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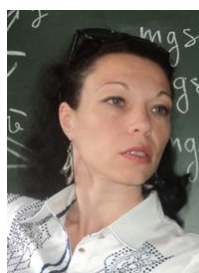
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**SECTION 31. Economic research, finance,
innovation, risk management.**

NUCLEAR POWER IN SUSTAINABLE DEVELOPMENT OF ENERGY INDUSTRY

Abstract: The article deals with the production of nuclear power as a sustainable energy technology, with modern state, advantages, and problems of nuclear industry development, resource provision, as well as global trends in nuclear power industry.

Key words: energy, nuclear power, nuclear reactor, nuclear power plant, sustainable development, uranium.

Language: English

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Introduction

At the modern stage of mankind development the problem of resource-ecological safety of civilization existence has become extremely acute. To a greater extent, the reason for this is the extraction, production and use of energy.

The viability of modern civilization is based on non-renewable processes and is inextricably linked to the ever increasing production and consumption of electricity and various fuels for all kinds of vehicles. Resources of raw materials for their production (oil, gas, coal), no matter how great they now seem, ensure the existence of this civilization without serious political and economic upheavals for about 50 years, not to mention unpredictable changes in the functioning of the biosphere as a whole, local environmental disasters and climate change.

No political and economic reforms will solve the impending problems if they do not have effective energy industry, which is the heart of the economy. It is necessary to develop and implement new principles and methods for obtaining energy without large-scale intrusion into biospheric cycles. It is necessary to change attitudes towards values, in order to stop taking resources from the Earth and future generations practically for free to enrich individual states and people.

The public's relation to natural resources underlies the definition of the sustainability of society. Society can be sustainable if the rate of consumption of renewable resources does not exceed the rate of their recovery.

Advanced nuclear power will release organic resources to meet humanity's needs for chemical energy, clothing, food, building materials, etc.

Stocks of nuclear fuel finding no other application than energy, are sufficient to solve problems of harmonization of human society and the biosphere on the way to its transition to the noosphere without fuss and political tension. In addition, nuclear fuel does not burn, it turns into fission products, among which are valuable for the technogenic civilization nuclides from alkali metals to noble metals and gases.

It is worth noting that nuclear power is now increasingly being considered as a quasi-renewable energy technology. This is due to the fact that the properly organized structure of nuclear fuel in the mode of closing the fuel cycle for actinides (thorium, uranium, plutonium, etc.) can work with constant reproduction and even an increase in the necessary degree of the neutron potential of the system. Fuel resources (uranium) in this case are practically unlimited and in the structure of nuclear power, a system of high-temperature nuclear reactors capable of efficiently producing hydrogen from water can be created.

In a new energy system that is acceptable for long-term and large-scale use, the nuclear power plant can fulfill the role of not only an effective energy source, but also take over the functions to maintain (control) the required level of CO₂ emissions into the atmosphere and the required level of radioactive radiation. And a part of the funds

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received due to taking into account the relevant externalities in organic energy for the sake of extending its life and increasing its own efficiency should be aimed at creating a nuclear fuel corresponding to the needs of sustainable development.

In order the nuclear power to really help humanity to cope with the problems of sustainable supply of energy, it must become large-scale, i.e. it must be multi-component both in reactor types, and in the capacity of single units, and in the degree of autonomy of nuclear power plants.

The sustainability of the nuclear power development is determined by the preservation of the accumulated potential of knowledge, the experimental and theoretical base, technologies and industries.

The world economy is now in a transitional state and the future of civilization, the main wealth of which are people and natural resources, is associated with the transition to a new technological and economic order.

The basis of the global economy should include the global energy that meets the requirements of resistance to various disturbances (natural, political, economic), reliability, security, acceptability (ecological, resource, economic, psychological ...) as an essential element.

