# Siberian Energy Industry: Optimizing Its Structure

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**The paper analyzes a structure of the energy industry in Siberia (the Siberian Federal District) though its comparison with Russian and world ones. We show how economic efficiency of large energy producers could change if we allowed for all the social and ecologic costs. We prove that the development of a nuclear power industry is necessarily advisable to be speed up in the territory of Siberia as well as complete modernization of the coal industry, withdrawal of constructing new large hydroelectric plants there and ensuring better security of old ones, and promotion of energy generation by local mini- or micro-power generating systems working on traditional and alternative sources of energy.**

***Key word*: energy resources, atomic power generation, coal generation, hydropower generation, socio-ecological costs**

1. At present an energy balance of any country or large region may be presented by a fuel component (such as coal, oil, gas and etc), and nuclear- and hydropower ones. The more balanced and reasonable a ratio of such components is, the higher the sustainability of an energy system may be.

Any component, in its turn, should be represented by all kinds of producers - large, medium and small ones – with reasonable balance of them as well. Moreover, at any period of time the domination of new technologies or the most recent ones in each component is important. None of such conditions can be observed in Siberian energy industry at present.

Public and private investments into energy industries could serve as a locomotive to “push” regional economies as well as national ones off the crisis. Moreover, they could become a “pushing” factor for the period of economic recovery.

Thus, it is advisable to assess and optimize the economic, social, ecological and technological costs required to develop a nuclear power industry as well as those needed to introduce new technologies into a heat power industry, and those required to ensure sustainable and safe operation of a hydropower industry; the higher share of medium and small enterprises are also considered advisable for all such industries.

The structure of energy production (consumption as well) is presented in the Table 1.

The table is very much illustrative in displaying the dynamics of volumes and structures of energy production over the long run. The last column, which includes our calculations of the present structure of energy consumption in the world, is of our special interest here. As it shows, the world energy consumption in whole is equal to its production (and this is true assuming that the non-energy use and the increments of such resources are neglected). As for Russia and Siberia, their consumption were calculated as the production volumes minus the amounts of both inner and home export-import balances and – in the cases when we succeeded in doing so – minus the non-energy consumption and increments.

As we can see, in Russia a share of coal in energy consumption is twice lower than the world average one while, in Siberia, it is 1,5 times higher. On the other hand, in Russia a share of gas is twice bigger than the world average one whereas in Siberia it is tiny. The share of hydropower in Russia is almost three times greater than in the world in average while in Siberia it is indecently high. However, the atomic power is of the less importance to Russia, and, in Siberia, it is not produced at all.

Of course, each country has its own profile of energy industries. However, the fact, to what degree Russia (Siberia especially) stands out against a background of the world, make us cast doubts on whether the energy sectors in these regions are sound and balanced.

TABLE 1. WORLD PRODUCTION OF ENERGY SOURCES IN 1900-2020
(IN RUSSIA 1990-2020)* (|_ - SFD***)

| Source of energy | 1900 | 1990 | 2000 | 2010 | 2020 | at present**** |
|---|---|---|---|---|---|---|
| Total in the world, ton of equivalent fuel (times) (%) | 1 | 11 (100) | 11.5 (78**) | 14 (89) | 18 (102) | |
| | 100 | 100 | 100 | 100 | 100 | 100 |
| Including:- coal | 56 | 29 (14) | 31 (11) | 33 (13\|75) | 35 (15) | 33 (16\|50) |
| - oil | 2 | 40 (39) | 35 (31**) | 28 (28\|7) | 20 (27) | 28 (22\|17) |
| - gas | 1 | 22 (41) | 22 (49**) | 21 (48\|3) | 21 (45) | 21 (40\|8) |
| - hydropower | 2 | 2.5 (3) | 3 (4) | 3 (4\|13) | 3 (3) | 3 (8\|22) |
| - nuclear power | - | 6.5 (2) | 8 (3) | 10 (4\|0) | 12 (6) | 10 (8\|0) |
| - others (including alternative sources) | 39 | - (1) | 1 (2) | 5 (3\|2) | 9 (4) | 5 (6\|3) |

