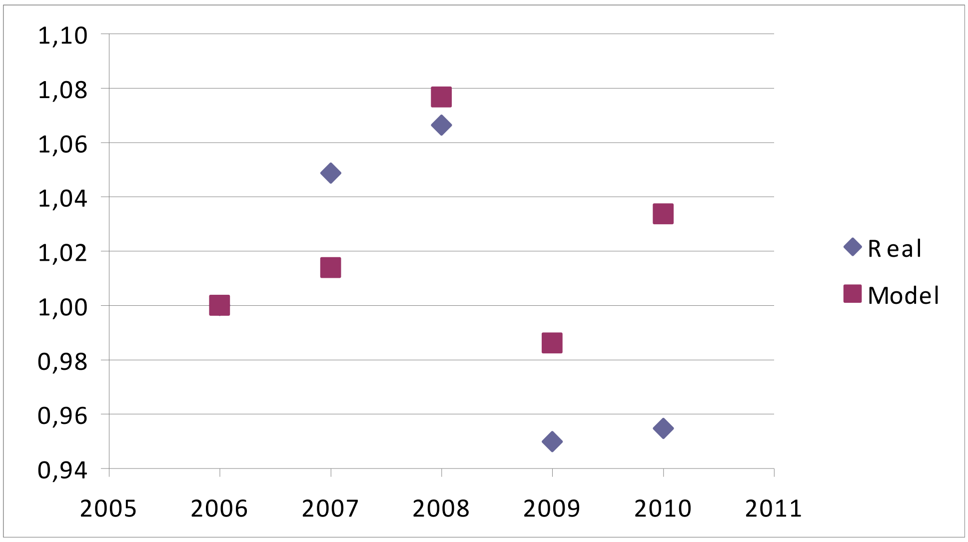
Table 10: Export price of energy carriers (source: Russian central bank, 2010)

	Natural gas			Crude Oil			Oil products		
	Quantity (bil. m3)	Value (USD)	Price (USD)	Quantity (mil. tonnes)	Value (USD)	Price (USD)	Quantity (mil. tonnes)	Value (USD)	Price (USD)
2006	202.8	43806.2	216	248.4	102282.9	56.32	103.5	44671.7	431.63
2007	191.9	44837.4	233.66	258.6	121502.8	64.28	112.3	52227.6	465.15
2008	195.4	69107.1	353.69	243.1	161147	90.68	118.1	79885.6	676.54
2009	168.4	41971.4	249.27	247.5	100593.2	55.61	124.5	48144.9	386.76
2010	177.8	47739.3	268.48	250.7	135799.3	74.11	133.2	70471.1	529.16

In first instance, we have experimented with the assumptions used on the international market. It was found that the set of closures available to us from state-of-the-art modeling did not seem to reflect the reality of the international market to a sufficient degree. In general equilibrium modeling, relatively inflexible assumptions are made to balance the international trade account. For example, by fixing the exchange rate or fixing the amount of foreign savings and debts. Given that the shock in energy prices had a large influence on the international market equilibrium, it was found that modifying the so-called 'closure' of the international market had a large influence. By allowing more liberty in the adjustment of the trade balance, exchange rate and domestic price deflator, the model results did match better with the empirical results. In this way, we were able to reproduce the real changes in domestic product to a relatively good degree. *Figure 6* shows the result of a trial-and-error attempt to match the change in domestic product during the crisis.

[9] The match on yearly basis is not perfect, as the real crisis did already commence in the end of 2008 and recovery was already visible in the end of 2009. However, given that we use yearly averages for our model results, this was a necessary abstraction.

Figure 6: Model versus reality, comparison of change in GDP (y-axis= change in % from baseline with fixed growth rate of 3.5%)



Our experiments in WP9 show that a stronger effect on domestic prices, caused by a more stringent exchange rate and foreign savings policy, creates a larger fluctuation in domestic product within the model. Increasing the flexibility in the exchange rate and foreign savings considerably decreased the impact of price shocks on the international market for energy and could actually lead to beneficial results. The reason for this is that the lower prices for energy sources are benefitting the output of energy intensive sectors and consumers. A depression in the amount of energy exports leads to pressure on the ruble to devaluate, promoting the output of non-energy sectors and decreasing imports.

What we can conclude from this simulation is the following: The SUST-RUS model could replicate a recession of the Russian economy, based solely on the fall of international energy prices on the market (as they occurred in reality). Even though sufficient liberty was given to the modeler to calibrate the model to the empirical data, the fall in energy prices cannot capture the whole story. By 2011 the prices of energy are almost back on their levels of 2008, but the real growth in GDP of Russia is lagging behind. The model overstates the economic recovery of Russia based on the market prices, which is an indication that more factors are influencing the Russian economy after 2010.

