# Kazakhstan: Selection of Policy and Energy Conservation Measures from the point of view of GHG emissions reduction

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**Abstract**: Republic of Kazakhstan is a Party of UNFCCC since 1995. In 2009 Kazakhstan ratified the Kyoto Protocol and then took the voluntary obligation not to exceed emissions level of base year during the period 2008-2012. Over 65% of Kazakhstan electricity and heat demand is generated using coal. Due to cold climatic conditions a considerable share of energy consumption is for heating with inefficient centralized heating supply systems that suffer significant losses. Updating Climate Change policy is a key feature of the general renovated path of the national development aiming to low carbon economy. This paper presents the comparative analysis of GHG emissions scenarios for post-Kyoto era using different models; taking into account the effects of new state innovative policy and the crisis phenomena in the world economy. The real potential of energy saving in housing and commercial sectors is estimated 35% of the actual fuel consumption. In conclusion: reliable forecasting will help to define post 2012 target and understand how a changing climate will alter the shape of development programs in Kazakhstan; the realization of energy conservation options will bring co-benefits and ancillary benefits, will promote development of energy security and other strategic economic goals. Complex approach and portfolio of measures is necessary to realize the potential effectively.

**Keywords**: Climate Change policy, $CO_2$ reduction

## 1. Introduction

Climate Change and Sustainable Development (SD) issues are in the attention of the Republic of Kazakhstan (RK) and are integrated into governmental programs. The legislative provision is the most important supporting component in the transition of Kazakhstan to SD. In 2007 the "Ecological code" was accepted, incorporating into Chapter 45 the governmental regulation of GHG emissions and sinks; the "Law on renewable energy resources development support" was accepted in 2009; the "Law on energy conservation and improvement of energy efficiency" was expected to be approved by the Government in 2011. Rational use of energy resources, ecological clean energy technologies promotion and energy efficiency improvement including heat supply is of special urgency for Kazakhstan.

The Republic of Kazakhstan (RK) as independent state participates in all United Nations (UN) conferences defining the future world community development since 1992. RK is a Party of the United Nations Framework Convention on Climate Change (UNFCCC) since 1995. Kazakhstan ratified the Kyoto Protocol (KP) in 2009. According to Marrakesh Accords[1], Kazakhstan become an Annex I Party for the purpose of the KP in accordance with Article 1, paragraph 7 of the KP; according to Nairobi decision, 1992 was defined as the base year for Kazakhstan; according to Poznan decision, RK undertook the voluntary quantitative obligation not to exceed emissions level of 1992 for the period 2008-2012. In 1998 RK issued the First National Communication to UNFCCC (FNC) and in 2009 the Second National Communication (SNC) [1].

The reliable forecast of GHG emissions is important for planning and implementing effective climate change mitigation and adaptation policies and measures. The analysis of scenarios of greenhouse gas (GHG) emissions dynamics in 2008-2012 was important for deciding on the KP ratification and developing strategies of how to use GHG emission reductions (quota).

This paper presents the comparative analysis of previous GHG emissions forecasts for Kazakhstan using different modeling tools and recent corrections with MARKAL taking into account the innovation cycles, effects of economy crisis. The results of the study also include recommendations on defining the indicative goal of GHG emissions levels which will help to define the volume of free quota for the purposes of its efficient realization while implementing international agreed obligations in the field of climate change and defining the potential for energy conservation measures in housing and residential sectors.

[1] Article 4, paragraph 2 (g), Kyoto Protocol

## 2. Review of experience and analysis of GHG emissions modeling in Kazakhstan for the period 1998-2005

GHG emissions modeling in Kazakhstan is taking place for more than 10 years now and it's possible to track results from the FNC in 1998. The inventory of GHG emissions for the period 1990-1994 and the forecast up to 2020 that was developed using the ENPEP model[2], were presented in the FNC. The first trends of GHG emissions forecast were built taking into account the existing by that time research works, expert studies and the main indicators of energy development Program. In the baseline (Figure 1) no measures on climate change mitigation were planned, while in the integrated scenario they planned to introduce the following technologies for nuclear, wind, solar and hydro energy. According to the evaluation of the baseline, $CO_2$ emissions were going to reach the level of 1990 in 2011 and exceed it by 37% in 2020[3], and on the integrated scenario the growth of emissions was expected to be only 20% in 2020 compared to the level of 1990. The total annual potential for $CO_2$ emissions reductions due to the implementation of all the options ("Integrated scenario") considered increases from 3% in 2000 to 11% in 2020.

