

Environmental Characteristics of Various Methods of Electric Power Generation



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Energetics, being one of the integral and most important components of a human civilization, at the same time, is also the most powerful factor of an adverse effect on the environment at all stages of the fuel cycle from the fuel production to energy use. The Russian fuel and energy complex has been the greatest contaminator of the environment. It produces over 30% of polluted wastewater discharge, approximately 50% of hazardous substances emission into the atmosphere, over 30% of solid waste and up to 70% of the total amount of the greenhouse gases emission.

There was a significant growth in consumption of primary energy resources and electric power over the last 30 years. Current annual consumption of natural resources is 0.0005 from fossil fuel resources (oil, gas and coal altogether) or 0.0003 from uranium resources. However, these exhaustible energy resources in total don't make up even the fifth part of the annual solar energy flux to the Earth, which generates wind energy, hydropower and energy of photosynthesis. After all, there is also enormous geothermal energy of the Earth, large-scale development of which has just begun [1, 2].

Oil, coal and gas, along with the nuclear power, are going to remain main sources of energy within the next few decades. Moreover, the share of the energy production, based on use of hydrocarbons, will remain the largest one. Nevertheless, it is obvious that oil and gas reserves are limited. The prospect of their active use is clear only for a few decades. Power-generating capacities, which use oil and gas, must be replaced by others during this time. There are only two alternatives of the replacement – to use capabilities of either coal power or nuclear power. Up-to-dated technologies of the use of both raw materials will allow to meet the mankind's energy demand for the next hundreds of years.

Compared to coal power, nuclear power is much more attractive in respect of its anthropogenic impact on the environment. Mankind has already exceeded the limit of industrial development capability for the preservation of biological systems sustainability and is on the verge of biosphere's self-destruction [3]. Such environmental threats as the greenhouse effect and irreversible climate change, the ozone layer depletion, acid rains, biodiversity loss and the increase of toxic substances content in the environment require a new development strategy, which will provide coordinated functioning of the economy and ecosystem.

Production, transportation and use of oil, natural gas and coal on the present scale are inevitably associated with a tremendous negative impact on the environment, considering the scope, depth (both in literal and figurative senses) and scale of consequences. Hydropower construction projects almost inevitably cause one or another environmental problem. Even lines of energetics development on the basis of the renewable sources, which are vindicated by the majority of environmentalists, are criticized by other 'greens' as being related to one or another negative impact on environment: wind turbines harm birds, affect landscape views and the like; production of solar panels and their disposal at the end of the operating period are scientifically environmentally hazardous; the ecological compatibility of biofuel, especially of that produced from crop production and forestry, is put in doubt; etc.).

Attempts to overcome the ecological crisis looming large are presented in the UN global program, known as sustainable development program. A sustainable development is the development, which doesn't cause destruction of natural basis of existence and functioning of the entire economy. Environmental impact should not exceed the assimilation potential of the milieu, and regulatory capabilities of the biosphere should not be suppressed. In other words, the transition to the sustainable development means a balanced solution of socio-economic development's issues, meeting the needs of present and future generations, while reducing impacts on the biosphere down to the ecologically permissible limit, which is determined by the adaptive and regulatory capabilities of the biosphere. Under the circumstances, environmentally friendly sources of energy are the basis of such development.

Undoubtedly, nuclear energy is one of these sources. Besides the fact that NPPs (nuclear power plants) do not consume oxygen, do not emit hazardous chemicals into the atmosphere and water, they can save

significant amounts of fossil fuels, reserves of which are rather scant. Particularly, in five most developed countries of the world nuclear power saves up to 440 million tons of coal annually (in Russia – 65.3 million tons), 350 million tons of oil (in Russia – 40.3 million tons), up to 280 milliardcbm of gas (in Russia – 36.8 milliardcbm), prevents combustion of over 450 million tons of oxygen (in Russia – 36 million tons), saves landscapes on the territory of 70 thousand hectares (in Russia – 11 thousand hectares). France is said to be the pollution-free region of Europe, where nuclear power generation exceeds 70% of the total power generation.