3. Potential impact and main dissemination activities

3.1. The potential impact

The SUST-RUS modeling tool provides Russian scientific community and policy makers with the sound scientific support for formulating policies aimed at sustainable development, which is characterized by a balanced integration between social, economic and environmental policy objectives. The use of the approach will assist implementation of the Russian strategy for sustainable development as well as efficient incorporation of the sustainability goals into the existing Russian policy tools at regional and federal levels. The SUST-RUS modeling approach represents the state-of-the-art in many different areas of knowledge and, hence, is superior to other policy assessment models available for Russia in current situation.

The SUST-RUS aims at filling in the major gap of the sustainability assessment practices in Russia. It is a unique operational assessment tool to be used for the evaluation of packages and/or individual sustainability policy measures.

We foresee the impact of the project in the following areas and applications:

- The SUST-RUS model helps to make educated and consistent judgments about alternative sustainability policy options, both for priority setting and for making proper evaluations about their impacts on sustainability along all three dimensions: economic, environmental and social.
- It allows the comparison and selection of the effectiveness of varied policy options in many dimensions.
- It allows to go beyond the present state-of-the-art in the assessment of sustainability policies by linking the three dimensions of sustainability in a unified framework.
- The developed assessment tool will be suitable for a very broad range of policies and available to all interested parties.

The developed SUST-RUS modeling tool is publicly available. This includes the design of the modeling approach and full description of the modeling framework.

3.2. The main dissemination activities and exploitation of results

During the project all partners actively participated in dissemination of the project information and results. The adopted dissemination strategy was twofold. Firstly, it aimed at dissemination of the knowledge developed, such as the methodological advancements and the results of the assessment of sustainability policy packages. Secondly, it disseminated and exploited the developed modeling tool for policy evaluations. Specific attention was given to the transparency of the method in order to enable third parties to understand when and how the developed tools can be applied.

A plan for using and disseminating knowledge obtained during the project was developed during the first stage of the project. The plan was aimed at raising public participation and awareness. Special attention was given to the following target groups:

- Russian policy makers in the area of sustainability, economic development and trade
- Relevant research institutes and companies
- World-wide research community
- General public

The adopted dissemination strategy ensured that policy makers, dealing with sustainability assessments of the Russian and international sustainability policies, were aware of the SUST-RUS project results and do know how they can obtain the modeling tool and work with it.

The dissemination strategy and actions were based on the rich experience of the consortium participants in dissemination of the and involvement of stakeholders ('target groups' with government and society). From the start on, the project launched the website (www.sust-rus.org) to provide easy and direct access to the project documentation and results for a wide public. The project website is a gateway for public to the proceedings and findings of the Consortium. The SUST-RUS web site is also a platform for discussion and collection of feedbacks on the project activities and deliverables. The information and reports about project activities and events are presented on website in full details. The website will remain available after the completion project and efforts will be made to keep it further up to data and alive.

In addition to passive distribution (website) more generic channels were actively exploited.

3.3. Using and disseminating knowledge

To enable an optimal match between the products made by SUST-RUS and the needs of potential users an exploitation strategy was developed. Potential stakeholders were identified and interviews were made to outline their needs and to ensure that SUST-RUS activities match them as well as possible. Specific attention was given to the transparency of the methods in order to enable third parties to understand when and how the developed assessment tool can be applied. The end-user interviews and presentations in the first half of the project were used to fine-tune the needs of potential users.

3.3.1. Academic and research community

- Dissemination of the database through the SUT-RUS website

Generation of the balances set of the regional social accounting matrices is a valuable output for Russian and international research community. The ruling principle of the disclosure of data of the SUST-RUS project dramatically increases interest of different research groups to the SUST-RUS activities. Multiple requests for presentation of the dataset were met by the consortium partners. Availability of the benchmark dataset on the project's site enables researchers from other institutions to use results of the SUST-RUS team in their work. Excellent reviews of developed database were done by researchers from CASE (Poland) which benefited from the use of the SUST-RUS data.

- Dissemination of the model's code through the SUT-RUS website

There is a substantial interest in the SUST-RUS code. The code will be available on the site as soon as all documentation on the project will be finalized by the Commission. There are multiple requests from different research groups for the SUST-RUS code.

- The final project conference

On December 15, the final project conference Energy efficiency and sustainability policies in Russia took place in Moscow. This conference summed up the three-year project effort and presented the policy implications and availability of the SUST-RUS assessment tool. The concept of the conference was to bring together an impressive audience of leading experts on sustainability policies and energy related issues to discuss the project results, the SUST-RUS model and its policy and academic implications.