As presented in Figure 1, scenarios imitated nearly linear growth of $CO_2$ emissions, pro rata ambitious growth of economy factors, as a result, level of uncertainty estimated by experts as 20%, look to be much above.

Forecasting of GHG emissions during 2000-2005 was done by means of internal and external resources with use of the following modeling tools: CGE-KAZ, GAMS Programmer 4 Complex [2] for different analytical reports ordered by the Government [3], [4], [5], [6] with the authors' inputs. For description of the dynamics of $CO_2$ emissions for economies in transition the interfiled economic balance model was used (Figure 2). Initially it was developed by Gordon Hughes, but later it was reworked by E. Gurvich, A. Golub and others. Later this model was used for research on "National Strategy of GHG emissions reduction in Russia". The given model was complemented with several exogenous parameters such as Gross Domestic Product (GDP) structure, energy-carriers prices and environment pollution payments. The econometric model used various exogenous parameters to calculate the share of new technologies and energy sector structure (fuel mix) for Kazakhstan. The main model assumption included replacement of old technologies with new ones after economical reforms started, while during transaction

[2] ENPEP model, model of the Argonne National Laboratory (USA)

[3] First National Communication of the RK under the UNFCCC, Almaty, 1998, ch.4, page 57

period old and new technologies work in parallel.

Since 2005 the resilience factor proposed in work [7] was used for revision parameters in Kazakhstan model. Probabilistic model for $CO_2$ forecast had the following type:

$$CO_2^t = CO_2^{0*}(e^* \alpha/100+1)^t \qquad (1)$$

Where $\mathbf{CO_2^t}$ - $CO_2$ emissions in t year;
**e** - $CO_2$ resilience factor on GDP;
**α** - annual GDP growth rate in percentage.

The results of the Kazakhstan $CO_2$ forecasts, prepared with authors' input, are presented at Figure 3. The forecast trend is in the relative unit, while baseline emissions are estimated as 100%, base year for Kazakhstan is 1992.

Two scenarios - "with technological progress" and "without technological progress" - are presented at Figure 3. The International Energy Agency (IEA) statistics data for the period 2000-2004[4] were used for comparison. The analysis of the estimations brought authors to the following conclusion: according to the scenario «without technological progress" the emissions from energy industry will not exceed the level of 1992 by 2014. From the point of view of the least influence on environment the most profitable scenario is the scenario «with technological progress», under which supposed emissions from the energy industry will reach 90% from 1992 level by 2024. According to the conservative estimation of the IEA, the data for that time period corresponded to the baseline «without technological progress».

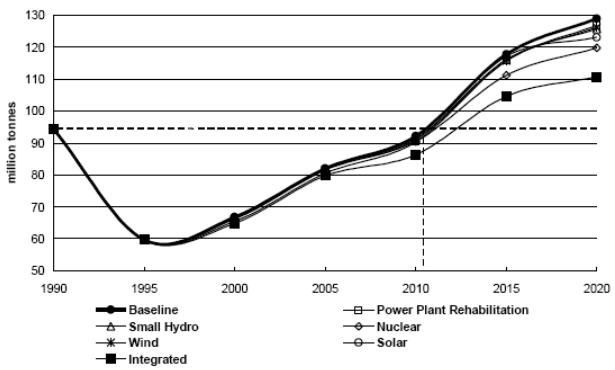


Figure 1: $CO_2$ emissions for the baseline and mitigation scenarios(Kazakhstan).

The results of the forecast, reflected in a number of official documents (e.g. The First National Communication), have influenced upon making the political decision on KP ratification, so additional undertaking research on GHG emissions modeling was required.