Discussion

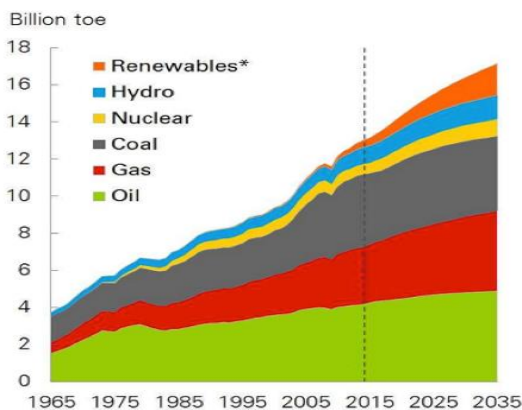
Despite the ongoing debate concerning the nuclear power plants operational risks the development of world nuclear power industry is characterized by positive trends recently. The active construction of new and modernization of existing reactors in many countries evidence it. The nuclear power currently accounts for 11.5% of global electricity and as predicted by the International Energy Agency (IEA), its share will continue to grow. Plans for large-scale development of nuclear energy (especially in certain regions of the world) are due to several reasons:

- increasing demand for energy supply due to the constant increase in population in the world and the rapid industrialization of production;
- increased competition for access to raw materials markets;
- exhaustion of reserves of traditional energy sources and the inevitable rise in their prices, and political instability in countries exporting oil and gas;
- the need to protect the environment in terms of greenhouse gas emissions that are causing "global warming";
- desire to create energy resources independent from external factors.

However, there are objective factors that significantly impede the development of the industry. First of all, these are the accidents at power plants that form negative public opinion and promote the adoption of appropriate policy decisions in the nuclear field. Furthermore, there is a necessity to address safety problems of nuclear power in terms of its impact on people and the environment, as well as problems of spent nuclear fuel.

Since the 2000s nuclear power is at the stage of recovery, largely due to the large-scale construction of nuclear power plants in the countries of the Asia-Pacific region. The world celebrated the accelerated closure of old nuclear power plants, increasing demands on the state and international regulation of safety of the industry. However, the accident at the nuclear power plant "Fukushima" in Japan in 2011 added certain adjustments that negatively affected the projected rate of the industry development. Certainly, fossil fuels (oil, natural gas and coal) continue to satisfy the needs of most of the world, as no other energy source can compete with them in the availability, efficiency and scale. However, among nonfossil fuels the share of nuclear energy in the global energy consumption is predicted to slowly, but growing - from 4.5% in 2014 to 5.2% in 2035 (Figure 1 – Primary Energy Consumption by Fuel, and Shares of Primary Energy).

Primary energy consumption by fuel



Shares of primary energy

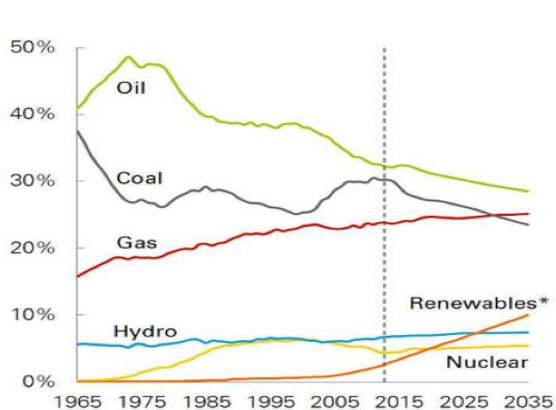


Figure 1 – Primary Energy Consumption by Fuel, and Shares of Primary Energy [from Annual Energy Outlook 2017] [1]

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Recently, the number of requests to the International Atomic Energy Agency (IAEA), particularly from developing countries is rapidly increasing, as for providing them with technical specification for creating energy systems in which nuclear power plays an important role. According to the World Nuclear Association, at March 1st, 2017, globally there have been 447 operating nuclear reactors, 59 reactors under construction, 164 reactors planned for construction and 350 reactors at the stage of proposals to build (Table 1 - Current and Planned Nuclear Reactors in the World). Of the total reactors

in service, 81.5% are light-water-moderated reactors and light-water-cooled reactors, 11.2% are heavy-water-moderated reactors and heavy-water-cooled reactors, 3.4% are light-water graphite-moderated reactors, and 3.4% are gas-cooled reactors. There are also 2 fast liquid-metal cooled reactors. Most nuclear power plants have been launched during the second half of 1960th - beginning of 1980th. Thus the average age of the reactors operating in the world is 28.5 years. And the oldest one is located in Switzerland, and has been operating for 45 years.