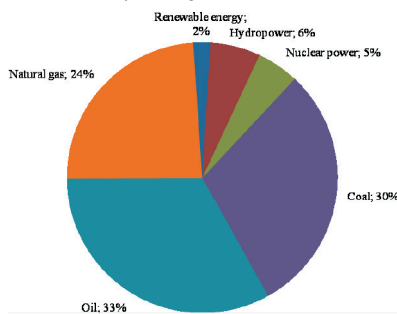
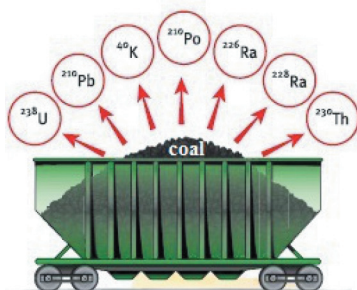


Figure 1. World electric power generation by energy source
Source: BP Statistical Review of World Energy, June 2012

Let us compare the environmental aspects of a number of energy sources.

Coal.

Atmospheric emissions from coal-fired power plants cause the so-called acid rains that damage flora, soil, water reservoirs and, first of all, human health. To estimate the amount of the falling acid rain, imagine one TPP (thermal power plant) with a capacity of 1000 MW, consuming coal with a sulfur content of approximately 3.5 % (despite the use of cleaning agents) and emitting 140 thousand tons of sulfur dioxide into the atmosphere annually; thus about 280 thousand tons of sulfuric acid is being produced. Nitrogen dioxide may cause pulmonary edema. Sulfur dioxide affects the upper air passages. A whole bunch of carcinogens and mutagenic substances is produced as a result of the coal combustion. Nowadays, the annual amount of ash and slag waste from TPPs of the CIS exceeds 120 million tons. Wind raises ash from the surface of the ash disposal area, thus causing dust storms.



The process of the coal combustion results in the radioactive contamination of the environment. Radionuclides, contained in coal (uranium, thorium, radium, polonium-210, lead-210, etc.), are concentrated in the ash during the coal combustion.

The environmental impact of TPPs depends heavily on the type of fuel. The most 'clean' fuel for TPPs is natural gas. However, natural

gas has certain disadvantages. We will not linger round them, since they are widely known. Let us enlarge upon such a source as shale gas, which is produced in the United States on an industrial scale.

There are 5 main environmental problems, related to the shale gas production:

1. Pollution of the aquifers by the highly-toxic substances and of the surface water by the waste water.
2. Methane emissions into the atmosphere.
3. Increase in the radioactive background in the areas of extraction.
4. Probability of causing the earthquakes.
5. Withdrawal of considerable land and water resources from circulation.

Wind energy.

Wind energetics, as any other kind of the human activity, has a negative impact on the environment:

- Alienation of the vast territories (in France, current level of electricity production with the use of wind energy will require 20 thousand km², or 4% of the country)
- Uncontrollability of wind energetics as a source of energy
- Noise pollution (one wind power generator with a capacity of 2-3 MW makes such a noise, that it is necessary to disable it in the night time)
- Interference in air communication, broad- and telecasting, violation of the migration routes of birds (a wind power generator with a capacity of 2-3 MW must have 100 m in rotor diameter)
- Local climate change because of the violation of the natural air circulation
- Posing a hazard to migratory birds and insects
- Alteration of conventional shipping, marine life affection (wind power plants are installed in the aqueous medium in order to save land resources)
- Landscape incompatibility, unattractiveness, visual aversion, discomfort

Solar energy.

