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GLOBAL ENERGY-ECOLOGICAL REVOLUTION OF THE 21ST CENTURY

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INTRODUCTION

At the outset of the 21st century a global civilization has faced new challenges threatening future of the humanity. The world is struck by waves of energy and ecological crises which in resonating have given rise to a new phenomenon — ***global energy-ecological crisis***. Surmounting the crisis may only be through a global energy-ecological revolution. Its result will be the formation of a ***noospheric energy-ecological mode of production*** which will first establish itself in the vanguard civilizations then transforming the look of the entire planet. All these fundamentally new phenomena and processes require an in-depth scientific conceptualization, identification of their objective basics and tendencies, working out scenario-based forecasts and a global energy-ecological strategy. Such energy-ecological strategy would permit to overcome dangers of the energy-wasteful and ecologically hazardous mode of production and consumption of the industrial period based on the partnership among civilizations in the face of new threats to stop on the edge of the gulf and enter the path of the creation of such noospheric civilization. One of major elements of such civilization will be a noospheric mode of production and energy-saving style of life of the billions of people.

The Russian scientists have been concerned about the imminent threats and designing the ways to surmount them. N.N. Moiseyev elaborating on a theory of noosphere constructed by V.I. Vernadsky has offered his vision how a present-day ecological imperative will be implemented [1]. In the two volume treatise 'Civilizations: Theory, History, Dialogue and the Future' the role of natural-ecological cycles and crises was dealt with in the evolution of civilizations, disclosed the major outlines of the noospheric civilization and directions of partnership among civilizations were grounded in its building up [2]. The work 'Rent, Anti-Rent, Quasi-Rent in a Global Civilizational Dimension' done based on materials of the World Summit for Sustainable Development (Johannesburg, 2002) has introduced such notions into the scientific usage as the energy sector and energy rent, demonstrated the opportunities to apply a geo-civilizational macro model for analysis and forecasting dynamics of the energy sector [3]. The long-term forecasts 'Russia-2050: Strategy of Innovative Breakthrough' [4] and 'Integral Macro Forecast of Innovative-Technological and Structural Dynamics of Economy of Russia for a Period Up to 2030' [5] determine the prospects for the energy sector development in Russia in the context of world tendencies. The treatise 'Russia: Strategy of Transition to Hydrogen Energy' discloses the essence of a global energy-ecological crisis of the beginning of the 21st century, addresses the prospects of conversion to hydrogen fuel and fuel cells in the world and in Russia as one of alternative sources of energy, validates the project of the national scientific-innovative program 'Hydrogen Energy' for a period up to 2050 [6]. The site 'Energy-Ecological Revolution' was launched as a part of the Russian-English Internet portal 'New Paradigm' where it is characterized the regularities and tendencies of the energy-ecological evolution, contents of the energy-ecological revolution of the 21st century, alternative sources of energy, hydrogen energy, and energy-ecological education [7].

At the round table session at the permanent mission of the Russian Federation to the United Nations devoted to the global forecasting in the light of the heritage of Wassily Leontieff, Nobel Prizewinner (New York, October 2006) a proposal was made to resume the activities on a long-term forecasting within the United Nations [8]. This proposal was endorsed by the RF Ministry of Foreign Affairs S.V. Lavrov. A group of the Russian scientists drafted the concept of such global forecast and program for its individual sections [9] further approved at the meeting of the RANS Department for Cycle Studies and Forecasting, Guardianship Board and Academic Council of the Pitirim Sorokin — Nikolai Kondratieff International Institute (Moscow, RANS, June 14, 2007) and were supported by the RF Ministry of Foreign Affairs and President of the Republic of Kazakhstan N.A. Nazarbaev. It was resolved to make a forecast 'Energy-Ecological Future of Civilizations' as the first effort towards a global forecast. Russian and Kazakhstan scientists together with the specialists from other countries began to work out the forecast.

This report to be delivered at the 22nd Cross-Disciplinary Discussion within the 6th International Kondratieff Conference (Moscow, November 14, 2007), 20th World Energy Congress (Rome, November 16—20, 2007) and Energy Forum of the SCO (Peking, December 6—7, 2007) discloses the contents of the global energy-ecological revolution and the role of Russia in its implementation, the methodology and backbones of the global energy-ecological forecast, grounds the proposals for working out a global energy-ecological forecast for a period up to 2050 and its discussion at the United Nations and the World Summit.

What are **new points** included in this report?

First, new notions enriching the science — global and national energy sector, energy-ecological cycles and crises, noospheric energy-ecological mode of production and consumption are introduced, regularities and tendencies of the energy-ecological evolutions are inquired into. These notions are determined by an indissoluble connection and mutual dependence of energy and ecological dynamics; they are acquiring new dimensions under globalization conditions.

Second, the essence of the energy-ecological crisis at the outset of the 21st century is disclosed in a civilizational aspect as well as a global energy-ecological revolution of the mid-century, major outlines of the noospheric energy-ecological mode of production and way of life are characterized which will become prevailing first in the vanguard civilizations and then establish itself on the planet, radically changing the structure of the global energy sector and nature of interaction among civilizations, putting the principle of their long-term strategic partnership into life.

Third, have been worked out scenarios of energy-ecological development of civilizations for a period up to 2050, conditions and opportunities of the establishment of a noospheric energy-ecological mode of production and consumption, the opportunity to implement a normative forecast of a number of the G-8 summit members in Germany (2007) to reduce double the emissions of greenhouse gases into the atmosphere have been researched into.

Fourth, the role of Russia is shown in the global energy sector and the opportunities to turn it into one of the leaders of the global energy-ecological revolution, initiator of the working out the global energy-ecological strategy.

Fifth, using first put into scientific circulation energy-ecological matrix are done estimation and forecast of energy-ecological efficiency in the world and in Russia.

Sixth, it is shown that the global energy-ecological revolution may be successfully implemented provided only that all sound forces on the planet are rallied, strategic partnership of civilizations under the UN leading role as the major institute of the world community, recommendations for mapping a long-term global energy-ecological strategy and its discussion at the UN General Assembly and World Summit are validated.

Thus, the report addresses a new look at the essence and ways to resolve a global energy-ecological crisis, analysis of the prospects of its surmounting based on the implementation of the energy-ecological revolution and recommendations for a strategic partnership among civilizations in mastering of its achievements. These points will be addressed in more detail in making a global forecast 'Energy-Ecological Future of Civilizations' in 2008.