Table 1

**Current and Planned Nuclear Reactors in the World
(According to World Nuclear Association) [2]**

Country	Nuclear Electricity Generation 2015 (%)	Reactors Operable 1 March 2017 (No / MWe)	Reactors under Construction 1 March 2017 (No / MWe)	Reactors Planned March 2017 (No / MWe)	Reactors Proposed March 2017 (No/MWe)	Uranium Required 2016 (tonnes)
Armenia	34.5	1 / 376	0 / 0	1 / 1060		88
Belgium	37.5	7 / 5943	0 / 0	0 / 0	0 / 0	1015
Bulgaria	31.3	2 / 1926	0 / 0	1 / 950	0	327
Canada	16.6	19 / 13553	0 / 0	2 / 1500	3 / 3800	1630
China	3.0	36 / 32637	21 / 23086	40 / 45700	139 / 160000	5338
Czech Republic	32.5	6 / 3904	0 / 0	2 / 2400	1 / 1200	565
Finland	33.7	4 / 2764	1 / 1700	1 / 1200	1 / 1500	1126
France	76.3	58 / 63130	1 / 1750	0 / 0	1 / 1750	9211
Germany	14.1	10728	0 / 0	0 / 0	0 / 0	1689
Hungary	52.7	4 / 1889	0 / 0	2 / 2400	0 / 0	356
India	3.5	22 / 6219	5 / 3300	20 / 18600	44 / 51000	997
Japan	0.5	42 / 39952	2 / 2756	9 / 12947	3 / 4145	680
Korea RO (South)	31.7	25 / 23081	3 / 4200	8 / 11600	0 / 0	5013
Russia	18.6	35 / 26865	7 / 5904	25 / 27755	23 / 22800	6264
Saudi Arabia	0	0 / 0	0 / 0	0 / 0	16 / 17000	0
Slovakia	55.9	4 / 1816	2 / 942	0 / 0	1 / 1200	917
South Africa	47	2 / 1830	0 / 0	0 / 0	8 / 9600	304
Switzerland	33.5	5 / 3333	0 / 0	0 / 0	3 / 4000	521
Turkey	0	0 / 0	0 / 0	4 / 4800	4 / 4500	0
Ukraine	56.5	15 / 13107	0 / 0	2 / 1900	11 / 12000	2251
UAE	0	0 / 0	4 / 5600	0 / 0	10 / 14400	0
United Kingdom	18.9	15 / 8883	0 / 0	4 / 6100	9 / 11800	1734
USA	19.5	99 / 99535	4 / 5000	18 / 8312	24 / 26000	18161
WORLD	c 11,5	447 / 391,942	59 / 63,420	164 / 170,844	350 / 395,300	63,404

Recently nearly half of nuclear reactors in the world operate beyond designed service life. However, according to the International Atomic Energy Agency it is planned to extend the service life of 112 units. As an international experience corroborates, the extending designed service life of power units is caused by economic expediency and provides the required security level. According to the

World Nuclear Association, in 2016 [3] the first place in nuclear electricity production is occupied by the USA, France, and China. Besides, the structure of total electricity production in nuclear power accounted for a large proportion in some countries, thus in France - 72.3 %, Slovakia - 54.1 %, Ukraine - 52.3 %, Belgium - 51.7 %, Sweden - 40.0 %.

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Table 2

Nuclear Share of Electricity, by Countries (According to World Nuclear Association) [3]

