Technological Aspects of Greenhouse Gases Emission Reductions

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ABSTRACT

In the paper information on a newly accepted targets to reduce greenhouse gas (GHG) emissions on a national level by 2020 and requirements for GHG emissions regulation is presented. Results of analysis of additional measures in frames of the national policy to be planned are introduced. Rational measures to limit GHG emissions in the energy sector for the coming 10 years are pointed out, a possibility of CCS technologies implementation in the Russian energy sector is evaluated.

WHAT ARE THE REQUIREMENTS FOR GHG EMISSIONS

Combustion of any organic fuel at TPPs and boiler-houses leads to GHG emissions, making the impact on climate change. Over 99% of GHG emissions represent carbon dioxide (CO_2) while methane (CH_4), nitrous oxide (N_2O) and sulfur hexafluoride (SF_6) constitute less than 1%. Energy sector of the RF is a key branch of industry as referred to GHG generation, since 83% of all GHG emissions in the country comes from fuel combustion in various energy utilities [1] (power sector, housing and public utilities, industrial energy sector, etc.).

To limit a man-made impact on the climate system, in 1992 UN confirmed the UN Convention on Climate Change (UN FCCC) and in 1997 – the Kyoto Protocol (KP) to UNFCCC which entered into force on the international arena in 2005. Russia is the Party to both of them. Texts of both documents, all the decisions made in their framework, methodologies and guidelines, etc. are available at www.unfccc.int, having a Russian version of the main documents, and also at the Russian site www.climatechange.ru. For developed countries KP established specific commitments for reduction/limitation of GHG emissions in 2008-2012 as compared with the level of 1990. For the RF the commitment was that emissions in 5 years - during 2008-2012 divided by 5 shouldn't exceed the level of 1990. This target was successfully achieved by Russia, providing a reserve of about 6 billion tCO_2-eq in 5 years. To be fare it should be pointed out that such a success appeared due to the economic failure in 90-ies when emissions automatically reduced by 1/3. But it can't be neglected that the post-crisis recovery of economy took place on another basis, less material and energy intensive and with more concern of energy resources conservation which finally resulted in reduction of specific energy consumption per unit of GDP.

Due to different reasons, including refusal of some developed countries to continue participation in KP (Canada and Japan), to join it (USA), or to establish specific commitments for emissions for the future period (China, India and Brazil) and also incapability of the existing UN FCCC and KP measures to cope with the increase in GHG emissions in the world, Russia did not impose on itself new commitments up to 2020 in the framework of "prolonged" KP. The RF is intended to participate in a new, more effective and comprehensive agreement; as soon as there is no such an agreement the RF is performing the same way as other countries, i.e. according to its national plans and programs. Lack of commitments led to the fact that the RF has lost the right to participate in market-based mechanisms for greenhouse gas handling such as interstate emissions trading (Article 17 of the Kyoto Protocol) and Joint Implementation Projects (Article 6). At the same time the RF national policy relating to the climate change and GHG emissions is going on. Out of a number of the confirmed state documents in this field, an important one for the topic under consideration is the President Decree No.752 "On reduction of GHG emissions" dated 30.09.13 [2], which contains a target task to provide by 2020 the emissions not higher than 75 % of the level of 1990. It should be pointed out that according to some scenarios made by a number of entities which assumed an annual 2…3 % GDP growth, the level of 75 % can be exceeded. As to "Ecopolis Ltd" estimate this may happen with the emissions from the power sector if a medium sector's scenario is considered (from "The Program of Development of the Unified Power System of Russia by 2019" [4], confirmed by the Ministry of Energy in July 2013). While emissions in 1990 were approx. 780 mln tCO_2 according to the mentioned scenario, by 2020 they will reach 655 mln tCO_2 and cut by 25 % of the level of 1990 constitutes 585 mln tCO_2, i.e. the deficit may be 70 mln tCO_2.

