Benefits and risks of coal-fired power generation in Siberia in the frame of New industrial revolution and digital economy

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Abstract. New industrialization revolution correlates with new trend – digital economy, and these two novel phenomena will crucially transform society and economy in the XXI century. Power sector is a long-range engine of New industrial revolution and digital economy. Benefits and costs of coal-fired power generation, that is nowadays considered as old-fashioned, dirty and costly, should be transformed in the process of economic development of society to innovative, reliable and environmental-friendly source of electricity. Siberia as vast region of Russia from the Urals up to Pacific Ocean has posses a great energy, industrial and environmental capacity for implementing advantages of new trends. Siberia, in the distant future, cannot suffer a shortage in fossil fuels, especially in coal, which used to be cheap, abundant and transported by the developed energy infrastructure. Cross-disciplinary analysis of coal-fired power generation in Siberia is important for effective response of Russia to new global challenges.

1. Power generation as an engine of new industrial revolution and digital economy

New Industrial Revolution, which started at the beginning of the twenty-first century and, by experts’ assessments [1, 2, 3], will transform modern content of energy generation up to 2040 years by means of implementing advanced technologies for manufacturing energy equipment and involving new materials. Correlating trend of digital economy is driven by widespread of the Internet and development of transmission and distribution networks, automation and computerization of power sector and creates the environment for realizing the capacity of new and conventional sources of energy. The combination of conventional and renewable energy, by the judgement of the influential expert [4], is being transformed in the process of economic development of society, when renewables, i.e. wood, was on the edge of annihilation and non-renewable source of energy, i.e. coal, improved the situation during the First Industrial Revolution. New industrialization and digitalization in the twenty-first century change our judgements about benefits and costs of conventional and renewable sources of energy.

New industrialization revolution correlates with new trend, i.e. digital economy, and these two novel phenomena, according to the forecasting [5,6] will crucially transform society and economy in the XXI century. In scientific discourse there are different interpretation models of New industrialization, i.e. New Industrial Revolution by Marsh P. and Anderson C., Third Industrial Revolution by Rifkin J., Fourth Industrial Revolution by Rose G., Sixth Technology Mode by Glazyev S.U. and Lvov D.S. and other ideas. As it is known, the data in digit forms is used not one decade of
years, but scale and intensive deployment of digital technologies stimulated coming into being of a new type of economy, i.e. the digital economy. On the basis of these new concepts there were developed promising strategies and programmes, which are relevant to the emerging trends. For instance, in Russia there were adopted the National Technology Initiative and Programme of Digital Economy, in Germany Industrie 4.0, in China China Manufacturing 2025, in the EU Digitising European Industry Strategy.

Nowadays power sector is a long-range engine of New industrial revolution and digital economy. Significance of electricity for economic development of countries and regions is growing. The electricity, according to energy forecasting done by BP, MIT Energy Initiative, Energy Research Institute of the Russian Academy of Sciences, will be the dominant final energy carrier up to 2050 year, overcoming even fuels (petrol and others).

Strategy of Russia is to adjust to the New industrial revolution, digital economy and adapt to climate change. Such strategy stimulates the renewable energy acceleration, but renewables are still relatively expensive, out of the mainstream and needs a new energy infrastructure. Siberia, in the projected perspective, cannot suffer a shortage in fossil fuels, which used to be cheap, abundant and transported by the developed energy infrastructure. Cross-disciplinary analysis of alternatives for energy choices in Siberia is important for effective response of Russia to new global challenges [7].

According to the Energy Strategy of Russia up to 2035 year (dated Feb. 1, 2017) the total installed power generation capacity based on renewables is planned to increase from 2,1 GW in 2015 (where solar generation is 0,23 GW and wind is 0,1 GW) up to 10 GW in 2030, where solar generation will be 2,7 GW and wind power will be 4,7 GW. Alas, according to the Forecasting of Science-Technological Development of the Russian Fuel and Energy Complex up to 2035 year, power generation is not prepared to implementing the scenario “Energy Revolution” with using renewables, and at higher degree can follow the evolution scenario, where coal and gas generation prevails. For the transition to the energy of the future it is necessary to comprehend all anticipated benefits and possible costs from the development of conventional and renewable power.