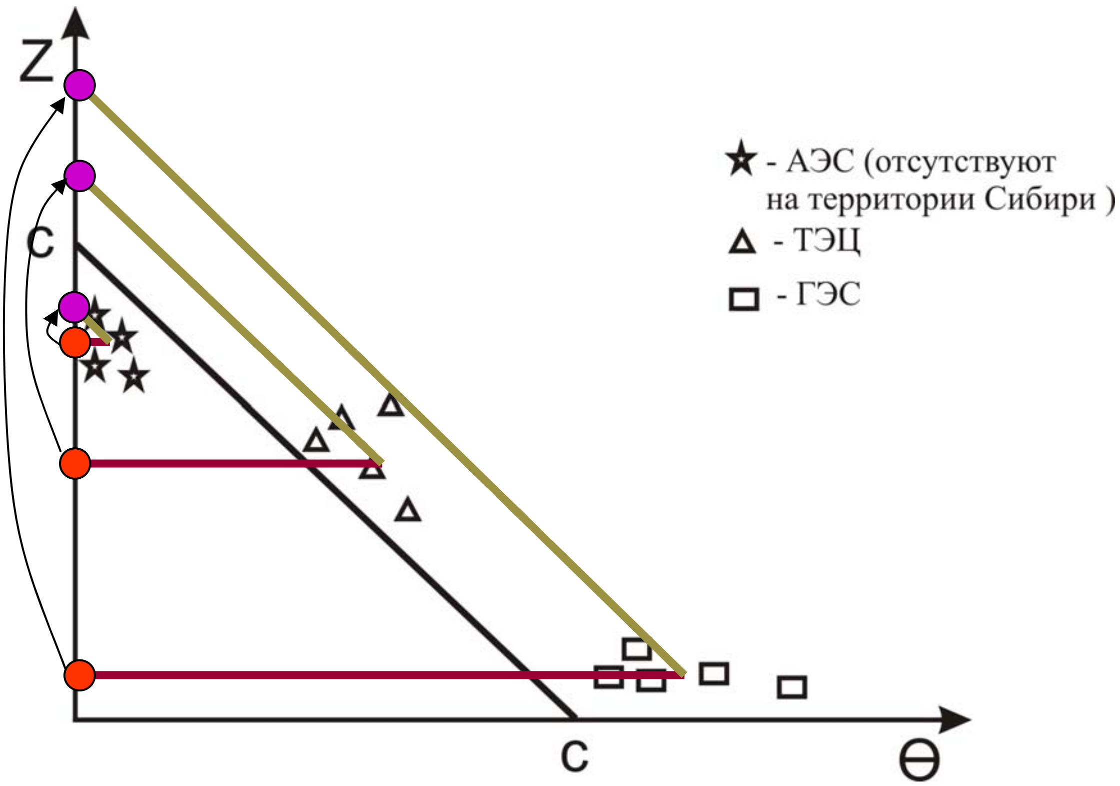
* М.В.Голицын и др. Альтернативные энергоносители. – М.: Наука, 2004. – 159 с.
** updated
*** assessed by IEIE SB RAS
**** consumption, assessed by IEIE SB RAS

If we want to have a structure of energy industries optimized, it is reasonable to rely on actual costs of the energy generated by different sources. Today the share of ecological and social costs (such as compensations and risk insurance) in actual costs is too small. This fact can be illustrated by the Figure 1.

As the figure shows, the atomic power plants has the lowest socio-economic costs per unit since they include practically all such costs into current (economic) expenditures – normally, a price of energy produced includes the construction and maintenance costs made on waste storages and clarifiers. The highest cost per unit is observed at the heat-electric generating plants (please note that here we speak of the large ones located in plains). All this imply that we suffer damage from events such as the transfer of territories with vast and highly productive lands; resettlement of the population; loss of native homes by scores of people - even thousands of them - a price of which is paid by them and which neither is reimbursed to them nor unlikely will be; and the growing losses caused by the climate change. As for coal power generation, the socio-economic costs per unit are also very high (see below) but they are less than those for hydropower generation.