Country or area	Nuclear share of electricity (%)											Nuclear electricity production (billion kWh)	
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2015	2016
Armenia	42.0	43.5	39.4	45.0	39.4	33.2	26.6	29.2	30.7	34.5	31.4	2.6	2.2
Belgium	54.4	54.1	53.8	51.7	51.1	54.0	51.0	52.1	47.5	37.5	51.7	24.8	41.3
Bulgaria	43.6	32.1	32.9	35.9	33.1	32.6	31.6	30.7	31.8	31.3	35.0	14.7	15.8
Canada	15.8	14.7	14.8	14.8	15.1	15.3	15.3	16.0	16.8	16.6	15.6	95.6	97.4
China:													
- Mainland	1.9	1.9	2.2	1.9	1.8	1.9	2.0	2.1	2.4	3.0	3.6	161.2	210.5
- Taiwan	19.5	19.3	17.1	20.7	19.3	19.0	18.4	19.1	18.9	16.3	13.7	36.5	30.5
Czech Rep	31.5	30.3	32.5	33.8	33.3	33.0	35.3	35.9	35.8	32.5	29.4	25.3	22.7
Finland	28.0	28.9	29.7	32.9	28.4	31.6	32.6	33.3	34.6	33.7	33.7	22.3	22.3
France	78.1	76.9	76.2	75.2	74.1	77.7	74.8	73.3	76.9	76.3	72.3	419.0	384.0
Germany	31.8	25.9	28.3	26.1	28.4	17.8	16.1	15.5	15.8	14.1	13.1	86.8	80.1
Hungary	37.7	36.8	37.2	43.0	42.1	43.2	45.9	50.7	53.6	52.7	51.3	15.0	15.2
India	2.6	2.5	2.0	2.2	2.9	3.7	3.6	3.5	3.5	3.5	3.4	34.6	35.0
Japan	30.0	27.5	24.9	28.9	29.2	18.1	2.1	1.7	0	0.5	2.2	4.3	17.5
Korea, S	38.6	35.3	35.6	34.8	32.2	34.6	30.4	27.6	30.4	31.7	30.3	157.2	154.2
Mexico	4.9	4.6	4.0	4.8	3.6	3.6	4.7	4.6	5.6	6.8	6.2	11.2	10.3
Netherlands	3.5	4.1	3.8	3.7	3.4	3.6	4.4	2.8	4.0	3.7	3.4	3.9	3.8
Pakistan	2.7	2.3	1.9	2.7	2.6	3.8	5.3	4.4	4.3	4.4	4.4	4.3	5.1
Romania	9.0	13.0	17.5	20.6	19.5	19.0	19.4	19.8	18.5	17.3	17.1	10.7	10.4
Russia	15.9	16.0	16.9	17.8	17.1	17.6	17.8	17.5	18.6	18.6	17.1	182.8	179.7
Slovakia	57.2	54.3	56.4	53.5	51.8	54.0	53.8	51.7	56.8	55.9	54.1	14.1	13.7
Slovenia	40.3	41.6	41.7	37.9	37.3	41.7	36.0	33.6	37.2	38.0	35.2	5.4	5.4
South Africa	4.4	5.5	5.3	4.8	5.2	5.2	5.1	5.7	6.2	4.7	6.6	11.0	15.2
Spain	19.8	17.4	18.3	17.5	20.1	19.5	20.5	19.7	20.4	20.3	21.4	54.8	56.1
Sweden	48.0	46.1	42.0	34.7	38.1	39.6	38.1	42.7	41.5	34.3	40.0	54.5	60.6
Switzerland	37.4	40.0	39.2	39.5	38.0	40.8	35.9	36.4	37.9	33.5	34.3	22.2	20.3
UK	18.4	15.1	13.5	17.9	15.7	17.8	18.1	18.3	17.2	18.9	20.4	63.9	65.1
Ukraine	47.5	48.1	47.4	48.6	48.1	47.2	46.2	43.6	49.4	56.5	52.3	82.4	81.0
USA	19.4	19.4	19.7	20.2	19.6	19.2	19.0	19.4	19.5	19.5	19.7	798.0	805.3
TOTAL												2441	2490

It is assumed that in 2050 nuclear capacity will be about 1 200 GWh, providing 24% of the world electrical supply. The growth of nuclear power is possible due to the rapid transition to standard reactors of the 3rd and 4th generations, as well as to the fast neutron reactors. It will solve the problem of uranium ore security as well as the problem of spent fuel, and increase economic performance and safety of nuclear power plants. It is worth noting that at the plants measures to improve safety taking into account the lessons of the accident at the nuclear power plant "Fukushima" are constantly being provided. The basic element for strengthening

nuclear security infrastructure pursued by countries and other relevant organizations is the IAEA Action Plan on Nuclear Safety [4].