Dilemma of energy choices is urgent for Siberia as vast region of Russia from the Urals up to Pacific Ocean, which has posses a great energy, industrial and environmental capacity for implementing advantages of New industrial revolution. Siberia is closely connected with the Arctic by environment and climate (the taiga, rivers, etc.) and energy capacity (Vorkuta with its coal mines, wind offshore stations in Kamchatka, etc.). Global agenda on climate change makes urgent to seek the balance between abundant conventional sources of energy in Siberia and renewables, that seem to be the real driver of new industrial&digital age and the catalysis of climate change.

In this paper we try to represent the evidence that coal generation can be innovative, reliable and environmental-friendly. Russia can be included in the world top ten producers of coal-fired electricity. Three top coal-fired electricity producers in the world are China, United States and India. And in our country, coal generates 15% of total electricity [10]. Nowadays there are to be constructed 1 199 coal-fired plant in the world. As for our country, 28 projects are supposed to be realized [8]. Coal remains to be one of the key resources of energy and coal stations continue to operate and some more will be built up in the nearest future. But these figures also mean, that coal generation differs profoundly not only between countries, but varies significantly from region to region, especially, when country is big.

In Russia coal power generation is concentrated in Siberian and Far East regions. And new coal plants are supposed to be mostly built there too.

2. Three benefits of coal-fired power generation

2.1. Energy security

It’s no doubt, that for the present even after the shale revolution, coal remains to be the abundant fuel resource in the world [9]. As for Russia, we are the second after the USA by proven coal reserves. Power generation and industry are the main sources of coal demand. More than 60 percent of the coal consumed was used to generate electricity and heat [10]. And this tendency will be only growing. In Russia power generation needs about 30 per cent of coal production [11]. So, it’s twice less than in the world. In our country coal used in power generation will be decreasing. It happens mostly because of
increasing export. More than 30 per cent of coal production is being exported. More than half of this export is currently sold to Europe. But it is expected that the export will be shifted to the Pacific market, especially China.

2.2. Energy independence
Coal reserves are quite equally spread in the world. In 2016, 61 countries produced coal and 104 countries consumed it. Russia is the world’s third largest coal exporter, behind Australia and Indonesia. New coal stations regularly produce electricity without serious blackouts. Electricity generation doesn’t depend on sunshine or wind blowing. Coal power generation can go on in any weather and any climate.

2.3. Innovation activities
Usually innovation processes in energy go hand by hand with the renewables and shale revolution with its new fracking technologies. At the same time, when you look at figure 1, you can see that patent activities rose up significantly in coal generation during the previous years.

![Figure 1. Dynamics of patent applications in coal power generation*](image)

* The search terms: “coal power generation”, the Derwent manual code – X11 “power generation”

Source: author’s estimates based on the Thomson Derwent database

In this current, it will be important to analyze subject areas of patent applications. Two periods are represented at fig. 2 for comparing – the first period is from 2000 to 2005 and the second period is from 2006 to 2014. Most patent applications refer to the wide science subject areas. More than 80 percent of applications in coal generation refer to Engineering. But a significant growth rate of record accounts refer to the specific subject areas such as water treatment, computer science and etc. For example, record accounts rose up in 11 times in polymer science.
In Siberia R&D projects devoted to energy issues are being carried out (Kutateladze Institute of Thermophysics in Novosibirsk, Institute of Coal in Kemerovo, Melentiev Energy Systems Institute in Irkutsk, etc.) and also training courses and education programmes in the field of energy is being put into life (Novosibirsk State Technical University, Siberian Federal University, etc.). Looking at the above-mentioned issues the matter of coal looks quite well but - on the other hand, it was neglected in the world energy discussion, including our country.

3. Three “PPP” shortages of coal-fired power generation

3.1. The first “P” – Politics

The meaning of this “P” varies from country to country and depends on the source of energy. For instance, the construction of nuclear plant depends more on politics than in the case of building coal station. For example, in Germany, after Fukushima, they decided to shut down nuclear plants. And they started to buy coal from USA and build new coal plants. For the present it seems that coal has won but this victory concerns only victory over nuclear.

Though there is another example. Everybody has heard about oil and gas wealth of the Emirates. However at the end of last year they decided to build first clean coal-fired power plant in Dubai. This project has a capacity of more than 1000 MW and it is expected to start to operate by 2020. This decision is aimed to diversify sources of energy. The structure of generating electricity by 2020 should be as follows: gas – 71%; nuclear – 12%; coal – 12%; solar – 5%. The Emirates is shining example of strong political will.