We do not only publish this report in Russian and English but also place it on the Internet (www.strategy.newparadigm.ru and www.kuzyk.ru) with a view to attract attention of scientists and professional men, businessmen, politicians, public figures, young people from various countries to the pressing problem of the future of the planet and will redound to the rallying of all sound forces for working out adequate responses to the threatening challenges of the new century.

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1. REGULARITIES OF ENERGY-ECOLOGICAL EVOLUTION

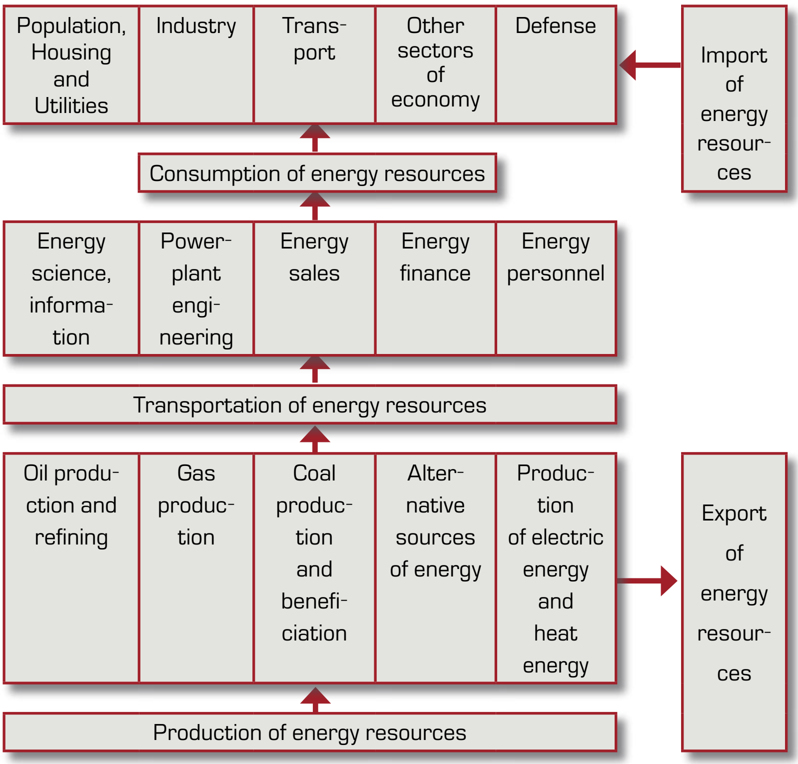
1.1. The Key Role of the Energy Sector in the Development of Society

A human is a product of evolution of natural systems and is indissolubly connected with them. Society draws sources of energy and material resources from nature; it depends on the natural environment and renders a growing influence on it. This is the essence of the theory by V.I. Vernadsky about noosphere (10) expounded by N.N. Moiseyev with respect to a new stage of co-evolution of nature and society (1).

Connection of nature and society is traced most notably in energy. Society takes major sources of primary energy from **energy** — wood and fossil fuel, energy of water, wind and electricity, atomic and hydrogen power. The use of some such sources is accompanied by emissions of harmful gases, steam-electric plant dumping places and radioactive contamination inflicting considerable damage on the environment.

Energy sector comprises in actual fact all spheres of reproduction and life of society (*see Fig. 1*): prospecting, production, processing, transportation of various fuel and

Figure 1. STRUCTURE OF ENERGY SECTOR



energy, their use in all sectors of economy and private households, export and import of energy resources.

Energy sector plays a key role in the building up and development of society. There is no family, enterprise, organization, country which fails to use primary energy resources or those ones transformed into heat energy. The level of power availability per man determines its productivity. A transition of society from one historical stage to another is connected with the involvement of new energy sources in production and concurrently — strengthening of society's impact on the natural environment.

1.2. Energy and Ecological Cycles and Crises

Energy sector of the world and any national economy evolves in accordance with the **cyclical-genetic regularities**. An energy cycle begins from mastering of a new energy resource (as it was the case with mastering energy of rivers, wind, coal, electricity, oil and gas, atomic energy etc.). A breakthrough takes place in one country (or region), then it expands broadwise and depthward involving more and more new branches and countries (as it was with a steam engine in the industrial revolution). This is a stage of diffusion of the energy cycle. The stage of saturation of demand for such source comes thereafter; it does not generate previous high growth rates in labor productivity. A crisis stage follows next when an increased volume of demand for energy by society can't be satisfied by a prevailing set of energy sources. There is an active search for fundamentally new sources, analysis of possible alternatives and selection of most efficient, and a new energy cycle, new whorl of the spiral of energy evolution begins then.

The laws of energy genesis are observed in such case — laws of inheritance, variability and selection in evolution of the energy sector. Knowledge and skills assimilated in energy support of society are not lost or discarded at the next stages of the energy sector evolution. They are accumulated, modified, transformed according to the variability laws and make a part of the inheritable nucleus (genotype) of the energy sector at the next stage of its evolution. Selection of most efficient changes is performed in the competitive battle based on cooperation, partnership of scientists and inventors who find new ways to satisfy energy demands of society, engineers and businessmen implementing innovations, civil servants supporting such innovations.

Energy cycles are an integral part of technological cycles and their duration is various. Nowadays a change of the leading generations of equipment (technologies) occurs each decade introducing certain changes in the energy base of society, energy technologies employed. A change of prevailing technological orders is observed each half a century and energy-ecological orders change with them. Each several decades the establishment of a new technological mode of production in the vanguard countries occurs — and concurrently (as a part of it) an overturn takes place in the energy sector. Deep-seated and protracted energy and ecological crises precedes it further surmounted by the **energy revolution**.

The list of energy revolutions for nine millennia of human history is given in *Table 1*.

The second energy revolution evolved in the valleys of great historical rivers (Nile, Tigris, Euphrates, Indus and Huang He) and became the basis of the formation of the first generation of local civilizations based on highly productive irrigation husbandry, and also development of river oar-propelled fleet, contacts among civilizations, international trade and military campaigns.

