

Carbon budgets in the northern cities

Key words: Anthropogenic impact, fuel and energy balance, carbon emissions and uptake, C budgets, northern cities, carbon-free zone, energy efficiency, modernization, population, the local climate and environment

Anthropogenic impact, including carbon emissions, on the climate change is one of the most relevant scientific and social problems since 1992, when the United Nations Framework Convention was adopted. Kyoto (December 1997) and Paris (December 2015) protocols are ratified by the governments of many countries, are the basis for the implementation of national concepts to reduce carbon emissions. In Russia, it is currently being discussed the issue of creating carbon-free zone in Eastern Siberia.

According to the Ministry of Natural Resources and Environment of Russian Federation, the transition to renewable energy sources, the introduction of carbon taxes, tax benefits, subsidies for the use of best available technologies, the growth of forest plantations and the establishment of a carbon market will contribute to this [3]. They consider the proposal to waive the coal power generation in favor of hydro, gas, nuclear power generation and coal chemistry development [15]. However, modern emission-free technologies (nuclear and hydro generation) is still characterized by high environmental and social risks, and require a significant amount of investment in the environment.

The Republic of Sakha (Yakutia) could become the one of the Russian carbon-free zones in the nearest future. The assessment of carbon emission and uptake by natural environment are actual scientific and practical tasks. The evaluation of carbon emission is available only for particular countries or big cities, in overall, based on national statistics. For Russian regions and settlements carbon emissions data are not available yet due to incomplete information about local fuel and energy complexes.

Fuel and energy complex (FEC) is an inter-branch system of extraction and production of fuels and energy (electricity and heat), their transportation, distribution and use. It is composed of the fuel industry (oil, gas, coal mining) and electric and heat power industry.

FEC of Yakutia is a complex, open system because of the vast territory, the availability of different sources of electricity and heat generation. About 40% of the territory of Yakutia (1222 sq km), where about 85% of the population inhabit, are covered by centralized power supply in the Western (mostly hydro generation), the Central (natural gas, coal) and South Yakut energy districts. Most of the territory of the Republic (60%) with a population of about 150 thousand people apply to the North energy district - the zone of decentralized power supply on the basis of energy sources of low power, mostly diesel power plants (DPP JSC «Sakhaenergo» with a total capacity of 216 MW). It is also being tested renewable energy sources there (solar panels, wind power generation) [11].

The total heat electric capacity of power plants in Central and Southern Yakutia is 2457 Gcal/h. In addition, heat sector includes local boiler houses with relatively small capacity 0,1 Gcal/h to 60 Gcal/h: 1092 boilers (69,9%) – up to 3 Gcal/h; 421 boilers (26,9%) - from 3 to 20 Gcal/h; 42 boilers (3,2%) - from 20 to 100 Gcal/h [13].

The volumes of carbon emissions in Republic of Sakha (Yakutia) were estimated in according with methodology of Intergovernmental Panel on Climate Change (IPCC) [2, 12]. The original data was taken from of Fuel and Energy Balance of the Republic of Sakha (Yakutia). It develops by the Institute of Physical and Technical Problems of the North of the Yakut Scientific Centre of Siberian Branch of the Russian Academy of Sciences, the data are available from 1980 to 2008 [5, 6, 7] (Tab. 1.).

Fuel and energy balance (FEB) is the ratio of production of different types of fuel, power generation (income) and their use in the national economy (expense). Different types of fuel vary in calorific value. Oil and gas have the highest calorific value. In order to calculate FEB, different types of fuel are converted into standard fuel (SF). This method is also applicable for the conversion of heat and electricity power into SF (1 unit of SF has a calorific value of 7000 kcal) [1].

As data shows (Fig. 1) the share of firewood, coal, oil and oil products including gas condensate declined in the structure of internal consumption of fuel and energy in Sakha (Yakutia) in 1980-2008. This is the result of the implementation of the program of gasification of settlements of Yakutia since 2001. In 2000 - 2014, the number of heating plants consuming coal and oil and oil products decreased on 38 % and 37 % respectively. In 2000-2014, the share of boilers gas fueled increased by almost two times, from 16% to 31%. Nevertheless, the share of boilers operating on solid fuel (coal) is still high, in 2000 – 65 %, in 2014 - 54% [8, p. 50].