In order to provide the fulfillment of the mentioned state task that very Decree ordered the Government to work out the related plan of measures including indicators of emission reductions by sectors of economy; this was done in April 2014 [3]. The Plan comprises 3 topical parts:

(1) formation of GHG emissions inventory and accounting system including development of concepts, methodological base, etc.;

(2) emissions forecasts up to 2020 and further on until 2030 and evaluation of GHG emissions reduction potential by sectors of economy;

(3) measures of state regulation including estimates of the efficiency of the policy and measures, development of proposals to stimulate realization of pilot projects, development of norms, rules, regulations and methodological base for the projects that need state subsidiaries, development of proposals to amend the related national programs and to provide assistance of project activities, analysis of international practice of market instruments of regulating GHG emissions, development of a concept and an action plan to limit emissions by 2020 and further on until 2030.

Climate change policy in Russia is accompanied by the measures to switch the national industry to a modern level. In March 2014 the Government Decision No. 398-r established a set of measures to eliminate old and low-efficient technologies and switch to the principles of the best available technologies (BAT) and introduce the state-of-the-art technologies [5]; on July 21, 2014 a new Federal law No. 219 "On amendments to the Federal law "On Environmental Protection" and to some other legislate acts of the RF" [6] was adopted, and it also established application of BAT principles. Since low-level GHG emissions can be achieved at high efficient equipment both of the documents are in direct relation with the topic under consideration.

Summering the mentioned requirements it can be concluded that despite of the limited participation of the RF in the prolonged KP, the tasks towards GHG emissions

regulation found its definite place in the state regulative system and will definitely require appropriate measures of the industry and business. Firstly, this affects introduction of BAT as well as GHG inventories, account, reporting, imposing of quotas, forecasting and including GHG emissions in Environmental Impact Assessment of design documentation of new enterprises.

ON SOME STATEMENTS ON TECHNOLOGIES PRESENTED IN THE RF 6TH NATIONAL COMMUNICATION TO THE UN FCCC AUTHORITIES

National communications are periodical reports of countries to UN FCCC authorities. In the RF 6th national Communication [1] together with scenarios "without measures" (i.e. nearly without increase in energy efficiency and energy saving) and "with measures", the third scenario "with additional measures" is indicated there; and it is explained in the following way:

(1) introduction of GHG emissions tax or quota trading system;

(2) introduction of technologies of utilizing methane from mines, technologies of CO_2 capture and storage (CCS)**;**

(3) rapid transformation of a fuel mix in the power sector.

Since these additional measures can be demanded, below are the related comments, taking into account the period of time until 2020.

Comments to the measure 1. Introduction of just emissions tax will lead to higher production cost and it is not obvious that this will help to initiate additional technical measures. This is testified by the experience of ecological payments, this system did not become a stimulating one in the RF. The systems "cap and trade" or "tax and trade" which are recognized in the world as the most effective ones, combining "whip and candy", are in action in many countries and bring good results. Nevertheless in the nearest years it is not realistic to gain good results from "cap and trade" system in Russia. In EU imposing quotas among 12,000 enterprises took approx. 5 years and was accompanied by a great number of difficulties and disputes. Beside the distribution of quotas, creation of an infrastructure will be needed for functioning of such a system (methodological provisions, verification of emissions, keeping a register in work, launch of the emission stock exchange, etc.). In the RF preparatory and research works in this field are under way for a long time and a testing phase could be tried now. Much can be taken from the European Emission Trading System (EU ETS) which is in action for a long time. The System "tax and trade", which includes issuance of certificates of the achieved emission reductions and their accounting in tax payments, seems more simple and more swift for introduction. The power sector seems to be the most prepared branch for testing one of the above mentioned systems; there are several reasons for that.