[4] key_stats_2001, 2002,2003,2004, source: *http://www.iea.org/*

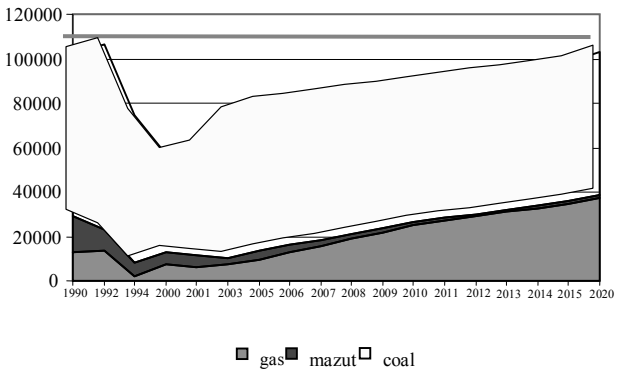


Figure 2: $CO_2$ emissions distribution from different types of fuel, scenario 2A («self-balance») [3].

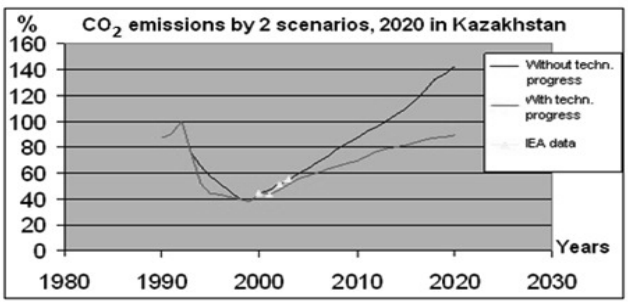


Figure 3: $CO_2$ emissions forecast in Kazakhstan (results by the authors): "with technological progress" (lower path) and "without technological progress" (upper path). While calculating in the case of innovative scenario "with technological progress" they used resilience factor e= 0,2.

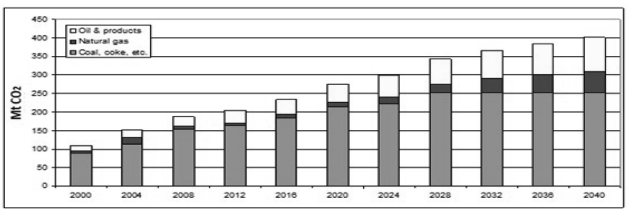


Figure 4. $CO_2$ emissions by fuel in the baseline scenario (A-MK-BAU) (Kazakhstan energy sector) [8-9]

In Kazakhstan a macroeconomic model of energy distribution on a market (MARKAL) [5] has been introduced since 2005 and later on since 2011-2012 the System of the long-term planning of alternatives in energy sphere (LEAP) is planned for the project PROMITHEAS-4.

[5] For an overview of the MARKAL family, please see Goldstein, G.A., L.A. Greening, and the Partners in IEA ESAP, 1999

## 3. MARKAL KZ is a model for analysis and forecast of the different sectors of economy development in the Republic of Kazakhstan

Standard MARKAL is a" bottom-up" modeling tool using linear programming techniques. The main method used in design analysis is a discount cost method. This method is based on determination of the future costs of the year t + 1 ($C_{t+1}$) as costs of the year t ($C_t$), enlarged on value equal to the bank percent rate ***r*** [8]:

$$C_{t+1} = C_t \times (1 + r) \qquad (2)$$

MARKAL is a tool for the analysis of cost evaluation following the assumed development policy based on the energy sector and selection of the optimum measures on change legislative, regulative and institutional framework for increasing of efficiency in long-term prospect. MARKAL-TIMES generates models for prospective analysis of the future scenarios (not a forecasting model).

A group of experts - with authors included - developed in 2006 the first MARKAL KAZ model, later used in preparation of the SNC. The following macroeconomic assumptions were used for the baseline scenario (A-MK-BAU) (Figure 4): the period of forecasting is 2000-2050; GDP of 2000 (18282,4 million US dollars in constant prices) is growing twice by 2015; saving of annual growth rates of the country's economy are not less than 10 % by 2012, 12 % by 2018, 14 % by 2024[6] and grow smoothly. Population in 2000 was 14862,7 thousands; the annual population growth rate was -0,3% for 2000, 0,6% for 2010 and 0,7% up to 2050. The emissions factors were used as default factors according to IPCC. For example, according to the National Statistics in 2005 the real GDP rate growth was 9,5%[7], and in 2008 it decreased to 1,2%. The results of the calculations are presented at Figure 4.