The parity of prices in our country were such that the highest energy price has atomic power plants, and the lowest – hydropower ones. The coal power generation stands in the intermediate position. If all socio-ecological costs were fully included into costs the inverse rating would be observed, but both coal power generation and hydropower one would be economically ineffective.

2. The circumstances were such that there are no atomic plants in Siberia. At that, there are large atomic enterprises of the military industrial complex (those located in Krasnoyarsk, Tomsk, Angarsk and etc.) which positively or negatively have affected the social-economic environment and ecology. The positive effect, as we believe, is that Siberia has accumulated the highly qualified human resources and a science-intensive infrastructure; and the negative one – there are some large nuclear waste burials from atomic weapon production.




- Z – an economic component;
- X – an ecological component;
- Y – a social component;
- Θ = X+Y
- C – a market price of heat-electric power
- C = Z+X+Y
- C = Z+Θ

АЭС- atomic power plant (there is none in Siberia)
ТЭЦ - heat-electric generating plant
ГЭС - hydro-electric power plant

Figure 1. Economic efficiency of the largest sources of heat-electric power in Siberia

We suppose that it is advisable to make, in the coming decades, a share of nuclear power generation high as quick as possible through building the large, medium and small enterprises for the following reasons:

- to have the more sustainable energy system in Siberia; and
- to increase the share of highly skilled workers in energy industries; this, in addition to other advantages, will help significantly reduce ecological risks produced by the nuclear waste burials.

If we want to see the atomic power generation in Siberian attained the Russian average level, it would be reasonable to plan the construction of two atomic plants, each of two gigawatt power supply units. They, in our opinion, may be located in Seversk (Tomsk) and Zheleznogorsk (Krasnoyarsk). To reach for the world average level would mean to build, at least, other two atomic plants of the same power. They could be located in Novosibirsk or Angarsk and somewhere in the Far East. Two more such palnts would allow our position at the high world level.

Our arguments for construction of the atomic plant in Seversk:

FEASIBILITY OF CONSTRUCTION OF ATOMIC STATION IN THE TERRITORY OF THE CLOSED ADMINISTRATIVE-TERRITORIAL FORMATION SEVERSK

1. Tomsk Oblast is historically a “nuclear” region –five commercial reactors have operated at the Siberian Chemical Concern since 1955. There is the highly qualified staff,

personnel training system and infrastructure necessary for operating the atomic plant.

2. There is a necessary construction base which practical experience of construction of large industrial enterprises amounts to decades.
3. The scientific and educational base in Tomsk is so wide that it can provide the training of different specialists including those necessary for atomic industry. (For example, 14 former and current directors for atomic plants or research centers and 13 chief engineers are graduates of the Tomsk Polytechnic University).
4. The atomic plant can operate here with minimal transportation costs as there are basic facilities of a full nuclear fuel cycle beginning with uranium production and ending with waste storage

3. “The coal power generation in Russia at present is an office of the Underworld on the Earth”

Current techniques for assessing the economic effectiveness of enterprises misrepresent a real situation in the coal industry as they do not reflect social damages (such as a high risk of losing labour capacity, health and even death risks, unfavorable impacts on demographic situation, and etc.), and environmental damages (such as the land restoration of open-cast mines and ash dumps, air venting, and etc.).

Today, there is someone who has paid for such damages and will have to sooner or later. Thus, correction of the current legislation is obviously urgent – to make compensatory payments and ecological penalties many times higher or, perhaps, in the tens order (20-30 times), which should be shouldered on the offenders involved in causing harm. This will certainly increase the absolute and relative levels of prices for natural gas, coal, electric energy, heat, and different by-products.

A new equilibrium point may occur completely unacceptable, for example, by the reason of too high prices for energy. To avoid this, introduction of new technologies into all phases of the coal energy production circle– mining, preparation, calibration, processing, transportation and stocking, thermoelectric generation, production of by-products, delivery of heat and electricity to consumers, and land revegetation - is required.