The main topics of discussion were:

• Developing a sustainability model for Russia
• The Economic and Environmental Implications of Russian Sustainability Policy
• SUST-RUS model: Regional, industrial and social aspects of energy strategy
• Scenarios of CO2 emissions in Russia up to 2030 and potential for reduction based on best available technologies

The conference program featured presentations from all consortium members as well as invited experts in economic modeling from the Environmental Defense Fund (Washington, DC, USA). The audience of the SUST-RUS final conference included:

Representatives of the Russian government and non-government organizations responsible for environmental, sustainable development and energy policies of the Russian Federation

• Representatives of the embassies of European countries
• Academic scholars and modeling experts from Moscow high schools and universities
• Regional policy makers
• Journalists

The detailed report in two languages (English and Russian) and presentations from the conference are downloaded into project website and easily accessible to general public.

- Dissemination of knowledge via master's level educational courses:

Russian partners of the consortium developed an "Introduction to the Applied General Equilibrium Models" course. Upon the completion of the project, examples from the SUST-RUS dataset, code, scenarios' evaluation would be introduced in the teaching materials. The list of academic institutions, where the course is already taught, includes:

• National Research University - Higher School of Economics, a master level course
• Moscow Institute of Economics, Russian Academy of Science (Laboratory of the Macroeconomics, led by Academician V.M. Polterovich)
• The Russian Presidential Academy of National Economy and Public Administration (ANE), a master level course
• Urals Federal University, a master level course

3.3.2. Federal policymakers

- The administration of the President of the Russian Federation

There were several interviews and consultations with Assistant to the President of the Russian Federation Arkadii Dvorkovich. Mr Dvorkovich being in charge of Russian delegations to various meetings and conferences on climate was interested in SUST-RUS modeling results concerning increase in the energy efficiency of the Russian economy, possible effects of more strict international obligations on Russia's CO2 emissions, consequences of the natural gas price increase for the domestic consumers, consequences of the Russian WTO accession. The results of SUST-RUS experiments were communicated to the office of Mr Dvorkovich, Ministry of Economy of the RF, Department of natural monopolies and natural resources.

3.3.3. Regional policymakers

It was essential to involve regional stakeholders into discussion of project findings. There is a clear need for a well-documented policy analysis tool at the regional level. This can be used for both propagating goals of sustainable development at the regional level and for assessing regional policy scenarios that are relevant for particular regional stakeholders.

- Far East Economic Forum 2009, 2010

The participation in the Far Eastern Economic Forums was a great opportunity to share project methodology and results with the policy makers and scientific community of the Far East Region. Presentations related to the SUST-RUS model always enjoyed the same success, mostly due to a very limited analytical capacity in the regions of the Russian Federation. During the Forum in August 2010 the representatives of Consortium had a meeting with Vice Governor of Primorskii krai in charge of economic development and discussed among other issues the needs of regional governance which might be met by SUST-RUS modeling tool. The issues of energy efficiency increase were identified as the one of the major concerns of the economic governance in the region.

- Yekaterinburg Economic Forum 2010

The Urals Economic Forum is famous for its high level of participants, among which are high ranking decision makers and prominent experts from the scientific community from all over Russia and a number of foreign countries. Open session devoted to SUST-RUS model and preliminary results were held in April 2010 an important feedback from forum participants both academic and policy making ones was obtained by project researchers.

During the VII International Conference "Sustainable Growth of the Russian Regions: Innovations, Institutions and New Technologies", which took place in Ekaterinburg (Ural Region of the Russian Federation) on April 23-24, 2010, the SUST-RUS consortium organized the public seminar – open session "Sustainable growth of the regions: world experience and models for Russia". Project partners gave an overview of the SUST-RUS project, FP7 framework as the source of the SUST-RUS funding; main objectives of the project, participants, project time-frame. The general framework of the SUST-RUS project was presented: types of relevant models, potential dimensions, etc.

The audience of the SUST-RUS open session included:

• students and researchers of the Urals region [Urals is one of the most industrialized regions of the Russian Federation, the major center of Russian iron and steel production];
• representatives of the Urals Energy Ministry and The Union of Industrialists and Entrepreneurs. Roundtable with policymakers

- Policy makers business breakfast

Another roundtable was organized at the end of the project – a business breakfast aimed at the top-level decision makers and CEOs of major energy companies in Russia (December 2011, Moscow).

The business breakfast agenda was focused on policy implications and availability of the SUST-RUS tool for the assessment of industrial gas price rise, gas extraction tax increase, as well as shifts in energy-saving investments. The aim was to make the results of the project clear to the policy makers, to present the SUST-RUS model as a working tool/instrument for the assessment of the sustainable development policy measures. In order to achieve this, there were made some calculations of a few economic development scenarios after the accession of Russia into WTO (a very hot topic at the moment, right on the day when WTO approved Russian accession). Some government officials had expressed their interest in the SUST-RUS modeling tool. The presentations from the roundtable are available from the SUST-RUS website.