Recently, nuclear power plants are operating in more than 30 countries in the world, and 30 more countries plan to build new nuclear power plants in the near future. The largest number of nuclear power plants is planned to be built in Asia, particularly in China and India. China is considering nuclear energy as an important part of its long-term strategy, seeking to achieve sustainable economic development and the reduction of CO₂ emissions. Most of operating power plant units in China are based on nuclear

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technologies from France, Canada, Russia and the USA. Thanks to its experience in the safe and reliable operation of nuclear power plants, and due to testing new reactors of the third generation China may become a global player in the market of nuclear technologies. It is noteworthy that China invests costs in the construction of nuclear power plants all over the world. Thus, the country invests \$ 9 billion in nuclear power plant construction (Hinkley Point) in the UK, also the Chinese company China National Nuclear Corp. invests \$ 14 billion in construction of the 4th and 5th nuclear power plant units in Argentina. On 22 July 2015 Beijing and Tehran signed an agreement to build two nuclear power plants on the southern coast of Iran. Given the success of Beijing on the Iranian market, China can overtake Russia and become its main competitor in Middle Eastern markets. The similar situation is in India, where the share of nuclear energy by 2030 is going to be increased more than in 7 times, i.e. to about 40 GW, that will bring the proportion of nuclear energy in the state energy balance to 25%. The experience of Russia where it is planned to build 25 new nuclear units in the near future is important as well. All the 33 units recently working in the country are the so-called open cycle reactors; as the results of their operation radioactive wastes are accumulated. This problem can be solved completely by introducing a new type of reactors that are closed cycle reactors.

A special attention should be given to development of nuclear industry in the EU. In fact, nuclear power, despite the disaster at the Japanese nuclear power plant "Fukushima" is regarded as an ecological source of energy along with renewable energy sources. The importance of nuclear energy is seen in the decisions on the European level accepted by the need to reduce greenhouse gas emissions by 20 % until 2020 [5].

Today, nuclear energy is the most in Bulgaria, Finland, Czech Republic, Slovenia, Sweden, Belgium, Hungary, Slovakia and France. In these countries the share of nuclear power is 32-77 %. Among the EU countries France is the largest nuclear power state, and it is the second in the world after the United States as for the number of active reactors. The country, despite the consequences of the disaster in Japan continues both quantitatively and qualitatively to increase nuclear energy capacity. The first nuclear power plant in France was built in 1956, but only after the oil "shock" in 1970s its nuclear power gradually took the leading place. And a special law adopted on 13 July 2005, assigned to nuclear power the status of the main sources of energy in the country. Due to the end of the lifetime of most nuclear power plants in 2020, the country gradually updates the equipment and actively implements the program of building new generation reactors meeting the requirements of economic

competition, environmental protection and increased security.

The country that radically changed the vector of nuclear power development among the developed countries of the EU is Germany. On March 14, 2011, the Chancellor Angela Merkel announced a review of safety standards for German nuclear power plants, and that date is the beginning of a radical change in the development of nuclear energy in Germany. Then the Ethics Commission for a Safe Energy Supply was established, which recommended the country to implement the withdrawal from nuclear power till 2021 and to stop the units. Thus, Grafenrheinfeld Nuclear Power Plant had to be stopped in 2015; Gundremmingen B – in 2017; Phillipsburg 2 – in 2019; Gundremmingen C, and Brokdorf – in 2021; Isar 2, Emsland, and Neckarwestheim – in 2022.

In May, 2011 the government of Switzerland also announced the decision to stop all the units of nuclear power plants in the country till 2034, and not to build the new ones.

The situation in the Eastern Europe is quite opposite. According to available forecasts Poland, Romania, Czech Republic, Slovakia, Bulgaria, Slovenia and Lithuania in certain circumstances can become engines of "nuclear renaissance" in the EU, and the construction of new nuclear power plants would solve several major problems: to get the relatively inexpensive electricity in large volumes, to achieve set environmental standards and to ensure energy security. In May 2014 The European Commission has adopted a new Energy Security Strategy [6]. The development of nuclear energy as key elements of the EU Strategy included:

- Research and development support within the Framework Program "Horizon 2020", including the question of nuclear waste;
- Creation of nuclear energy forum with the participation of all relevant social stakeholders to implement dialogue on the opportunities and risks of nuclear energy;
- Research of 4th Generation Reactors that use less resources and produce less waste.

In December 2015 in Paris during the 21st Session of the Conference of the Parties (COP) of UN Framework Convention on Climate Change [7] the nuclear energy was:

- recognized as a low carbon energy option;
- included alongside other low-carbon technologies to the funding to prevent climate change.