The third energy revolution relates to the Middle Ages and is in the use of wind energy and energy of falling water for construction of the network of wind and water mills, development of sailing sea fleet. This became the basis of the development of various crafts with independent energy sources, sea voyages and active dialogue among countries and civilizations, and further — for great geographical discoveries, conquering America and beginning of the establishment of colonial empires (Spanish, Portuguese, then British). Increased deforestation and numerous wars caused damage to the natural environment.

The fourth energy revolution at the end of the 18th — first half of the 19th cc. became the core of the industrial revolution

Table 1. ENERGY REVOLUTIONS

Time and Place	Description	Effect
7th–6th millennia B.C. Mesopotamia, Hindustan, Near East, Egypt	Neolithic energy revolution, Use of animal energy in husbandry, carriages	Use of ard, then plough Improvement of productivity in husbandry. Development of intertribal ties
3rd millennium B.C. Egypt, Mesopotamia, Hindustan	Energy revolution of the Bronze Age. Use of water energy in irrigation husbandry and transport	Systems of high productive irrigation husbandry. Nascence of local civilizations in the valleys of great historical rivers
2nd half of the 1st millennium A.D. Western and Eastern Europe, India, China	Energy revolution of the Middle Ages. Mastering wind power, falling water. Mills and sailing fleet	Construction of water and wind mills, sailing-ships. Great geographical discoveries. Craft-based system
End of the 18th — beginning of the 19th cc. Western Europe, then North America	Industrial revolution. Mastering of steam energy, coal	Building up machine industry, railroads, steam fleet. Establishment of colonial empires. Industrial centers
End of the 19th — beginning of the 20th cc. — Western Europe, USA	Mastering electricity, oil fuel. Electrification of production and everyday life, cars and airplanes	Chain of electric power stations, energy grids, monopolies, division of the world. World wars
Mid–20th c. USA, Western Europe, Japan, USSR	Mastering atomic energy. Use of gas fuel	Atomic weapons, atomic energy. Radioactive and heat pollution of atmosphere. Pipelines network
30–50s of the 21st century, USA, Western Europe, Japan, China, India and Russia (forecast)	Global energy ecological revolution. Mastering of alternative ecologically clean sources of energy (ethanol, hydrogen, sun, wind)	Establishment of a noospheric civilization. Reduction of a share of fossil fuel and hazardous emissions. Energy-efficient economy. Noospheric energy mode of production and noospheric way of life

and is in mastering steam energy and coal energy, creation of steam engines, steam locomotives, and steamboats. It became a precondition of the establishment of the world system of economy and colonial division of the world. Atmospheric pollution in the industrial centers increased therewith. Western Europe became the leader of the energy revolution (first of all, United Kingdom), and then the USA took the leadership positions.

The fifth energy revolution evolved at the end of the 19th — beginning of the 20th cc. in the USA, Western Europe, Russia and was in mastering electricity and liquid fuel. This allowed transmitting energy to distances using electric networks, electrified production and private households, to create motor car and air transport, reduce considerably transport costs. Pollution of the environment with emissions of harmful gases increased — by-products of operating electric power plants and transport.

The sixth energy revolution was going from the mid-20th c. based on mastering of atomic energy (atomic energy industry was created), and also accelerated development of gas energy. Damage to the nature increased as a result of nuclear explosions, failures at the nuclear power plants and growing emissions from heat power plants. The network of pipelines covered the countries thus increasing a threat of eco-catastrophes. The USA, USSR, Western Europe, and Japan were the leaders of such revolution. It became one of the factors for an accelerated economic growth in the 1st half of the 20th c.

The seventh energy revolution is anticipated in the 30-50s of the 21st c. It will become a response to the global energy-ecological crisis the signs of which are aggravating from the end of the 20th c. and it hit the greatest the countries of the African region. The major outlines of such revolution: conversion from the prevailing fossil fuel to alternative, ecologically clean sources of energy, including high technologic (nuclear reactors of new generations, hydrogen energy); relative and then absolute reduction of hazardous emissions into the atmosphere, prevention of irreversible climate changes; priority of energy-efficient technologies both in production and in housing and utilities; reduction of a share of costs for energy supply, cheapening energy. The leaders of the forthcoming energy ecological revolution will be the Northern American, Western European, Japanese and Russian (in case of realization of the innovative-breakthrough scenario) civilizations. The peak of the evolvement of such energy-ecological revolution in the vanguard countries will fall to the 30—40s years of the 21st c.

Energy revolutions will also occur in future as the prime elements of the building up new technological and ecological modes of production. One their feature should be noted therewith: reduction of periods of time between them as a result of operation of the general law of compression of historic time, speeding up of technological advance rates.

The regularities of the development of the energy sector were researched into by Academician *G.M. Krzhizhanovsky* — one of the originators of the GOELRO plan. He observed that humanity steps over an energy threshold from time to time (as an expression of a global energy crisis) that opens new space for the development of production forces.

The works of *B.N. Kuzyk* and *Yu.V. Yakovets* 'Russia–2050: Strategy of Innovative Breakthrough' (4), 'Civilization: Theory, History, Dialogue and the Future' (2), 'Russia: Strategy of Transition to Hydrogen Energy' (6) research into the regularities and tendencies of development of the global and national energy sector, give major outlines of the evolving global energy-ecological revolution and its possible effect.

1.3. Energy Rent and Ecological Anti-Rent

One of the elements of a new paradigm in the field of dynamics of the energy-ecological sector is the formation of the category of **energy rent and ecological anti-rent**. These notions were first formulated in the work of *Yu.V. Yakovets* 'Rent, Anti-Rent and Quasi-Rent in a Global Civilizational Dimension' (3) following the report at the round table session of the World Summit on Sustainable Development in Johannesburg (2002). Let's cite the fundamentals of the energy rent and ecological anti-rent concept (*see Fig. 2*).

We understand under ***energy rent*** a super profit generated from use of progressive sources of energy for satisfaction of society's demands for energy. As both energy needs and sources for their satisfaction are extremely diverse and changeable then energy rent is also highly diverse by structure and dynamical features.