The baseline scenario analysis of GHG emissions showed that, the1992 level (252.9 Mt $CO_2$ ) would be reached by 2018 (see Figure 4). The relation between the reduction and the cost is explored with the model by building scenarios accepting new technologies that have an increasing $CO_2$ mitigation cost. The year, when emissions from fuel combustion grow back to the 1992 level, is pushed back to 2020 by using new technologies with the cost below 5US$'2000/t $CO_2$. The average long-term level gives an approximate estimation of the cost of 70 KZT/'2000/t $CO_2$ [8] for the country to achieve the corresponding mitigation level with domestic policies and measures. This will occur if RK will begin to reduce the emissions on 5% immediately after 2010, this corresponds to GDP early loss about 0,2% [8] by 2020-2024.

According to baseline scenario (further in the recent analysis named "BAU SNC") analysis presented in the SNC the level of 1992 is expected to be reached during 2012-2014.

## 4. Innovative development is a key factor in the policy of Kazakhstan

Currently a number of new documents to include RK within the leading developed countries of the world are being intensively developed. Two of the key Governmental programs under implementation in Kazakhstan is the "Program on forced industrial-innovative development 2010-2014" (GPFIID), and the "30 Corporative Leaders of Kazakhstan".

The oil-and-gas sector remains to be a locomotive of the economy, due to the greatest contribution in the wealth of the country. In the chain of added costs, the greatest profit is received by companies that use technologies of high raw material processing. Optimization of innovative technology choice in the field of polymeric material is considered in work [9]. It should be mentioned that considered projects with innovations have associated advantages: reduction of pollutants and GHG emissions.

The analysis of IEA report [11] showed that energy generation without $CO_2$ emissions (due to the application of technologies on capture and disposal), use of renewable energy sources and in some countries, where it is possible, use of atomic energy, will be of great importance. The scenario analysis showed that global $CO_2$ emissions may return to the present level by 2050, and oil consumption growth may be half reduced. Energy efficiency is of paramount importance to achieve such results. Conclusions of this report mention that more sustainable energy in the future is attainable. Immediate steps on research work incentives, demonstration and introduction of perspective technology; introduction of clear and predictable measures on promotion of technology with low $CO_2$ emissions and diversification of energy sources are required. These findings are also confirmed by studies made in other countries. Impact on $CO_2$ emissions reduction of scenarios with technological innovations in the energy sector and economic changes and measures were considered in Japan (Figure 5). In spite of appreciable contribution of economic regulation in the achievement of goals on environmental protection, $CO_2$ emissions were considerably reduced due to exactly technological changes within the energy system (Figure 5). The MARKAL model, which was interconnected with MACROEM macro economy model, was used for making the studies.

[6] A number of indicators of SD in the Concept are too optimistic (note of the authors).

[7] www.stat.kz

[8] 0,6 USD at the rate as it was in 2000

## 5. Correction of $CO_2$ trend considering economic crisis

The history of human civilization development was always accompanied by crisis. In early ages that was expressed in insufficient food stuff production, and since the middle of the19th century - in the loss of the balance between demand, which decreases because of population solvency reduction, and in continuing production of goods, products of public consumption and services. New situations connected with reduction world economy growth pace, certainly, will influence the policy in the field of climate change.

For the purpose of recent analysis three main sources were defined, which made the greatest contribution into GDP of the RK: external loans, incomes from export and money mass. Along with that, an economic metrical model designed in the course of studies, has revealed that 80% of GDP increase in those years was achieved due to attraction of external credits.

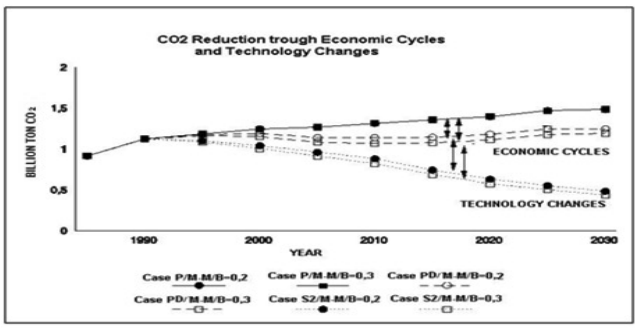


Figure 5: Japanese model with use of two resilience values 0.2 & 0.3. Source: Summary of Annex V (1993-1995) April 1997, ETSAP-97—1 http://www.etsap.org

So, each 1 million $ borrowed abroad enlarged GDP of the country by 915 million $ at the average[9]. In this case deficit of economy financing could be filled due to export receipts from sale of resources, which previously provided only 8.9% increase of GDP, since the bigger part was allocated for the National Fund establishment. However, during the period of 2008-2009, the prices for the main raw material goods fall and, as effect, income of Kazakhstan from export decreased.