Nuclear fuel production is a complicated, multistage and long process that consists of the following stages: extraction of uranium ore conversion, isotopic enrichment, production. The main uranium (97 %) is concentrated in 16 countries, including Australia - 1 706.1 thousand tons, Kazakhstan - 679.3 thousand tons and Russia - 505.9 thousand tons [8]. Stocks of these three countries

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account for 50 % of the world's (Table 3 Resources of Uranium).

Table 3

Resources of Uranium [9]

	tonnes Uranium	percentage of world
Australia	1,664,100	29%
Kazakhstan	745,300	13%
Canada	509,800	9%
Russia	507,800	9%
South Africa	322,400	6%
Niger	291,500	5%
Brazil	276,800	5%
China	272,500	5%
Namibia	267,000	5%
Mongolia	141,500	2%
Uzbekistan	131,100	2%
Ukraine	115,800	2%
Botswana	73,500	1%
USA	62,900	1%
Tanzania	58,100	1%
Jordan	47,700	1%
Other	232,400	4%
World total	5,718,400	

All the 447 reactors currently operating in the world, annually consume about 65 thousand tons of uranium. Statistics provided by the World Nuclear Association, assures that the global annual uranium mining increases every year, and in the past few years an average mining is about 58 thousand tons i.e. about 87 % of current world demand. The rest of

this raw material is supplemented by stocks (uranium conversion), spent fuel, and imports. The leading uranium miners nowadays are Kazakhstan (39 % of world supply from mines in 2016), Canada (22 %) and Australia (10 %) (Table 4 Production from Mines).

Table 4

Production from Mines (Tonnes U) [10]

Country	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Kazakhstan	6637	8521	14020	17803	19451	21317	22451	23127	23800	24575
Canada	9476	9000	10173	9783	9145	8999	9331	9134	13325	14039
Australia	8611	8430	7982	5900	5983	6991	6350	5001	5654	6315
Niger	3153	3032	3243	4198	4351	4667	4518	4057	4116	4300
Namibia	2879	4366	4626	4496	3258	4495	4323	3255	2993	3315
Russia	3413	3521	3564	3562	2993	2872	3135	2990	3055	3004
Uzbekistan (est)	2320	2338	2429	2400	2500	2400	2400	2400	2385	2404
China (est)	712	769	750	827	885	1500	1500	1500	1616	1616
USA	1654	1430	1453	1660	1537	1596	1792	1919	1256	1125
Ukraine (est)	846	800	840	850	890	960	922	926	1200	1005
South Africa	539	655	563	583	582	465	531	573	393	490
India (est)	270	271	290	400	400	385	385	385	385	385
Czech Republic	306	263	258	254	229	228	215	193	155	138
Romania (est)	77	77	75	77	77	90	77	77	77	50
Pakistan (est)	45	45	50	45	45	45	45	45	45	45

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Country	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Brazil (est)	299	330	345	148	265	326	192	55	40	44
France	4	5	8	7	6	3	5	3	2	0
Germany	41	0	0	8	51	50	27	33	0	0
Malawi			104	670	846	1101	1132	369	0	0
Total world	41 282	43 764	50 772	53 671	53 493	58 489	59 331	56 041	60 496	62 850
tonnes U₃O₈	48 683	51 611	59 875	63 295	63 084	68 976	69 969	66 089	71 343	74 119
% of world demand*	64%	68%	78%	78%	85%	86%	92%	85%	90%	99%

According to the World Nuclear Association [10], in 2015 11 companies marketed 89 % of world's uranium mine production.

Table 5

Uranium Mining Companies [10]

Company	tonnes U	%
KazAtomProm	12681	21
Cameco	10926	18
Areva	9368	15
ARMZ - Uranium One	7849	13
CNNC & CGN	3303	5
BHP Billiton	3161	5
Rio Tinto	2757	5
Navoi	2385	4
Paladin	1435	2
Other	6631	11
Total	60,496	100%

The world price of uranium ore from the mid-1970s remains relatively low. However, in general, the uranium price is significantly volatile. The main factors that can influence changes in prices of uranium ore are:

- the difference between production and consumption. Today, the world demand for raw materials for nuclear fuel production exceeds uranium mining. The difference is covered with recycled materials inventory depletion which by increasing global demand could lead to a dramatic shortage of uranium ore and as a result to a jump in prices; limited stocks of uranium. Given the growing demand for uranium in several countries intending to build nuclear reactors can be concluded that in the next century the world's uranium ore reserves are on the verge of exhaustion that impact its price;

