ENERGY, ECONOMIC AND ECOLOGICAL MODELLING OF VARIANTS OF THE REPUBLIC OF KAZAKHSTAN ENERGY SYSTEM DEVELOPMENT AND ITS CONNECTION WITH THE GLOBAL ENERGY SYSTEM

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INTRODUCTION.

The TIMES-Kazakhstan is a mono-regional energy system model of the Republic of Kazakhstan (the RoK), built using the MARKAL/TIMES tool. The main purpose of this three-year-project is qualitative and quantitative analysis of the energy system of Kazakhstan using environmental, economic and engineering measurements to assist decision makers in determining the effectiveness of policies and decision-making.

MATERIALS AND METHODS.

TIMES (an acronym for The Integrated MARKAL-EFOM1 System) is an economic model generator for local, national or multi-regional energy systems, which provides a technology-rich basis for estimating energy dynamics over a long-term, multi-period time horizon. The model is described in terms of linear programming problems where the objective function maximizes total discounted profit of the system. There are about two hundred TIMES users in more than sixty countries around the world. Currently the most advanced energy system modelling tool, it was built with help from Italian consultants Gian Carlo Tosato and Rocco De Miglio, developers of the MARKAL/TIMES system [1].

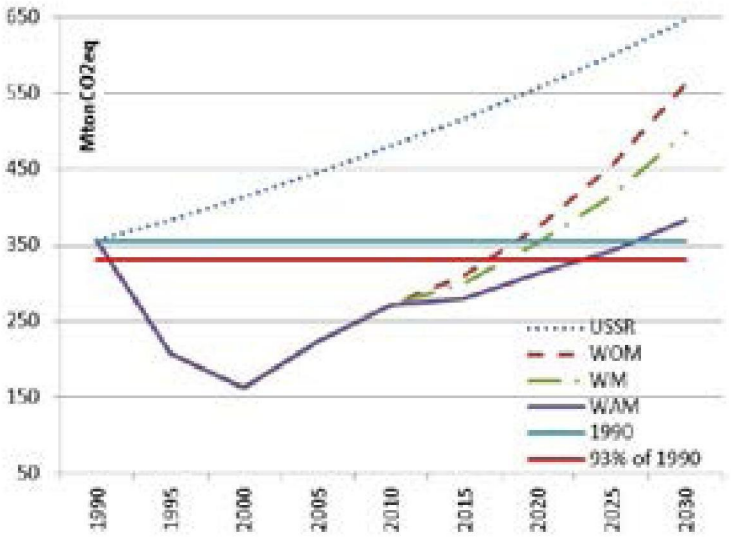
RESULTS AND DISCUSSION.

The existing energy system of the RoK was analysed. Fuel and energy balances for the period 2007-2010 were reclassified in accordance with the format of the International Energy Agency. Data on the main energy flows and the assets of the key sectors, socio-economic situation was collected and analysed. Main indicators were calculated. The energy system optimization model TIMES-Kazakhstan was built. The database of the model for the base year was filled. A demand for energy services, system losses, reserves of minerals resources, as well as a list of new technologies, scenarios, and constraints were defined. The disaggregation of the electricity sector and heat was improved. Dynamics generating capacity of disposal operation were calculated. Possible "new" technologies were introduced in the model. Social and economic drivers and model predictions for each driver were identified. Using econometric methods, the elasticity of the demand for each sector were evaluated in relation to its driver. The possibility of changes in demand for energy services, depending on changes in the prices of such services was introduced. The development of the energy system of the RoK by scenario calculations in three dimensions: economic growth, reduction of GHG emissions and disposals of generation capacity was analysed.

The data collected from industrial enterprises were used to update the structure of the industry in the model, replacing "Service oriented" the approach to "Process oriented" with updating of the processes of iron and steel, aluminium and cement sectors. The national energy balance was reclassified by type of coal according to the calorific value.

An overview of the practice of macroeconomic general equilibrium models for the analysis of macroeconomic effects of various energy policies and measures was provided.

The disposal of operating generating capacity was recalculated based on updated data. Four scenarios of the Kazakhstan energy system development with elastic demand, and taking into account the GHG emissions tax and the transition of Kazakhstan to the «green economy» were created. The first scenario is a hypothetical scenario of the RoK as part of the Soviet Union, in which GHG emissions amount reaches 647



Mtons of CO_2 equivalent by 2030. The second scenario is the development of a system with frozen technological development from 2010, which implies an econometric estimation of emissions depending on the assumptions on the dynamics of the main macroeconomic indicators. The amount of emissions in this scenario is 562 Mtons of CO_2-eq. in 2030. The remaining two scenarios were calculated using the model TIMES-Kazakhstan in terms of emissions from fuel combustion. The emissions from non-combustion processes were calculated by the research group, and future changes were estimated econometrically. The baseline scenario takes into account technological progress, and emissions are 498 Mtons of CO_2-eq. by 2030. Measures to reduce emissions may lead to an additional reduction of emissions by 108.8 Mtons of CO_2-eq. by 2030, compared to the baseline scenario. The model results in terms of GHG emission projections were presented at workshops at the Ministry of Environment and Water Resources Protection of the RoK. The results of the TIMES-Kazakhstan model were used for defining the boundary quantitative commitments of Kazakhstan in the second period of the Kyoto Protocol, and for preparation of the sections 4 and 5 of the Third-Sixth National Communication of the RoK to the UN FCCC.

The article «Impact of power plant retirement policies in Kazakhstan» was presented at the International Energy Workshop 2012 in Cape Town (South Africa). The article «Electricity and heating system in Kazakhstan: exploring energy efficiency improvement paths» with an impact factor of 2.723 was published in the «Energy policy» journal.

CONCLUSIONS.

The TIMES-Kazakhstan model is an effective tool of quantitative and qualitative evaluation of policies in the energy sector. The tool can also be used to assess cost-effective measures to reduce GHG emissions. In next stage of the project, the research group is planning to build a multi-regional model of the energy system of Kazakhstan. It will make the model more precise and accurate, thereby giving the possibility to analyze each region independently. The model will be developed to evaluate the effect of policies and measures in the energy sector.

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