The new approach presented here and aimed to improve the forecasts includes considering energy efficiency as one of the opportunities to attract investments into economy to accelerate development in post crisis period (energy efficient technology development will allow attracting up to 1 million dollars of investment»[10]). So, raising of RK market attractiveness at low risks in the economy is very timely.

Fundamental macro economical analysis is very complicated. In most cases it is impossible to take into account all factors affecting the market. That is demonstrated currently since nobody could describe a real threat of the expected crisis and even assess it because of uncertainty in information. The potential impact of the world crisis on the economy and on the calculated level of GHG emissions in Kazakhstan was not considered in calculations at SNC scenarios development. In this connection, analysis of GHG emissions considering crisis and introduction of innovative technology is to the point.

Here the attempt of improvement of forecasts is presented. While constructing the scenarios «BAU Author» and «Innov-author» the following work was implemented using the MARKAL KZ model for improvements:

(a) crisis phenomena in economy and innovative cycles making essential impact on GDP growth and the whole economy. Corrections of forecast GHG trends were introduced into the model according to the experience of Japan (see above). Input assumptions for GDP growth for the period 2000-2020 were recalculated (annual rate growth was decreased up to 5-6% for the period 2010-2020 using correlation method, and resilience factor 0,2)

(b) the annual population growth rates were recalculated according to modern tendencies. For instance in 2006 the real rate accounted 3,13% while in 2008 -1,23%, so it was increased up to 1-2% for the period up to 2020;

(c) the IPCC requirements for all sources of emissions were considered. In particular the local emission factors were used for calculation and evaluation of the GHG emissions in power and heat sectors, taking into consideration the construction of new plants according to GPFIID, decrease of energy intensity 10% by 2015 towards the parameters of 2008,

(d) comparative analysis provided towards baseline scenario presented in SNC, here named as " BAU SNC", and new developed "BAU author" and "Innov- author" (Figure 6).

The scenario BAU SNC corresponds to the basic scenario presented in SNC, it is designed on the basis of data in table 1.1, Fig. 3.3, fig.4.6 and raw data on emission inventory 2005[11]. According to SNC the level of GHG emissions from energy sector must reach the level of the base year in 2012-2014. At Figure 6 this point is shown by an arrow (<-level1992).

[9] Business Forum. "Searching for Panacea" International Business Magazine KAZAKHSTAN #5/6, 2008, http://investkz.com/

[10] 24.06.2009 / policy: www.eco.gov.kz, 23 June

[11] Total emissions of gasses with direct greenhouse effect in 2005 constituted 243.2 million t $CO_2$-equivalent, including 196.9 million t of emissions from energy activity, 15.3 million t from industrial processes, 22.8 million t from agriculture, and 8.2 million t from wastes; Specific GHG emissions constituted 16 t per capita, of which CO2- 12.4t), total GHG emissions were 29.8% less than in 1992, SNC page 51). *source:http://unfccc.int/national_reports*