Energy rent and quasi-rent include:

1) ***fuel rent (oil, gas, coal etc.)*** — to the extent mineral fuel produced serves satisfaction of energy needs (it may be used also as the original raw material for production of chemicals etc.);

2) ***hydro energy rent*** connected with the use of efficient hydro resources for electricity production;

3) transport rent connected with the use of more efficient modes of fuel carriage, and its derivatives, transmission of electric energy etc.;

4) ***technological quasi-rent*** — super profit generated in innovative mastering of more efficient technologies of production, processing, transportation and consumption of energy;

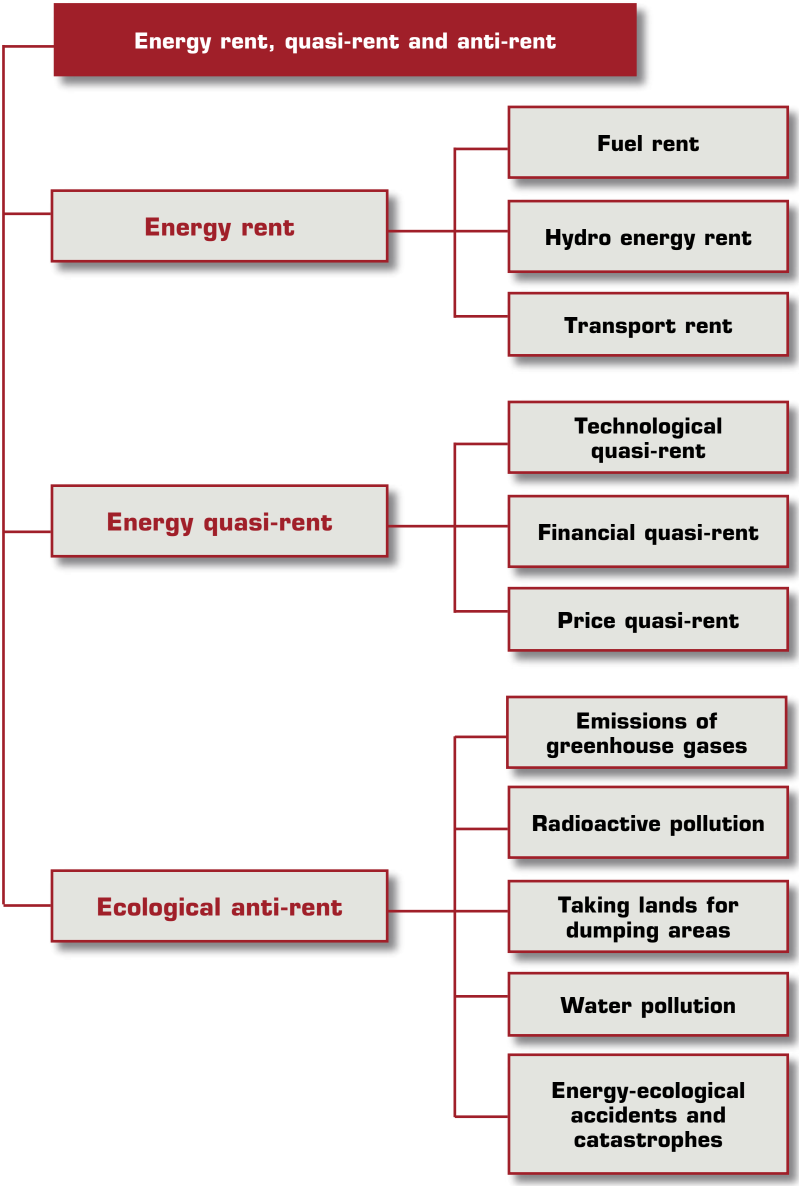
5) ***financial quasi-rent*** — a super profit generated in the movement of enormous financial flows connected with the energy sector of economy on internal and world markets, stock exchanges etc. as a result of drastic changes in prices, use of transfer prices by TNC, financial speculations etc.

Dynamics of energy rent is determined by a number of factors of both surface and in-depth nature. First of all, this is level, relation and change in ***prices*** at the stage of the end consumption, at the intermediary and initial stages. The matter in question prices and tariffs for electric and heat energy, domestic gas and engine fuel, mineral fuel produced and its derivatives, equipment, materials and services of the energy sector, and also tariffs for transportation of fuel and energy. The prices may considerably vary predetermining the emergence and increase in a super profit or vice versa its disappearance to the extent of transformation of individual enterprises and event sectors into loss-making.

A leap of world prices for oil in the 80s of the 20th c. caused a multiple increase in super profits of oil exporters and a knock-on effect of price and rent growth throughout the energy sector and then in the world economy while profits of other links of energy sector dropped, re-distribution of rent income inside the sector occurred. However, the world economy adopted then to a new system of prices, and oil rent reduced being influenced by two major factors: reduction of world prices for oil and oil products (but far from the level of the beginning of the 70s) and a growth of production costs, processing and transportation of oil as a wave of increases that involved the whole price chain returned to the starting point. In 1997—1998, reverse changes were observed related to a considerable drop in the world prices for oil and oil products. From the end of 90s the price grew again that resulted in the mass and rate of energy rent.

Another prime factor impacting the dynamics of energy rent is changes in the ***primary*** sphere as a result of discovering and involvement in production of new rich deposits of fuel, mastering of new efficient energy resources etc. Dynamics of energy rent is more inertial and unpredictable here as compared with the case when there is an impact of price fluctuations; it is traceable

Figure 2. ENERGY RENT, QUASI-RENT AND ANTI-RENT



both on local, regional and national levels and on a global scale. Resources of mineral raw materials are non-renewable. Rent arising at the stage of a fast growth of production is stabilized later beginning to reduce until disappear.

The third group of factors is of cyclical nature and influences the level, dynamics, structure and distribution of energy rent by:

➠ Changes of ***economic*** cycles (medium-term and long-term — Kondratieff). At the recovery and rise of economy the volume of rent usually grows, at the maturity stage — it stabilizes and begins dropping, at the stages of crisis and depression — they are reduced to minimum or disappear due to a fall of demand for energy and reduction of opportunities to implement efficient innovations;

➠ Changes of stages of ***technological*** cycles. At the stage of innovative mastering of new generations of equipment and technological orders there is nearly no energy rent (its technological kind), at the stage of spreading it increases vehemently, at the maturity stage — it begins to reduce, at the crisis stage — it comes down with a run and disappear;

➠ Changes of stages of ***ecological*** cycles connected with a transition to new stages of a life cycle of mineral fuel deposits, its comprehensive processing, with reaching of the critical level in the environmental pollution (growth of ecological anti-rent) or on the contrary with mastering of ecologically clean technologies.

Political factors may also influence the dynamics of rent, for instance, political confrontations, local wars and conflicts, state-political restrictions etc.