Since natural gas is giving lower carbon emissions than oil and coal, the effect was obtained in dynamics and structure of FEB. Data shows that the carbon emissions due to anthropogenic sources reduced until 2008 (Fig. 2). State programs of heat sector modernization and energy saving including gasification of settlements of Yakutia made a significant contribution to reducing carbon emissions.

In Yakutia there is competent authority for energy and resource conservation State Budgetary Entity «Regional agency for energy saving» (RAES). The purpose of its creation is to increase the effectiveness of the current State budget expenditures for utilities through the implementation of comprehensive energy conservation measures for optimizing fuel and energy balance (FEC).

According to RAES, as of 2016, the best results for the implementation of energy-efficient measures have been achieved by Neryungrinsky, Ust-Yansky, Namsky districts and Zhatai settlement [4]. In Neryungrinsky, Ust-Yansky districts energy efficiency measures had begun even before coming into force of Energy Efficiency Act.

Tab.1. - Fuel and energy balance of Sakha (Yakutia) in 2008, ths. tons of SF

Indicators	Fuel (sources)						Energy		Total
	Coal	Natural gas	Oil and gas condensate	Oil Products	Fire-wood	Hydro Generation	Electricity	Heat energy	
Production (output) of fuel and energy	10066,8	2189,1	1026,8	20,7	545,0	378,1			14226,5
Import of fuel and energy	27,3	0,0		904,5			18,3		950,1
Export of fuel and energy	-8166,8		-761,9				-125,1		-9053,8
Internal consumption	1927,2	2189,1	265,0	925,2	545,0	378,1	-106,8		6122,8
Output of electrical energy	-842,2	-619,8		-263,3		-378,1	948,3		-1155,1
Output of heat energy	-1085,1	-1554,9	-265,0	0,0	-545,0		-67,3	2339,8	-1177,5
Losses of energy and energy consumption by power plants							-165,9	-166,1	-332,0
Net output of energy (motor fuel)		14,4							14,4
Net output of electrical and heat energy				661,9			608,4	2173,7	3444

Source: Energy strategy of the Republic of Sakha (Yakutia) for the period till to 2030/ Government of the RS (Y). Yakutsk; Irkutsk: Media holding "Yakutia", etc.; 2010. – 328 p.

Fig. 1. - The structure of production (output) of fuel and energy of Sakha (Yakutia) in 1980-2008, %