ASPP (solar power plant) operation stage is a nonpolluting stage. But there are certain challenges, related to the SPP operation:

- Solar radiation intensity for the midland of the European part is 150 W/m², which is 1000 times less than the heat flux from TPP boilers;

Object	Atmosphere	Hydrosphere	Lithosphere
Fossil fuel TPP	<ul style="list-style-type: none"> · Oxygen consumption · Emissions of chemical compounds, solid particles, radioactive substances, aerosols, etc. · Thermal pollution 	<ul style="list-style-type: none"> · Pure water consumption · Discharges of polluted water · Thermal pollution 	<ul style="list-style-type: none"> · Alienation of the territory · Waste pollution · Landscape changes
NPP	<ul style="list-style-type: none"> · Emissions of gaseous radioactive waste (in case of accident) 	<ul style="list-style-type: none"> · Pure water consumption · Possible discharges of radioactive waste · Thermal pollution 	<ul style="list-style-type: none"> · Alienation of the territory · Burial of waste · Landscape changes
HPP	<ul style="list-style-type: none"> · Evaporation of water from the surface of water storage reservoir 	<ul style="list-style-type: none"> · Change of qualitative and quantitative composition of the river runoff · Change of fishery conditions 	<ul style="list-style-type: none"> · Alienation of the territory · Change of seismicity
Power transmission lines and substations	<ol style="list-style-type: none"> 1. Formation of zones with heightened tension of electromagnetic fields 	<ol style="list-style-type: none"> 1. Formation of zones with heightened tension of magnetic field 	<ol style="list-style-type: none"> 1. Alienation of the territory 2. Disafforestation 3. Stray currents emergence 4. Landscape changes

Table 1. Main environmental effects, caused by power plants

- Alienation of the vast territories and their eventual degradation: a SPP with a capacity of 1 GW and 10% efficiency factor, being located in the midland of European part, requires an area of 67 km², not taking into account the lands under manufacturing enterprises, which produce materials, used for the SPP construction and operation;
- Dim-out of the vast territories because of the solar concentrators;
- High material consumption (time and human resources costs are 500 times more than for the conventional energetics);
- Eventual leakage of the working fluids, containing chlorates and nitrites;
- Overheating and inflammation of the systems, contamination of the production by the toxic chemicals when using solar systems for the agriculture;
- Change of the heat balance, humidity and wind rose within the SPP's site;
- Climatic effect, provided by the cosmic SPPs; transmission of the power from the space to the Earth in the form of microwave radiation, unsafe for the living organisms and the human being.

Biomass.

Adverse effects of the bioenergetics on the environment include:

- Emissions of the solid particles, carcinogens, toxic chemicals, carbon oxide, biogas and bioalcohol;
- Heat emission, change of the heat balance;
- Loss of the soil organic matter, soil depletion and erosion: production of 1000 MW from biogas will require manure from 80 million pigs or 800 million birds and a territory of 80-100 sq.km;
- Explosibility: biogas plants must be verified and kept in order according to the instruction manual
- Great amount of wastes as a by-product (flushing water, distillation residues).

Hydroenergetics.

Nowadays, among all the types of the renewable energy, the hydropower is the only one to make a significant contribution to the worldwide electric power production (17 %). In most highly industrialized countries there are scarce untapped hydropower resources.