As economic, technological and ecological crises are mainly synchronized, overlapping and produce a resonance effect there are grounds for speaking about ***energy cycles*** as a complex manifestation of various mutually connected cycles in the dynamics of the energy sector. They fall within the pulsation of medium-term (decennial), long-term (semi-centenary Kondratieff) and super long-term (civilizational) cycles and make an essential element rendering effect on other elements of the cyclical structure of society.

Ecological anti-rent — 'illegitimate' super profit generated by entrepreneurs (both national and TNC) generated by a predatory use of natural resources and non-standard emissions of pollutions into the environment. In actual fact this is a result of a theft of the environmental assets and life conditions of future generations that will require in the future additional costs for reproduction of natural resources and remedy of ecological damage caused. A removal of the ecological anti-rent by the state is not an administrative-economic sanction for unlawful actions but a compensation of a real economic damage to the society. It should render loss-making a wasteful use of natural resources and non-standard pollution of the environment. The payers of such ecological penalties should be entrepreneurs, and in the event of trans-border pollution and damages — countries causing such damage. A receiver of such ecological penalties shall be the countries suffered or world community represented by international organizations (for example, Global Ecological Fund).

Taking of ecological anti-rent has also a positive stimulating function inducing efficient innovations in such sphere as it provides a publicly recognized limit for estimating the efficiency of ecological innovations and investments.

It follows that the energy rent and ecological anti-rent exist in a close unity, complement each other being major elements of a ***noospheric economic mechanism***. ***Such mechanism*** operates on the national and global levels and combines optimally state (and inter-state) ***ecological regulation*** in the interests of present and future generations and ***market beginnings*** creating a real ecological-economic interest with commodity producers and energy consumers. Moreover, harmonious interaction of these two categories meets the laws of the market to a greater extent as it aligns economic conditions of competitions for entrepreneurs who are in unequal natural-ecological conditions.

2. ENERGY-ECOLOGICAL CRISIS AND GLOBAL ENERGY-ECOLOGICAL REVOLUTION OF THE 21st CENTURY

2.1. Global Energy-Ecological Crisis of the Beginning of the 21st Century

The start of the 21st c. is characterized by the evolvement of the energy-ecological crisis that precedes the energy-ecological revolution of the 21st c. as an element of the establishment of the post-industrial civilization and noospheric energy-ecological mode of production and way of life adequate to it.

The first precursor of the energy-ecological crisis was the world energy crisis of the 70s of the 20th c. that resulted in an increase of world prices for oil 16.5 times for a decade and speeded up scientific researches into alternative sources of energy. The Chernobyl catastrophe became an additional alarm signal and checked for a while the development of atomic power, and leaded to its partial winding up in a number of countries. However, in the 80-90s the energy crisis was mainly surmounted, consumption of fossil fuel, especially of natural gas and oil grew at high rates. Pollution of the atmosphere with energy emissions increased.

In 2002, in Johannesburg at the World Summit on sustainable development the focus of discussions was on the problems pertaining to the development of renewable sources of energy, energy-saving and reduction of atmospheric pollution.

A vehement increase in prices for fossil fuel from 2003 became a symptom of the evolving energy-ecological crisis of the beginning of the 21st c. that is of a global and protracted nature. Surmounting this crisis is possible only based on a conversion to a new energy-ecological mode of production and consumption implementing the noospheric principles.

The end of the 20th — beginning of the 21st cc. witnesses the high rates of energy use (*Table 2*), especially in rapidly developing civilizations (China and India).

For 13 years the consumption of the primary energy resources in the world increased by 28% — average annual growth rate by 1.7%, growth per capita — 0.3 %. In such race of energy consumption the leaders were the Moslem civilization (Middle East and North Africa) — 4.3 and 2.3% of growth, Chinese — 3.6 and 2.6% respectively and Indian civilization — 3.3 and 1.5%. For the years of economic crisis Russia reduced energy consumption by 22% but at the recovery stage of economy is building it up again.

With the general increase of CO_2 emissions in the world by 19.1% emissions per capita are nearly stabilized (in 2003 100% of 1990). However, they are increasing fast in China (by 52% for 13 years), India (by 59%), in North Africa and Middle East (by 36%). Germany has achieved the most impressing results in energy-saving. The energy consumption reduced by 2.3% here, energy-efficiency (GDP per unit of energy used) increased by 32%, CO_2 emissions dropped by 18%, and per unit of GDP — by 43%.

Table 2. TENDENCIES OF ENERGY CONSUMPTION AND CO_2 EMISSIONS IN THE WORLD

Countries	Consumption of energy resources in mln t oil equivalent			Per capita, kg oil equivalent			Emissions CO_2 per capita, t		
	1990	2004	% growth	1990	2003	% growth	1990	2003	% growth
World	8610	11062	128	1685	1793	106	4,3	4,3	100
Countries with high income	4369	5513	126	4842	5410	114	11,8	12,8	108
Includ. USA	1928	2326	121	7722	7843	103	19,3	19,9	103
Western Europe (Euro zone)	1053	1245	118	3568	3964	112	8,3	8,2	99
Japan	446	533	120	3610	4053	116	8,7	9,6	110
Australia	87,5	116	133	5130	5762	112	15,9	17,8	112
Countries with low and medium income	4267	5549	130	1008	1068	106	2,4	2,4	100
Includ. China	866	16,9	186	763	1242	163	2,1	3,2	152
India	362	573	158	426	531	125	0,8	1,2	150
Russia	775	642	83	5211	4460	86	15,3	10,3	67
	603*	642	106*	4121	4424	107	9,8	2,2	105***
Latin America	460	645	140	1050	1187	113	2,4	2,4	100
North Africa and Middle East	194	357	184	861	1189	138	2,5	3,4	136
Africa south to the Sahara	317	452	143	693	703	103	0,8	0,8	100

Sources: 2002 World Development Indicators. Washington: The World Bank, 2002. P. 167; 2007 World Development Indicators Washington: The World Bank, 2007. Pp. 154—156, 158—160.
*1999, **2000—2004, ***2000—2003

The tendencies formed indicate an accelerated growth of consumption of non-renewable resources of fossil fuel and increasing of heat pollution of the planet (although at lesser rates than energy consumption is growing).

What are the differences of the global energy-ecological crisis from the world economic crisis (*Table 3*)?