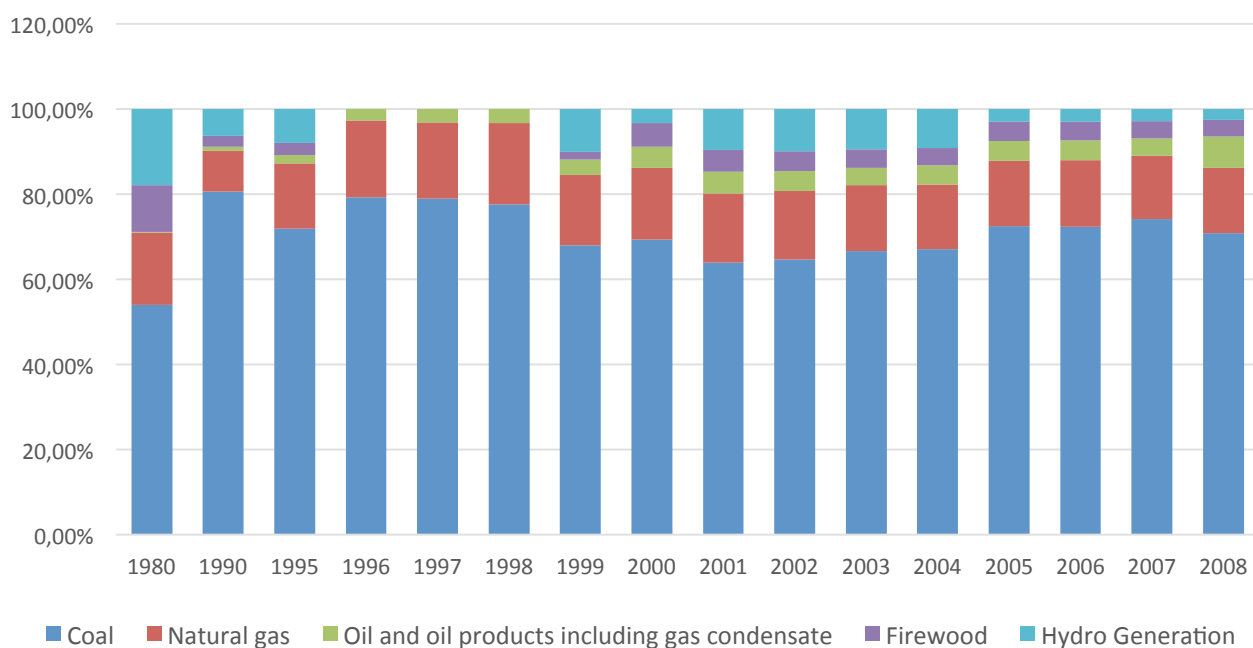
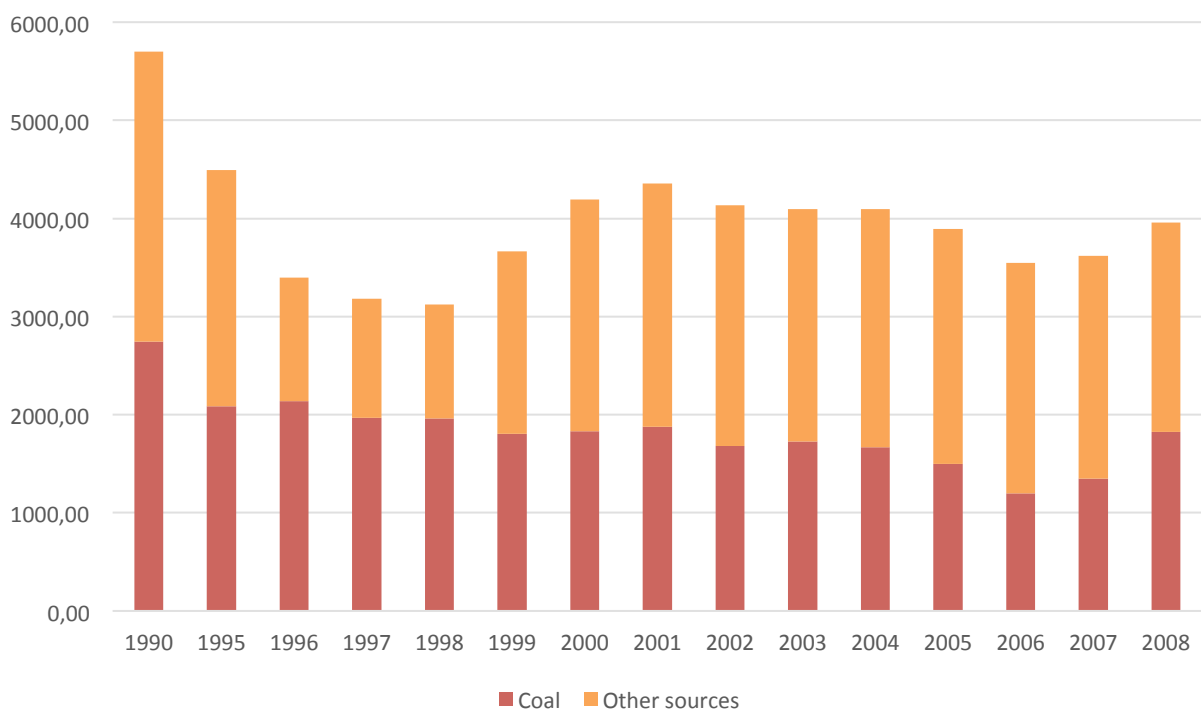


Fig. 2. - C emission from fuel and energy consumption in Sakha (Yakutia) in 1990-2008, ths. tons



Modernization of local energy in Yakutia is currently underway through the implementation of integrated energy service contracts on concession principles. This is one of the successful financial mechanisms for implementation of energy saving measures without the involvement of the budget. The greatest economic effect is obtained by implementation of the set of measures: reduction of building heat loss in the central items; installation of metering devices for electricity, heat and water; automation and dispatching equipment, systems and metering devices; regulation of hydraulics with intelligent automation [14].

In Namsky district energy saving projects are implemented through the mechanism of concessions and energy service agreements (contracts). Especially there are modernized 12 boilers in Namsky district (settlements Appany - 6 boilers, Khamagatta - 5, Grafsky Bereg- 1). As a result of modernization of the boiler in Appany there was: reduction in energy consumption by 46%, reducing gas consumption by 60%, reducing emissions by 55%. For this boiler, the actual gas savings in real terms is equal to 6,515 thousand m³ or 5,212 tons. If we assume that the reduction of greenhouse gas emissions as a result of modernization of each boiler will be 60%, the modernization of all boiler plants in the Republic will reduce carbon emissions to 14,6% (given the input of the boilers to GHG emission) and even more (if converted all boilers to natural gas).