There are such technologies today – the extraction of methane from coal strata; coal gasification; production of water-coal fuels (cavity technologies); coal pipelines; modern methods of fuel combustion (a two-step combustion system and “Fluidized bed” boilers), and depuration of hazardous emission; TERMOKOKS- and SIBTERMO-technologies; and production of a number of products made of ash wastes. Modern technologies of coal conversion allow us to have a wide specter of energy sources as well as many other products – beginning with the aviation kerosine of high quality and combustion gas to humates.

The Table 2 can display the ecological advantages of modern water-coal fuels.

TABLE 2. QUANTITY OF HAZARDOUS SUBSTANCES IN EMISSIONS

| **Hazardous substance in emissions** | **Coal, coal-dust flame** | **Masut M-100** | **Water-coal fuels, “Fluidized bed” boilers** |
|---|---|---|---|
| Dust and smut, g/m3 | 120–240 | 2,5–5,8 | 1,0–2,8 |
| Sulfur dioxide, mg/ m3 | 450–800 | 350–700 | 450–800 |
| Nitrogen peroxide, mg/ m3 | 350–650 | 120–760 | 60-210 |

Water-coal fuels proved to be more economically efficient as it ensures a 5-10% decrease of capital capacity per unit of total capacity and a 25-35% decrease of electricity prime cost (Data source: information of "SibTeploEnergoProekt").

A hydraulic coal mining is one more example of new technologies which was applied before but today - is out of use. This technology was applied by some mines in Kusbass area in the 50-60$^{th}$ of the last century under the auspice of the Russian Research Institute "Hydrocoal" established (Novokusnetsk) and headed by Prof. V Muchnik. These hydromines demonstrated a 2-or 3-fold increase of productivity of labour, and a 30-40% reduction of a prime cost in comparison with traditional mines. They proved to be ecologically friendly and could practically eliminate the methane explosions.

However, the USSR Ministry of Coal Industry did not support this project, the mines were closed, and the project initiators, Prof. Muchnik and his team, left the Institute for IEIE SB RAS.

The tragedy event – the methane explosion at the Mine "Raspadskaya" (Kuzbass area) on the night of the May ninth, 2010 which caused almost a hundred of miner's deaths - would not have happened if this technology had been applied. The project for this mine had already been developed providing for the application of this technology. It was economically reasonable since the mine had to produce the coking coals of high quality and high methane explosion hazard. Nevertheless, the USSR Ministry of Coal Industry again had rejected the project; so the mine had been built as a traditional one. Today we bear the fruits of this decision.