1. Economic crisis finds its expression in the fall of major macro economic indicators, a drop of the growth rates or GDP reduction in the group of vanguard countries (especially in change of technological orders, Kondratieff cycles as it was the case in the mid—70s and in 1929—1933), a fall in demand on the world markets of commodities and services.

The global energy-ecological crisis is characterized by a growth in production and consumption of primary energy resources, increase in demand on the world energy market (due to priority growth rates of consumption and demand from fast growing economies of China, India, Viet Nam, Middle East and North Africa, Russia and other CIS countries) under limited opportunities to increase production and supply of fuel because of depletion of a number of the best deposits and long-term development of new large fields. A sign of such economic crisis is an excess of supply over demand under the energy-ecological crisis, a demand for energy resources exceeds their supply.

2. Economic crisis is accompanied by a reduction in emissions into the environment due to decline in production in resource-intensive sectors. Under the energy-ecological crisis it is observed the reverse tendency — an increase in the environmental pollution due to a growing consumption of mineral fuel.

3. There are observed significant differences by factor of time. Economic crises usually occur each decade and continue a year-two (in change of technological orders and Kondratieff

Table 3. COMPARISON OF ECONOMIC AND ENERGY-ECOLOGICAL CRISES

Parameter	Economic	Energy-Ecological Crisis
Market conditions	Excess of supply over demand for goods and services	Excess of demand over supply of energy resources
Dynamics of production	Decline in production	Growth of production and consumption of energy resources
Ecological dynamics	Reduction of ecological pollution	Growth of ecological pollutions
Time factor	Once in a decade, semi-century	Once in a semi-century, in several centuries
Dynamics of prices	Prices down	Prices for energy resources grow
Dynamics of rent	Rent drops	Energy rent drops

cycles — 3—4 years). Energy-ecological crises occur once in several centuries (in the recent period — approximately once in a semi-century) and continue one-two decades until the prevailing energy-ecological orders or modes of production change.

4. Under economic crises due to an excess of supply over demand a fall in prices occurs on the world market and national markets of crisis-hit countries. Under the energy-ecological crisis on the contrary an excess of demand over supply leads to a growth of world and internal prices for energy sources, and then the chain of rising prices spreads to all economy generating an inflation wave. Coincidence of time of economic and energy-ecological crises causes a phenomenon the economists call 'staflation': a growth of prices under a decline of production. Such phenomenon clearly manifested itself in the period of economic and energy crises of the 70s.

5. A fall of mass and rate of rent is observed under economic crises as a result of a reduction in the overall level of prices under an increase of costs that results in a fall of volume and rate of profit and a sharp reduction in the mass of super profit making the nucleus of rent income. The energy-ecological crisis is accompanied by an increase in mass and rate of rent income (both energy rent and ecological anti-rent) due to an increase in prices for fuel, accelerated depletion of the best deposits and a growth in emission of greenhouse gases into the atmosphere.

6. Economic crisis usually hits to a greater extent the developed countries, leading to a temporary lessening of the gap between rich and poor countries and civilizations. At the recovery stage this gap increases again due to a faster adaptation of technological base of economy of developed countries to the changed conditions of reproduction. Under the energy-ecological crisis the largest volumes of energy-rent is appropriated by energy-excessive countries and civilizations supplying the major portion of energy resources to the world market (a number of Moslem countries, Russia, Kazakhstan, Azerbaijan, Turkmenia, Indonesia, Venezuela, Nigeria etc.). However, under conditions of the energy-ecological revolution at the recovery stage of a long-term energy-ecological cycle the vanguard countries and civilizations with a more powerful technological and investment-innovative potential adapt faster to new demands of reproduction and market, and polarization of income increases again; a growth of prices for equipment and new materials surpasses an increase in prices for energy sources (and sometimes such prices fall — as it was the case in the 80s, 90s), world technological quasi-rent outraces sharply by growth rates and volumes the world mining rent (including fuel rent).

Energy-ecological crisis makes a completing stage of a long-term energy-ecological cycle, leads to violations in the reproduction process to redistribution of resources and income between reproduction sectors (in favor of the energy-raw material sector for account of a consumer), becomes a brake of the economic growth and tells adversely on the life level of population. As the energy-ecological crisis is of a pronounced global nature, then in order to surmount it a global energy-ecological strategy and a long-term program under the United Nations pursuing such strategy are required based on a long-term scientific forecast. Such program will permit, based on the partnership among civilizations, surmounting faster the energy-ecological crisis and master the achievements of the next energy-ecological revolution.

2.2. Forthcoming Energy-Ecological Revolution

The preconditions for surmounting the energy-ecological crisis are created based on the cluster of epochal and base innovations making the contents of the next global technological and energy-ecological revolution indissolubly connected with it that will end with the establishment of the noospheric energy-ecological mode of production and consumption, energy-saving way of life in the scale of a global civilization.

Preconditions of the approaching revolution are matured in the period of the energy-ecological crisis, in the first two decades of the 21st c., concurrently with preconditions of the global technological revolution, nascence and establishment of the sixth technological order (the first stage of the post-industrial technological mode of production, humanistically-noospheric post-industrial world civilization). What are such preconditions?

1. ***Establishment of a scientific base of the forthcoming overturn.*** In the new scientific paradigm which is underway to replace the industrial paradigm the issues of ecology, problems of building up noosphere and alternative energy, ecologically clean transport are among key directions of scientific knowledge and scientific search.

Meeting new challenges of the 21st c. the scientists focus their attention on the problem of ensuring rational co-evolution of nature and society; creation of alternative sources of energy of the six technological order — hydrogen and fuel cells, ethanol and other biofuel; development of independent plants operated on alternative energy sources; development of ecologically clean transports; development of non-waste technologies; problem of foreseeing natural catastrophes and unfavorable changes in climate using global ecomonitoring etc.