Comments to the measure 2. Implementation of technologies of carbon dioxide capture and storage (CCS) leads to substantial additional capital investments, reduction of TPP efficiency and increase in the cost of the produced electricity not lower than by 30 %. These works in the RF are still under the phase of familiarization with the technologies and analysis. In case additional investments in the power sector are required, a special attention should be paid to introduction of gas turbines, combined cycle and gas turbine toppings, for which there's a tremendous potential in the country (for instance, on the European part of the country a share of natural gas in the fuel mix of TPPs exceeds 90 %, and a great number of TPPs uses low-efficient facilities with worn-out steam turbines). This measure unlike the expensive CCS technology will lead to substantial efficiency increase (for combined cycle gas turbine equipment of medium and high capacities – more than 1.5 times; GHG emissions will be lower to the same extend).

Comments to the measure 3. Switch of the fuel mix in the power sector to a natural gas takes place in the country since the beginning of 1980-ies and now came to an end. In the document named "The Scheme and the Program of the Unified Power System Development until 2019" [4], confirmed by the RF Ministry of Energy in July 2013 it is forecasted that by 2020 a share of gas in the fuel mix will increase only by 0.7 % (abs.) as compared with the nowadays figure. Almost all of the existing coal-fired power plants are connected with the coal basins (Kuznetsky, Kansko-Achinsky, Podmoskovny and Zabaikalsky basins). Natural gas became available for TPPs of Sakhalin, Kamchatka, Khabarovsk and Primorsk Regions (while at the end of XX century they were not considered as potential gas-firing plants). And later on a switch to gas (except for some rear cases) is probable for TPPs, located near the main gas pipelines under construction. There is some potential to use associated oil gas at oil and gas fields (oil and gas companies have already constructed, are constructing or plan to construct a number of small- and medium-scale power plants for own purposes/auxiliaries).

ABOUT MEASURES AND PROJECTS TO REDUCE GHG EMISSIONS IN THE ENERGY SECTOR

GHG emissions resulted from fuel combustion are completely dependent on amount and type of fuel. For engineering calculations the following formula is applicable: emissions are equal to amount of fuel (expressed, for instance, in tons of coal equivalent) multiplied by the emission factor which according to IPCC [7] constitutes 1,65 tCO_2-eq./t c.e. for natural gas, 2,78…2,96 tCO_2-eq./t c.e. for coal (for hard coal the value is lower, for brown coal the higher one), for residual oil it is 2,27 tCO_2-eq/t c.e. (these factors are converted from IPCC units, expressed in tCO_2/TJ).

Correspondingly the main measures, aimed to reduce/limit GHG emissions in the RF for the coming 10 years will still be:

- increase in efficiency of energy production, transmission, distribution and consumption;
- energy saving, reduction of all kinds of energy losses;
- implementation of renewable energy sources;
- use of biofuel and wastes as a fuel;
- switch of TPPs and boiler-houses to natural gas.

It is clear that the technologies under the mentioned fields are directly connected with BAT system which is under introduction at the time being in the RF.

Specific technologies are not considered here, they are thoroughly described in other sections of the Information System.

GHG emission reductions are calculated using the achieved saving of fuel, heat and electricity. Approved international methodologies can be implemented for this purpose, they are published at UN FCCC site www.unfccc.int/methodologies. Totally about 100 methodologies for various technologies and model projects can be found there.

In the RF power sector for assessment of TPP efficiency specific fuel consumption per 1 kWh of electricity and/or 1 GCal of heat are usually used. Specific GHG emissions are proportional to them. A factor of proportionality is the emission factor average weighted for different fuel (presented above in this subsection). Thus, specific GHG emissions are not only indicators of environmental impact of a TPP, but also its energy efficiency (under environmental impact influence on the climate change is meant).