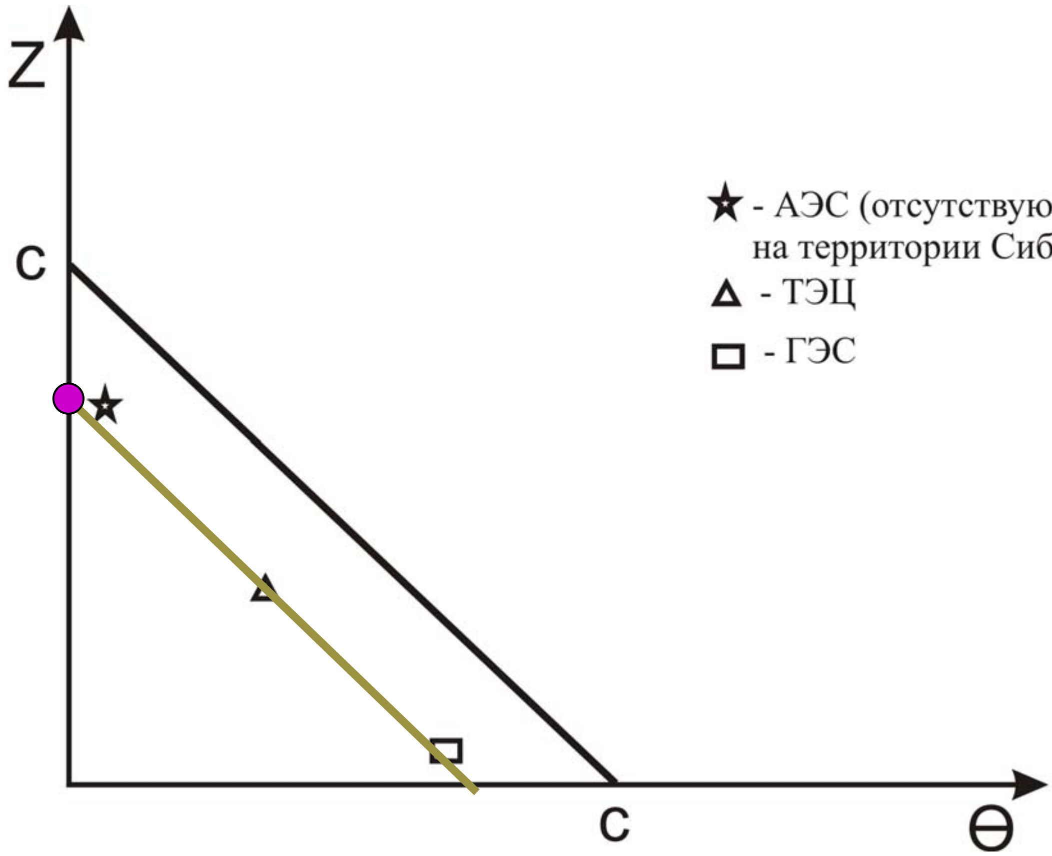
4. A share of hydropower generation in Siberia is excessively high for today; so, to build new hydropower plants especially large ones, as we believe, are hardly reasonable. In our opinion, the construction of the super-hydropower station in the Evenki Autonomus Okrug, should be regarded as criminal negligence since there are no electricity consumers as large as the plant is planning to be; moreover, the ecological impacts may be just catastrophic. The future enlargement of hydropower generation in Siberia may be connected with construction of medium or small hydropower plants in the areas experiencing shortages of electricity such as Altai Republic, Northern Yakutiya, and etc. as they have rather good hydro resources.

The most important problem of the Siberian hydroenergetics is its safety. Depreciation of the large hydropower plants in Siberia, especially those located on Angara and Yenisei rivers is close to 100% (and sometimes even higher). So, to ensure their accident-free operation is the urgent need. This won't cost relatively much, and could be done through both automatatization of the monitoring systems of dams, hydroelectric generating sets, controlling units and etc., i. e. by avoiding a human factor, and building a sound balance of commercial profitability and technologic feasibility.

5. To expect to build an overall heat generation net in Siberia is hardly possible because of its vast territory and a weak communication system as well. However, the largest electric power plants and super-plants dominate in heat generation here. So, to reach higher economic efficiency in the Siberian energetics means to make a share of local heat generation higher, which means, in its turn, to use mini- and micro-heat electric power stations working on both traditional (see Fig. 2) and alternative sources (even the reactors and heating units having served their time at nuclear submarines). Speaking of the alternative sources, we imply the solar and wind stations, the tidal, wave, thermal and heat pumps, straw and turf, wastes of human life, dung and so on. What else could be use for these goals, the mankind is to find out.

The potential of one of the alternative sources of energy – the Sun – is huge.

The world' demand for fuel is 10 billion tons of equivalent fuel. The Sun provides the Earth with energy equivalent to approximately 100 trillion tons of equivalent fuel per year. 3-4% of this energy is consumed by the vegetable kingdom and marine blanket.