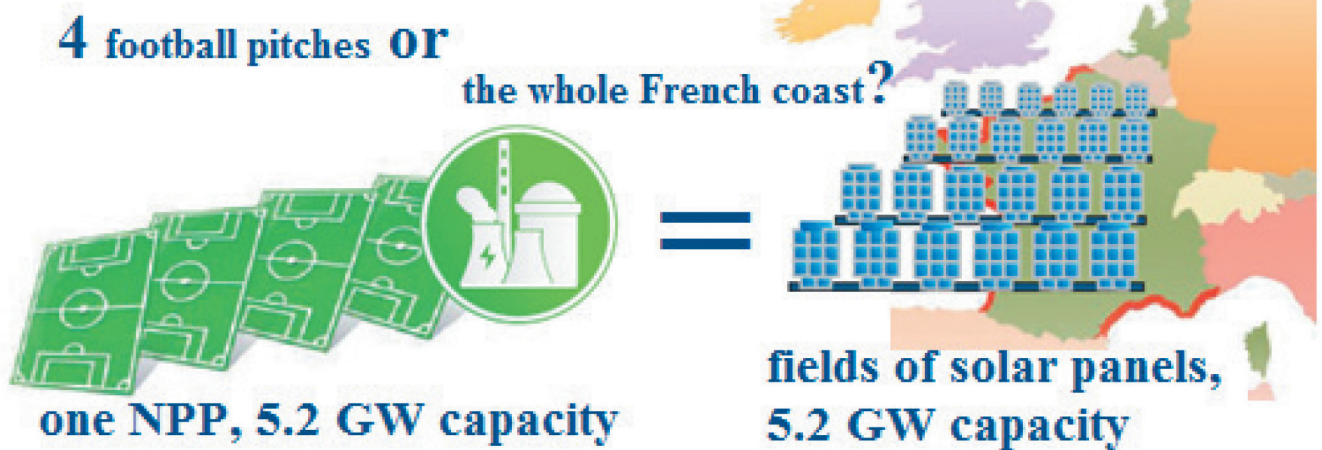


Figure 4. Alienation of the vast territory for SPP

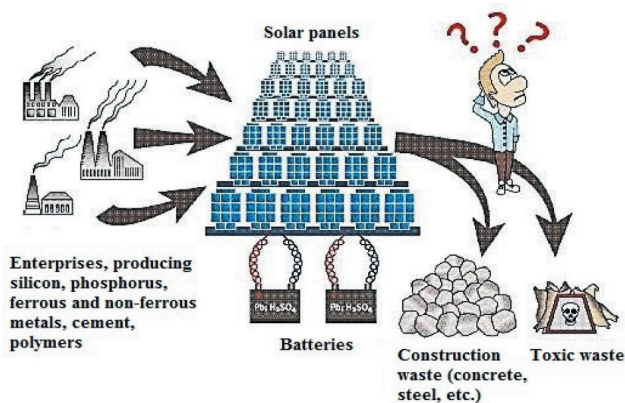


Figure 3. Real waste of solar panels production

Adverse impact of hydropower on the environment mainly comes to:

- Flooding of the agricultural lands and settlements;
- Water imbalance, which alters flora and fauna;
- Climatic impact (change of the heat balance, increase in the rainfall, wind velocity and cloudiness, etc.);
- Reservoir siltation and shore erosion, deterioration of flow waters self-purification and reduction of the oxygen concentration hinder the free passage of fish;
- Hydropower constructions may potentially cause large-scale catastrophes. E.g., the accident at the Morvidam (India) took about 15 thousand lives in 1979, another accident at the Vajontdam (Italy) caused death of 3 thousand people in 1963, and recent accident at the Sayano-Shushenskaya HPP took 75 lives in 2009.

In the view of the above, several general conclusions may be drawn:

1. Oil remains the dominant source of energy on the contemporary stage of the world economy, providing more than 1/3 of the total energy demand, first of all, of the transport sector, although world production of this energy source has increased at a rather low rate (less than 1% a year) in the 21st century; the complexity of the technological exertion (and financial expenditure) for oil production is growing in the new decade.

2. Technical advance in the sphere of the renewable energy sources has achieved rather high growth rates of the green power production (17-19% annually). However, wind, solar, geothermal and other renewable energy sources as yet provide less than 2% of commercial energy supply and are concentrated in a few countries because of the high initial capital intensity. Half of the world renewable energy sources' capacity is owned by four countries – the USA, Germany, China and Spain.
3. The increase in the renewable energy sources consumption is the cold reality of the contemporary world, reflecting the bearing of the leading countries of the world.
4. Global environmental challenges are the CLIMATE, WASTE, PURITY of the AIR and of the GLOBAL OCEAN. Their impact and their amount are increasing, and the compensatory capabilities are impairing. Solution of these global issues requires a tremendous amount of energy, and the energy itself turns into a challenge due to the depletion of energy reserves and its growing threat.
5. Natural gas will remain the main technology for many years during the transition to the full-scale use of environmentally sound renewable energy sources.
6. Development of the renewable energy sources will be based on the innovation, not on the technology of yesterday. In the near future (current century prospect) renewable energy will remain the auxiliary energy source for solution of the local problems.
7. Use of new types of energy creates new environmental impacts, which may alter the environment on both regional and global scale.

Literature

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