When RF was a full member of KP it participated in one of the market mechanisms of GHG emissions regulation on the international arena, i.e. stated in Art. 6 of KP Joint Implementation (JI) projects. JI projects provide a possibility to assign the achieved reduced emissions to a donor partner of the project. Totally 29 JI projects in the energy sector were registered; they underwent an international expertise (determination) and were officially approved in the framework of KP. They provided 40.3 mln tCO_2 reductions. Among them there were 12 projects related to renewable sources and biogas use and 17 projects were connected with the power sector and measures for energy efficiency increase. It is interesting to underline that among those 17 projects there were the ones related to the construction of new TPPs; for them emissions reduction is evaluated according to the substitution of old and low-efficient capacities in the related power system. Other 23 projects are connected with oil extraction and/or associated gas utilization in the energy sector. However, before a new international agreement instead of KP is accepted (which is envisaged by 2020) with participation of the RF, there is no possibility for the Russian companies to participate in JI projects.

CARBON DIOXIDE CAPTURE AND STORAGE TECHNOLOGIES (CCS)

CCS represents a wider spectrum of technologies than announced in its name. They comprise means to mitigate emissions at the stage of fuel pre-combustion, during combustion and not only storage, but also utilization of the captured CO_2 with converting it into products. Detailed classification of CCS methods, their characteristics, possible step-by-step technologies, etc. are available at IPCC web-site [8].

It should be pointed out that all CCS technologies need vast capital investments (plus additional 20…30 % to traditional ones) and their introduction requires high operational costs. As a result the cost of the generated electricity increases more than by 30…40 %. Besides, even most advanced technologies do not reach the wide-spread, commercial and industrial level the way it happened with flue gas desulphurization (FGD) and $DeNO_x$ systems. The rate of assimilation of technologies and their components is presented in Table below [8].

CCS component	CCS technology	R&D	Demonstration	Economically feasible under specific conditions	Mature market
Capture	Post-combustion			X	
	Pre-combustion			X	
	Oxifuel combustion		X		
	Industrial separation (processing of natural gas, ammonia production)				X
Transportation	Pipeline				X
	Shipping			X	
Geological storage	Enhanced oil recovery (EOR)				X
	Gas or oil fields			X	
	Saline formations			X	
	Enhanced coal bed methane recovery (ECBM)		X		
Storage in ocean	Direct injection (dissolving type)	X			
	Direct injection (lake type)	X			
Carbonization of minerals	Natural silicate minerals	X			
	Waste materials		X		

There is a tremendous potential of energy efficiency increase and energy savings in the RF. This obstacle makes CCS technologies, being very expensive, a kind of double economically unreasonable in the coming 10 years. There is no information about plans to implement such technologies at the Russian power companies. The CCS introduction at the time being is possible with participation in international projects. This is hardly realistic without state financial support which is not available.

At the same time in industrially developed countries rapid development and introduction of CCS technologies are under way. Totally there are 75 large-scale pilot and demonstrational CCS projects in different stage of progress. According to [9] in February 2014, 21 installations are in trial and experimental operation which is by half more than in 2011. They are aimed to capture up to 40 mln tCO_2 per year which corresponds to elimination of emissions from 8 mln vehicles.

Investments for the most expensive project constitutes $4,9 bln (Australia, production of synthetic fuel from coal, reductions of emission making 15 mln tCO_2/year, the beginning of the 1st phase – 2011). The world's largest two projects in the power sector are to be realized in the Northern America in 2014. China doubled the number of CCS projects to 12 large-scale installations.

One of the examples of a new CCS projects is presented in Fig. below. High specific capital costs per installed kW of electricity can be emphasized, it is 4.000-5.000 euro which is at least twice higher than for modern coal-fired units.

General outcome: Today in the RF CCS technologies cannot be referred as the best available.

Fig. RWE project: combined cycle GT with brown coal gasification and O_2 capture (2014): блок сушки угля - coal drying unit, кислородная станция - oxygen station, газификатор - gasifier, улавливание CO_2 - CO_2 capture, газовая и паровая турбины - gas and steam turbines. Capacity of 450 MW (330 MW net); efficiency of 35 %, incl. CO_2 transportation and storage. Amount of CO_2 captured makes 2.6 mln tCO_2/year. Capital cost - €1,7 bln (2007), incl. CO_2 transportation and storage.

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