2. The center of gravity of innovations and investments is shifting to the energy sector. To satisfy growing demands of the world community for energy under reduction of growth rates of such demands and conversion to energy-saving consumption (industrial and private) a huge volume of investments (estimated in trillions dollars) will be required and their orientation to base innovation for assimilation of alternative sources of energy, energy-saving and non-waste technologies, conservation and elevation of the environment. As the total volume of GDP and accumulation fund are limited, and the GDP growth rate has a general tendency to fall in a crisis situation, a drastic increase in investments in the innovative renewal of the energy sector may be reached for account of a relative reduction of investments in the sector of infrastructure (specifically, reduction of investments in an extremely swollen trade and network of intermediary agencies with a gradual expansion of e-commerce), and also for reducing investments in the arms race. According to the Stockholm Peace Research Institute military expenditures in general in the world after a period of a reduction by one fourth in 1990—1995 began growing at the priority rates reaching 6% of the annual increase in 2006 and $2 trln (this is more than in the depth of the cold war), including the USA — $528 bln. The military-technical sphere, development and innovative assimilation of new generations of weapons are leading again in the technological revolution. A transition to the noospheric energy-ecological mode of production requires a reversal in such tendency, re-distribution of investment in favor of the energy sector and ecology.

3. It is observed shifting of business to the energy sector, revival and development of alternative sources of energy and energy-saving technologies. Major TNC spend a growing share of their profits and super profits (energy rent) for development and assimilation of new generations of means of transport on ecologically clean sources of energy (hydrogen with fuel cells, ethanol etc.), independent electric plants, nanotechnologies and other energy-saving technologies. A vehement growth of prices for fossil fuel prompts it making alternative energy sources more competitive and increasing the upper boundary of efficiency of energy-saving technologies. Innovative medium and small businesses turn to this sphere. Such flow of capital advances and accelerates mastering the achievements of the energy-ecological revolution of the 21st c. in the addition to the growth of budgetary investments in this sphere.

4. Problems of the energy-ecological revolution, mastering and diffusion of alternative sources of energy and energy-saving technologies turn to be in the focus of attention of the state and world community. The USA has adopted long-term programs for hydrogen energy and nanotechnologies. The European Union has approved a long-term platform for hydrogen energy and fuel cells for a period up to 2050. The alternative energy programs exist in Japan, India and China. Brasilia actively supports the replacement of fossil fuel with ethanol. At the World Summit on sustainable development (Johannesburg, 2002) the issues pertaining to the development of alternative energy and implementation of the Kyoto Protocol with respect to the steps for reducing atmospheric pollution with greenhouse gases occupied the central place. At the summits of G-8 in Russia (2006) and in Germany (2007) the principal documents on the issues of energy security and reduction of greenhouse gas emissions were approved. It may be said that the governments, international organizations, UN define the threats and effect of the evolving global energy-ecological crisis more and more clearly. However, a joint anti-crisis program and long-term strategy of the use of the forthcoming energy-ecological revolution on a planetary scale has not been elaborated yet.

5. Global civil society is concerned by the effect of the energy-ecological crisis and is ready to support such anti-crisis program. The intensification of the green movement, powerful manifestations of anti-globalists (alterglobalists), support by workers of culture and public opinion of the movie about danger of the eco-catastrophe shot under the guidance of ex Vice-President of the country A. Gore, a growing flow of speeches in mass media on this problem indicate it. However, a global civil society has no clear, science-based prospect and action plan for preventing such eco-catastrophe based on the mastering of base innovations of the energy-ecological revolution.

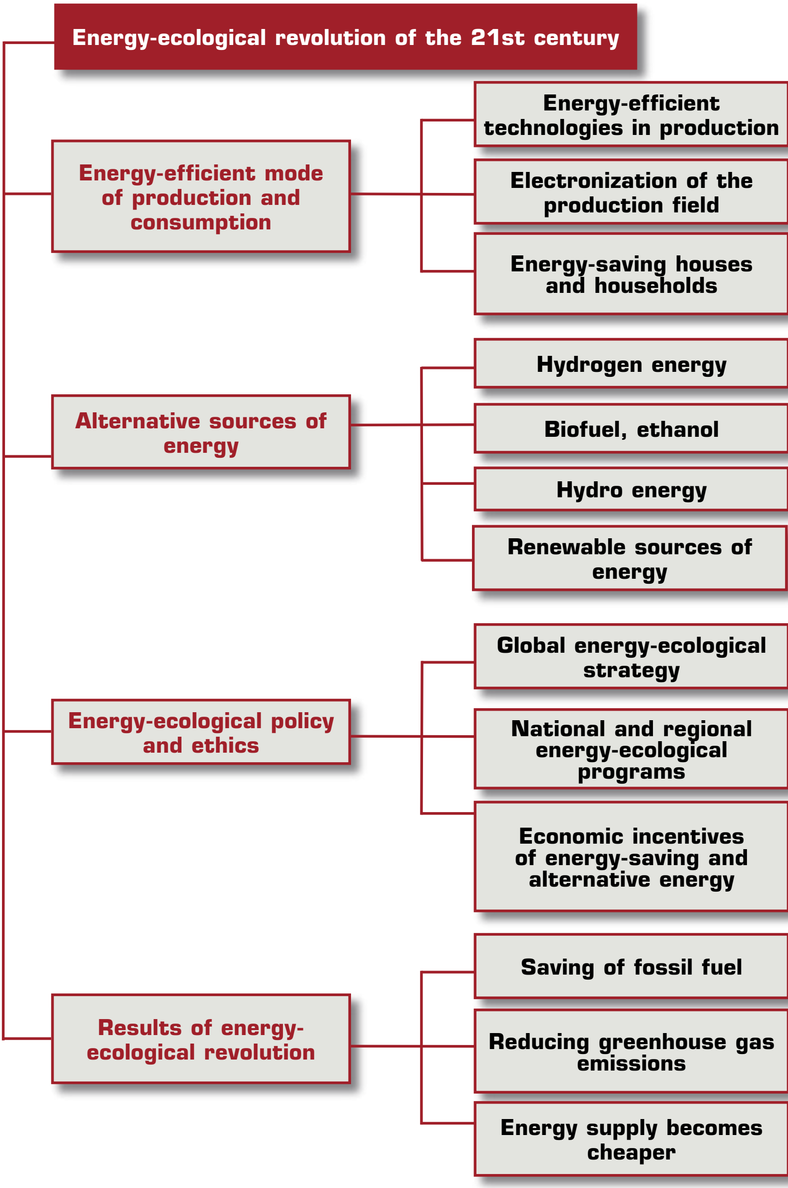
The referred preconditions of such revolution accumulate fast and give a synergy effect. It might be anticipated that the energy-ecological revolution will involve the vanguard countries already in the 30s, and in the 40—50s it will become the universal planetary epochal innovation radically changing the mode of production and consumption, look of the global energy sector.