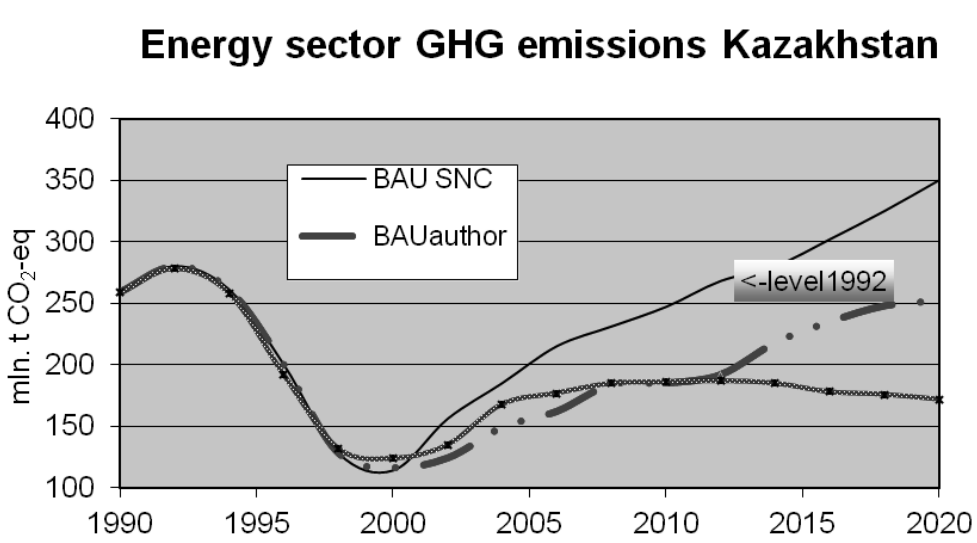


Figure 6. Analysis of GHG emissions scenarios in RK taking into account innovative cycles and the crisis phenomena in the economy of the Republic of Kazakhstan. Source: Authors' calculations using MARKAL KZ model

"BAU author" corresponds to innovative cycles, but "Innov author" to use of the best technology.

There is no GHG emissions growth in accordance with the scenario (BAU author) in crisis years -2008-2010, also GHG emissions growth is not expected for period 2018-2020; moderate emissions growth by 1% per annum is expected after that; in this case GHG emissions in the energy sector will reach the level of the base year in 2028.

In the case of RK transition on the path of innovative development that corresponds to the scenario (Innov author), stabilization of emissions at the level of 2016-2019 is expected, after that it shall reach 260 million tons of $CO_2$ at moderate growth by 0.5% per annum by 2030.

This GHG emissions analysis of the paper does not agree with some conclusions, presented in SNC. Particularly with the fact that using existing technology and allowing the same conditions of the branch - according to scenario BAU SNC - GHG emissions will reach the level of 1992 by 2012-2014, while with introduction of more efficient technology this will happen by 2024 [1] page 76 SNC and Fig. 4.6, Fig. 3.3 page 51. According to calculations done for this analysis, even according to the conservative basic scenario (BAUautor) emissions from energy will reach 90% of the base level by 2024 only. Therefore an indicative goal could be defined as follows: - the level of GHG emissions by 2020 - 12%-15% below the level of the base year.

## 6. Prospects of energy saving in Kazakhstan, calculations

As aforementioned, energy efficiency has been incorporated into the official policy of Kazakhstan as the most optimum way to achieve energy security. This problem has become very urgent in connection with rapid growth of a number of cities, particularly Astana, the new capital. In particular, work on GHG emissions reduction in the municipal heat supply is being realized and new technologies are being defined within the framework of UNDP GEF Project. Under this project it is planned to reduce emissions by 150 thousand tons $CO_2$ for the period of 5 years. New laws are being implemented in Kazakhstan: "On State Support of Renewable Energy Sources Use" (2009), changes to the law "On Natural Monopolies" - these measures: «will allow reducing GHG emissions in atmosphere for the period 2010-2024 approximately by 75 million tons of $CO_2$ equivalent substituting power energy from coal stations".

Integrated introduction of legislative and economic mechanisms and innovative technology will allow realizing the existing potential on energy saving, which is evaluated here as 30% in the sector of energy generation and transmission, and not less than 20% in housing-public sector. Introduction of measures, such as improvement of district heating supply systems (DHS) isolation, reduction of losses in distribution heat systems and improvement isolation of buildings along with metering and control will bring to approximately 35% of actual fuel consumption at DHS. The calculations done show that the GHG emissions reduction potential will be 1,0 million tons of $CO_2$ in 2020 because of use of energy saving technologies.

As it has been stated in the report of IPCC[12], the major part of energy saving potential in the sector of buildings in countries with the economy in transition is characterized by negative expenses - i.e. provides profitable investment possibilities. The existing barriers restrain active promotion of energy efficiency, and therefore energy efficiency improvement will depend on strong policy of the state and technological progress. Early investments determine long-term future, and both international investors and the state should be attracted for that. To realize the defined tasks, an integrated complex approach should be applied in Kazakhstan, which will allow realizing the existing potential effectively, more so that realization of energy efficient measures will result in additional accompanying and associate advantages such as:

- fuel saving (on consumer side);
- reduction of specific fuel consumption (on producer side);
- reduction of usual pollutants emissions (reduction of enterprise payments for pollution);
- improvement of environmental quality;
- reduction of population diseases;
- reduction of produced product prime cost at increasing of their quality.