- Commercial companies

BP Russia – consultations with chief economist.

The corporate sector in Russia does not often consult with the scientific community. However, BP corporation is always very interested in new research ideas, so this was the case with the SUST-RUS model. Representatives of economic office of BP always participated in dissemination activities of SUST-RUS project.

Ernst&Young Russia – consultations with researchers and partners.

Ernst&Young researchers and partners expressed their interest in general equilibrium assessment of the Russian WTO accession, which is one of the scopes of the SUST-RUS implementations. Ernst&Young representatives were especially interested in evaluation of region specific consequences of the WTO accession. The SUST-RUS model could generate sound estimates of different WTO accession scenarios, examining the scope and direction of possible regional changes.

Sberbank

Sberbank was appointed by Russian Government to be in charge of state wide CO2 reduction program. Experts of Sberbank expressed their interest in new research on effects of different climate policy options available for Russia for which SUST-RUS model is the best instrument.

3.3.4. Russian and world-wide research community

The International Conference on Economic Modeling (EcoMod) is a major international forum for researches and policy-makers in the field of economic modeling applied to today's most challenging issues. EcoMod-2011 brought together more than 100 selected participants from many countries and most continents. The papers presented at the conference covered all areas of applied modeling for economics, public and private finance and decision making in the government and business world. This was the best opportunity to share project results with the international community of economical modeling experts.

The SUST-RUS consortium participated in the EcoMod-2011 with the open session "Assessment of Sustainability Polices for Russia". This seminar provided an excellent opportunity to share an overall vision of the project, the innovative component of the SUST-RUS project (namely coherent work on different dimensions of sustainability) as well as technical details concerning its implementation.

In particular the following issues were discussed:

• SUST-RUS database: Regional social accounting matrix for Russia
• SUST-RUS model: a CGE model on regional level for sustainability policies in Russia • the economic and environmental implications of Russian sustainability policy

3.3.5. Media

The results of the project – a unique spatial-economic-ecological model for the Russian Federation and its possible applications – were of great interest to Russian modeling experts and journalists, who were mostly interested in the analysis of the WTO-accession implications for Russia. The aim of the press-conference was to raise attention to the policy assessment tool SUST-RUS and it resulted in a number of publications in the prominent Russian news agencies – Interfax, Vedomosti, Gazeta.ru etc.

The outcomes of the project were also mentioned in the articles published in the FREE Policy Briefs (an extensive network of leading academic experts on economic issues in Central and Eastern Europe and the former Soviet Union) internet project (http://freepolicybriefs.org/2011/12/22/russia-and-the-wto/). All these publications are also available at the SUST-RUS website.

3.4. Future plans

The partners actively promote the use of the tools in further studies. As all of them have a track record in successful transfer of the tools from the research stage to the use phase, they continue to use their capacities and skills to valorize the SUST-RUS. These new initiatives would be accompanied by applying for suitable support.

Papers are also submitted to the International Energy Workshop (IEW) at the University of Cape Town, South Africa (June 19–21, 2012), 19th Annual Conference of the European Association of Environmental and Resource Economics in Prague, Czech Republic (June 27-30, 2012) and 2012 Berlin Conference on Evidence for Sustainable Development in Berlin (October 5-6, 2012). Follow-up research projects, using results of the SUST-RUS The SUST-RUS team will continue to improve the model and to work on spin-off activities. There are at least two projects that have already started and many more to come:

- Refinement of the system of social accounting matrices – a joint project between CEFIR and SOPS, supported by HSE's laboratory of spatial economics (SPB). The SUST-RUS experts from CEFIR will participate in newly founded Spatial Economics laboratory situated in Saint-Petersburg. The essence of the proposed project is to investigate peculiar features of the Russian interregional trade that were discussed in the D2.1 Description on the SUST-RUS database.

- Development of soft link between RU-TIMES and SUST-RUS – a joint project between CEFIR and the Russian Presidential Academy of National Economy and Public Administration (ANE). The ANE team is working on the regionalization of the TIMES model. They successfully implemented the RU-TIMES model for several major Russian industries. Since the RU-TIMES model is a partial equilibrium model, soft link between SUST-RUS and RU-TIMES will enrich our knowledge on producers' behavioral response to CO_2 restriction in Russia. The connection between these two models would be very important in terms of meeting the demand from policy makers. An increase in energy efficiency under various policy scenarios will be studied carefully with the "soft link" between these two models.

4. Address of project public website and relevant contact details

The SUST-RUS public website: http://sust-rus.org/

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