The urban locality Zhatay is already known all over Russia the massive construction of «smart» energy efficient buildings. As of 01.01.2016, 154 contracts were implemented in 265 facilities in the Republic, including 22 apartment buildings, 221 budget institutions, 13 boilers, 4 street lighting systems, and 133 contracts for 348 facilities as of 01.09.2013. Nevertheless, there are factors that constrain the energy service activities, and it are connected, first of all, with the inadequate regulatory and legal framework governing this type of contractual relationship.

During research work of RAES there was modernization of car Toyota Camry, namely the fuel transfer from gasoline to liquefied propane-butane mixture. This event showed the economical and ecological use of the mixture: the in-car gas equipment pays off quickly (cost-effectiveness), carbon dioxide emissions after the event decreased by 22% (environmental friendliness). But in the Far North this fuel cannot be fully used due to the instability of the gas mixture in sub-zero temperatures.

Fig. 3. C emissions per capita (tonnes per inhabitant), world cities - 2008, Yakutia - 2015

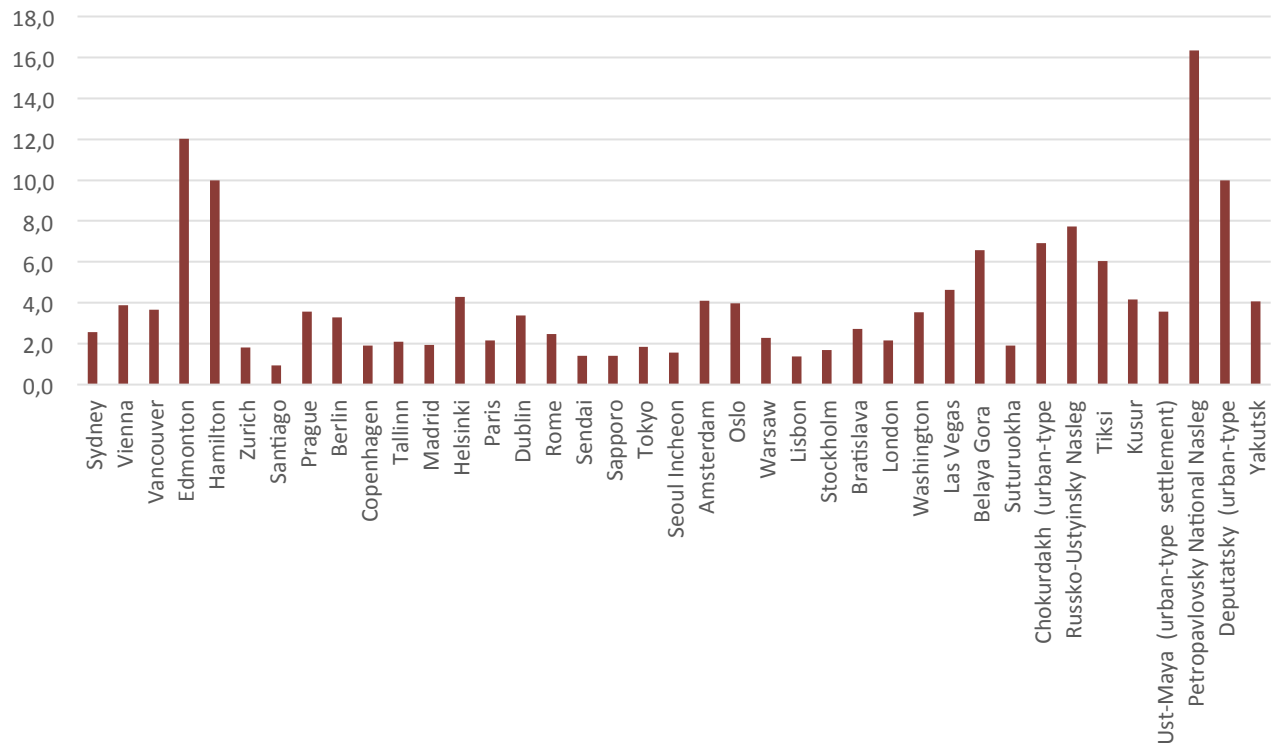


Fig. 4. C Budgets in 2015, t/ha/yr