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ТЭЦ - heat-electric generating plant
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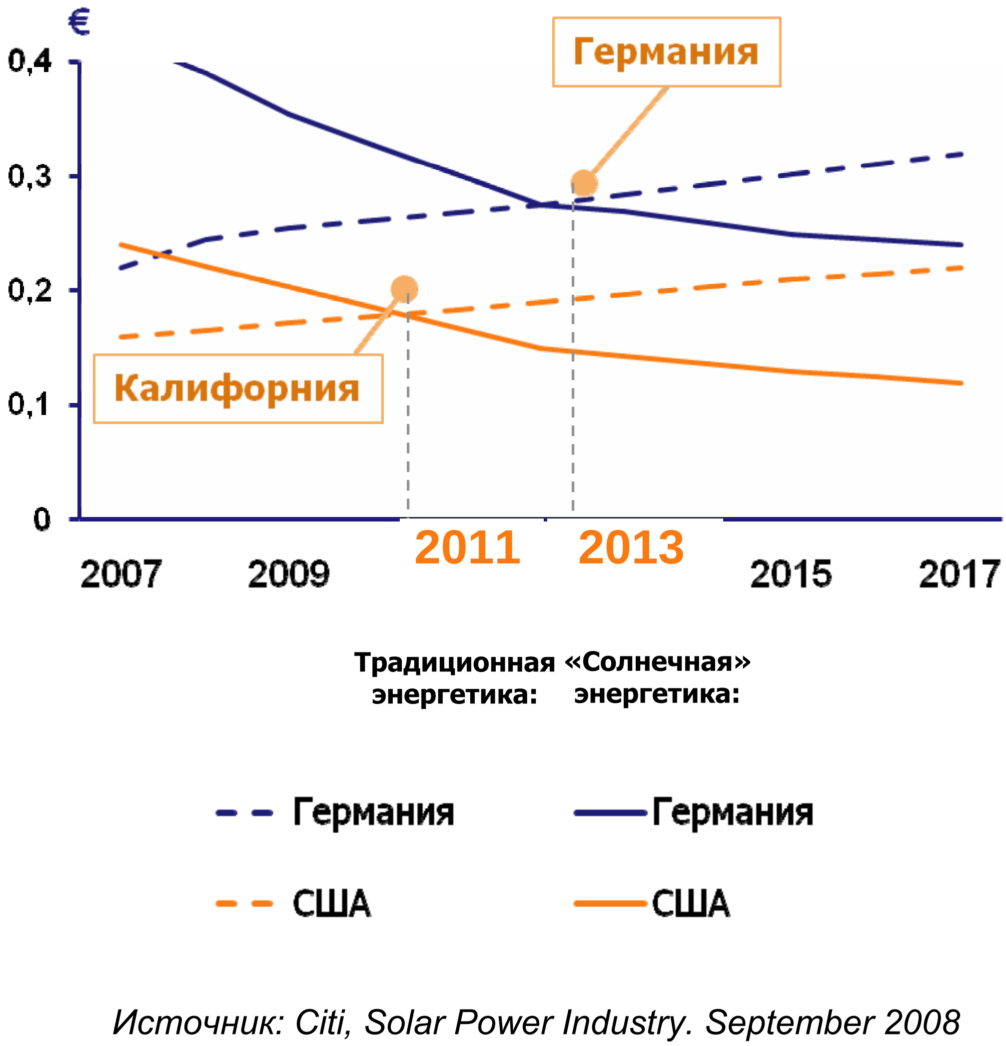
Figure 2. Efficiency of low-power sources of electric energy

The rest goes to maintain the climate, and turns into energy of rivers, waves, winds and etc. According to some estimation, there are 6 trillion tons of different hydrocarbons in the Earth. That means that the Sun could give the same energy to the Earth for three weeks only. At present the mankind consumes per year as much fossil fuels as it was accumulated for a million years. If we managed to use at least 1% of the Sun's energy (1trillion tons of equivalent fuel per year), this would solve the energy problems for next centuries. Theoretically, we already know how to obtain the one percent.

The era of the fossil hydrocarbon fuels will end before the reserves of oil, gas and coal will be depleted (see Fig. 3).

That is why Russia has to sell out its hydrocarbon riches rather intensively together with making preparation to face the energy future with confidence. Russia and especially Siberia have the richest deposits of quartzite of special quality which is good production of "solar silicon" used in modern technologies of the solar batteries production.




Germany California
USA
Traditional energetics: Solar energetics:
Germany Germany
USA USA
Source: Citi, Solar Power Industry. September 2008

Figure 3. Price of electric power, euro/ kW

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