- construction of new nuclear power plants. The extensive construction of new nuclear power plants increases the demand on uranium fuel;

- closed uranium market. The structure of the uranium market is very specific. If the majority of metals have stock prices, 90 % of uranium ore is sold under long-term contracts between suppliers and consumers. Only 5-8 % of the uranium ore consumed at power plants is sold in the so-called spot market;

- change in the US dollar rate. The market price for uranium is calculated as the ratio of 1 \$ per 1 pound. Accordingly, changes in the US dollar rate would change the world market price of uranium;

- uneven distribution. Uranium ore uneven distribution factor plays an important role in uranium pricing. The existence of regions with different densities of uranium ore occurrence leads to a specific demand and supply of uranium. Detection of new deposits and the depletion of old ones leads to changes in the market situation, which, in turn, affects the dynamics of price movements.

- transition to the new technology. The transition to the new fuel cycle technology that allows the use of spent fuel without additional chemical treatment can dramatically change the dynamics of prices for uranium. However, the extensive use of these technologies will become possible about 2020 and complete restructuring of modern system of nuclear power will cause huge material costs;

- force majeure. One of the clearest examples of the impact of force majeure on uranium market is an accident on October 22, 2006 which caused flooding of Canadian mine Cigar Lake. This led to a

Impact Factor:

ISRA (India) = 1.344	SIS (USA) = 0.912	ICV (Poland) = 6.630
ISI (Dubai, UAE) = 0.829	PIHHI (Russia) = 0.234	PIF (India) = 1.940
GIF (Australia) = 0.564	ESJI (KZ) = 3.860	IBI (India) = 4.260
JIF = 1.500	SJIF (Morocco) = 2.031	

sharp drop in uranium mining and a sharp jump in prices.

Since the mid 1990s the price of U_3O_8 was about \$ 10 per pound. From the early 2000s the price gradually increased and by the end of 2004 rose to \$ 20 per pound of uranium concentrate. During 2005

the price on spot contracts increased from \$ 20 to \$ 35. In 2006 the growth continued and till the end of the year the level of \$ 60 was reached. Then there was an increase from \$ 75 to over \$ 135 per pound (Figure 2 - U_3O_8 spot price).



Figure 2 - U_3O_8 spot price [11]

The rapid rise in prices since mid-2006 reflected consumer concerns regarding lack of raw materials. There was a significant reduction in production in many mines: Canadian McLean Lake (Areva and Cameco) and Rabbit Lake (Cameco), the Namibian Roessing Mine (Rio Tinto), Australian Olympic Dam (BHP Biliton) and Ranger (Energy Resources of Australia). Reduced uranium demand and the incine in the demand increased fears of fuel shortages in the medium term and led to explosive growth in spot price for uranium. At the moment the market price of uranium is calm, but given the market development in the medium term, the world's largest manufacturers have already started implementing a number of projects to increase uranium production. And the success of these projects will influence the dynamics of uranium prices in the near future.

Conclusions

Having analyzed the general trends of the global nuclear power industry, the following can be concluded:

- ambitious plans to build nuclear facilities (mainly in China, India, South Korea and Russia) indicate the expansion of its presence in the global energy sector for the foreseeable future;
- despite certain environmental risks associated with nuclear safety, it could take appropriate competitive position in the energy sector,

in most cases due to the relatively positive technical and environmental performance;

- price of nuclear energy is less dependent on external factors compared to hydrocarbon sources of energy;
- development of nuclear power in the world is stimulated by the possibility of dual-use of nuclear materials (for power and weapons of mass destruction);
- nuclear energy is a low-carbon and efficient in terms of costs.

However, despite the obvious objective benefits of the use and development of nuclear energy in general and problems remain, including waste disposal (especially high and radioactive) that complicate further development of this nuclear power industry. Today, there are solutions to these problems, but in most countries consensus on this issue has not been reached yet. Consequently, the uncertainty of the leadership of several countries on the development of nuclear power, a limited supply of information to the public on the pros and cons of nuclear energy, and disturbance as for the inability to prevent the consequences of possible nuclear accidents cause distorted public perception of nuclear energy in general and power plants in particular, and thus inhibit the development of nuclear power engineering.

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