## 7. Conclusions

1. Refining of macro- economic forecast is an established practice of the governments of many countries, depending on the situation created in the world economy. Modeling of GHG emissions in Kazakhstan considering many factors will allow introducing efficient policy at the national level in the field of climate change.
2. Active participation of Kazakhstan in KP mechanisms will be rather favorable for the image of the country. Financing and introduction of energy saving projects may be achieved through realization of mechanisms [13] for attraction of foreign investors.
3. It is recommended to realize energy saving potential in relation to greenhouse gasses emissions through:
   - *Optimization of an energy consumption structure with introduction of renewable energy sources in the energy balance;*
   - *Revision of the normative base and updating it in accordance with international standards promoting energy efficiency measures;*
   - *Attraction of additional investment for implementation of JI/ CDM projects including introduction of new cleaner technology, modernization of the existing equipment for energy generation and consumption.*
4. Preferences or restrictions for definite types of projects, encouragement of associate advantages and introduction of discounting or raising coefficients for projects mostly contribute to sustainable development[14].
5. The economic potential on impact mitigation, which, as a rule, is higher than the market potential on mitigation may be reached only at introduction of corresponding policy and removal of barriers [12]. Energy saving potential defined as 30% could be realized in the frames of innovative scenarios.
6. A considerable part of Kazakhstan quota for emissions, according to different forecasts, from 75 to 90% is used by Kazakhstan for its own needs. The remained part may be sold at the world quota market or preserved for use in future budgetary periods following the KP period (2008-2012). Efficient management of KP quota requires reliable emission forecast.
7. Even under the worst scenario Kazakhstan will not exceed the KP quota in the amount for the period of 2008-2012. The development of Kazakhstan on the way of technical renovation also will be accompanied by low pace of GHG emissions growth. Entering the mechanisms of the KP will transform the quotas in a new resource of economic value. This will create additional incentives for GHG emissions reduction on the basis of new technology (realization of the 3rd innovative scenario) so, in the opinion of the authors the Kyoto emissions budget will not be an obstacle for economic development of the RK.

[12] National Report on Human Development 2008, Climate change and its impact on the development of Kazakhstan in relation to human development, Kazakhstan 2008, UNDP, page 32

[13] IPCCC, Climate Change 2007, http://www.ipcc.ch/publications_and_data/

[14] Joint Implementation (JI), Clean Development Mechanism (CDM), Emission Trading

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# Казахстан: Выбор Политических Мер и Мер по Энергосбережению с Точки Зрения Сокращения Выбросов Парниковых Газов

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**Резюме:** Республика Казахстан является Членом РКИК ООН с 1995 года. В 2009 году Казахстан ратифицировал Киотский Протокол и принял добровольное обязательство не превышать уровень выбросов базового года в период 2008-2012 гг. Более 65% спроса на электроэнергию и тепло в Казахстане вырабатывается на угле. Вследствие холодных климатических условий, значительная часть энергопотребления связана с отоплением, что в основном осуществляется через неэффективные централизованные системы теплоснабжения характеризующиеся значительными потерями тепла. Модернизирование политики по изменению климата является ключевой отличительной чертой общего обновленного путя национального развития направленного на низкоуглеродную экономику. Эта статья представляет сравнительный анализ сценариев выбросов парниковых газов в период пост-Киото, выполненных с помощью различных моделей, а также учитывая последствия новых государственных инновационных политик и кризисные явления в мировой экономике. Реальный потенциал энергосбережения в жилом и коммерческом секторах оценивается 35% действительного потребления топлива. В заключение: достоверное прогнозирование поможет определить цель после 2012 года и понять как изменяющий климат изменит форму программах развития в Казахстане; реализация опций по энергосбережению принесет сопутствующие выгоды и вспомогательные преимущества, продвинит развитие энергетической безопасности и других стратегических экономических целях. Необходимы для эффективной реализации потенциала - комплексный подход и портфель мер.

**Ключевые слова:** Политика по изменению климата, Сокращение выбросов $CO_2$