As for Russia the priority of building a new coal station is given to Siberian and Far Eastern regions [12]. According to the General Scheme of Installation of Power Plants up to 2035 year (dated...
June 9, 2017) there is planned to modernize obsolete coal-fired power plants in Siberia (Gusinoozerskaya GRES, Krasnoyarsk GRES, etc.) and deployment innovative coal technologies (Berezovskaya GRES). Special attention is paid to conceptual views upon the strategic development of Siberia.

3.2. The second “P” – Price

The price is a big issue being a twofold one. The first issue means that a new coal fired power plant is capital intensive. It is the fundamental difference between gas and coal plants. More than 50 per cent of levelized costs of coal plant are initial investment, and more than 60 per cent of levelized costs of gas plant depend on fuel. The other side of the price is the operational costs, when a power plant is built and electricity is produced. These costs for coal plant are relatively permanent and low. But the competitive advantage of generating electricity depends on the relations of gas and coal prices [13]. In Russia the ratio of gas and coal prices is approximately one and half times, and in Central Region even lower – about one point three. It means that in Russia gas is one and half times more expensive than coal. In the USA gas is twice times expensive than coal. Relative high price of coal limits its use in Siberia power industry. But to switch from coal to gas generation isn’t an easy matter. If you look at this map you can see that we have very infrequent gas pipelines compared, for example, with the USA. And in European region in Russia where we have a lot of gas plants the density of gas pipelines is very small.

But besides investment and operational costs there are hidden costs of energy, so-called social costs. High efficiency new coal plants are not very expensive for commercial purpose but if we add social costs coal plants would be as expensive as solar or wind. But new coal plants with capture technologies won’t demand significant social costs due to high ecological standards but at the same time they are very expensive for private sector [14].

The first biggest coal plant with carbon capture was launched in 2014 year in the Mississippi state, USA. New plant Southern Co. with 582 MW IGCC capacity and capturing 65 per cent of CO2 produces electricity with operating costs per megawatt hour 8,45 USD, that is times higher for consumers than generated by conventional coal plant. New coal technologies are expensive, because these are innovative technologies, just coming to exist and we need to learn more about them. According to learning curve theory if we build more and more such plants, their costs will go down.

3.3. The third “P” – Pollution

This is the most complicated issue as the burning of coal is connected with the bigger emission into atmosphere than produced by any other sources of energy [15]. Coal generation produces a lot of CO2 emission. Burning coal produces twice more carbon than natural gas. And because of low generating efficiency Russian power sector has the biggest CO2 emission from coal. Building new coal plants with high efficiency can reduce emissions significantly. Plus to that there are fledgling technologies that just coming to exist, so called CCS (carbon capture and storage). These technologies significantly decrease the energy efficiency of the coal plant, but can capture more than 95 per cent of CO2. And capture technologies make coal to be very clean source of energy. Many of emissions of existing Russian power plants are the same for coal generation in other countries. But in several aspects there exists a dramatically big gap. For example, nowadays Siberian coal plants have lower rate of using slag waste. Being compared with China Siberia have a twice less slag waste and at the same time twice lower rate of using it. Only plants with high efficiency can deal with capture technologies, that’s why the first step in introducing these ecological-friendly technologies it’s necessary to provide a substantial growth of energy efficiency of coal stations [16].

The role of coal as the driver of innovative electricity generation for the new industrial development is complicated. On the world industrial agenda, coal continues to dominate global power generation due to it’s nature – significant reserves and well-distributed deposits, stability of production, flexibility of delivery, comparatively easily predicted prices and supply. A significant drawback of coal generation that is connected with the emission of toxic particulars (CO2, sulphur dioxide, nitrogen oxide, etc.) can be eliminated by new technologies, i.e. ultra-supercritical, integrated gasification combined cycle, carbon capture and sequestration. Technological inertia and capital-
intensive innovation processes determine the power generation as industry with medium-low R&D expenditures, which are roughly 1–2% of the net sales of power companies. World strategic innovators in power industry build up the technological trends of coal generation, however, recent public and private spending on R&D represents only a small fraction of capital, needed for wide scaled deployment of new coal-fired power generation technologies. Nevertheless, the intensified international cooperation between the largest coal users such as the USA and China makes quite possible the optimistic scenario for the future of a new coal generation. Education, finance and technology are the main factors of strengthening bilateral or multilateral cooperation. Siberia has obtained up to the moment, by experts judgments, well-educated engineers, valuable traditions of scientific schools and research practice in the field of coal power. That bestows Siberia good premises for making up international technological consortium with other, rich in coal regions, first of all, China and India.

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