What is the anticipated effect of the energy-ecological revolution of the 21st c.? (*See Fig. 3.*)

First of all, it is diversification of sources of energy consumption. The dominance of oil-gas fuel will be surmounted. It is hardly that it will be replaced by the prevalence of any other energy source, whether atomic, thermonuclear, hydrogen, wind energy etc. A wide range of energy resources will be made to serve society — both inherited from the previous orders but technologically transformed (solid, liquid, gaseous fossil fuel, conventional renewable sources of power — hydro energy, solar and wind energy) and fundamentally new sources of the sixth order (hydrogen, biofuel etc.) In various regions for various consumer groups the structure of energy consumption will be different but oriented to the end result — to satisfy demands of society for energy with possibly less costs and reduction of damage to the environment.

Second, it is ecologization (noospherization) of the energy sector in its entire links. To attain its ecological cleanliness and non-waste is impossible but it is possible and necessary to reduce to a reasonable minimum the volume of emissions and hazardous waste into the environment. It should become one of the major criteria in selection of the alternative sources of energy. However, the matter in question is not only emissions but also the complete extraction from the depth of fossil fuel, its complex processing and non-waste use. Now up to the two thirds of oil remains in the depths in Russia, oil recovery efficiency is falling, losses are growing in transportation; prior technologies do not ensure the world level of the depth working of oil. Such wasteful use of national assets, depredation of future generations (for centralizing the oil rent with the state and monopolists and channel it to foreign banks). Such practice comes into conflict with the major principle of sustainable development of humanity — to ensure the balance of interests of present and future generations.

Figure 3. DIRECTIONS AND RESULTS OF THE ENERGY-ECOLOGICAL REVOLUTION



Third, it is deconcentration, autonomism and demonopolization of the energy sector. In the 20th c. the tendency of concentration of production in mining, processing, transport and consumption of energy as a foundation of monopolization and generation of monopoly energy rent for account of overpricing. Increasingly larger mines were built, oil and gas producing and refining complexes, largest heat and water power plants, countries were enlaced with the piping network, power lines, heat pipelines, transport costs and losses grew. National and transnational super monopolies were established which dictate their will to the governments and legislators less regarding consumer interests.

A new technological revolution, sixth technological order changes such tendencies. Small and medium independent plants producing (co-generation) and consuming electric and heat energy in the necessary volume and with minimum expense and losses in transportation turn more efficient.

Surely, the principle of diversification, diversity will be observed here. Powerful water power plants, heat and atomic plants will remain for major consumers. However, for remote small and medium consumers independent co-generation plants operated on hydrogen, renewable or local sources of energy will be more efficient.

Fourth, it is a growth of economy in its entire links of the energy sector. Certainly, in the period when new sources of energy are mastered, this will require large expense and investments in fixed capital with a high innovative risk with no return at once. However, as a result of all transformations a share of social labor and other resources directed to satisfy demands of production and population for energy should significantly reduce. Economic justification of the energy-ecological revolution is in it, a prime criterion for selection of alternative sources of energy and priority innovative-investment projects.

2.3. Major Outlines of the Noospheric Energy-Ecological Mode of Production and Consumption

An accumulated bulk of researches and analysis of tendencies entitle us to render a primary estimation of major outlines of the future noospheric energy-ecological mode of production and consumption.

Energy-ecological mode of production and consumption is a new scientific category showing relation and penetration of technological and ecological modes of production and use of energy changing from a period to a period.

Technological mode of production characterizes a tech-nological level of economy, prevailing set of instruments of labor, sources of energy, usable raw materials and materials, technologies and forms of organization of production. A change of historical periods — world civilizations — rests on general technical (technological) revolutions, and in the very life cycle of a technological mode of production one could distinguish prevailing technological orders changing each other (with an approximate semi-century alternation in the recent centuries). In their turn they include 4—5 generations of equipment (technologies) changing each other with an approximate regularity of a decade.

It is correct to speak about **ecological modes of production** in the same aspect that is an element of technological modes of production but is beyond of it and characterizing a prevailing mode of interaction between society and nature, as V.I. Vernadsky [10] and N.N. Moiseyev [1] understand it — stages of transformation of biosphere into noosphere. A transition from a period to a period begins from the ecological crisis that germinates a new system of relations between society and nature, involves new natural production forces in production and creature comforts and deeply transforms the natural environment around a human.

Now it is possible to raise a question about one more, deeper and more synthetic scientific category — about **the energy-ecological mode of production and consumption**. This category embraces related sides of technological and ecological modes of production, ways to support society (production and population) with energy and ecological effect of the employment of such ways and energy supplying technologies, character of consumption of energy and level of energy-saving in industry and housekeeping. Accordingly one may speak also about ***energy-ecological orders*** from the energy positions characterizing interaction of technological and ecological orders.

The second half of the 2nd millennium A.D. — about five centuries — is the period of establishment, prevalence and transition to a crisis stage of the **industrial energy-ecological mode of production and consumption**.

Its identifying features:

- A considerable increase in growth rates of production and energy consumption that became the base for the establishment of the manufacturing and then factory industrial mode of production, many-time increase in labor productivity (for the 20th c. — 5 times general in the world, developed countries — 6.3 times, developing countries — 5.9 times, Russia — 3.8 times, by 1990 — 5.4 times) [11];
- Many-time increase in energy consumption in private household that would improve every day life and life conditions of people;
- Involvement of new natural energy source in reproduction (liquid and gaseous fuel, electric, and then atomic energy), conversion to the dominance of fossil fuel — first coal and then oil and oil products, natural gas;

➠ Growing an adverse impact of the energy sector on the environment — waste of mines, concentrating mills, drilling rigs, emission of fuel consumption and vehicle waste into the atmosphere; piles of solid waste; radioactive contamination after explosions of nuclear bombs and accidents at the atomic power plants. All this has worsened the quality of life of people (especially in mega cities), leads to an increase of the level of various illnesses, to unfavorable climatic changes. The energy monster created by a human begins to threat the very existence of such human as a result of a global ecological catastrophe or a series of local catastrophes.

Long-term energy forecasts made by various organizations and scientists indicate that the industrial energy-ecological mode of production and consumption is in the crisis state, in the deadlock.

How appears the outlines of the noospheric energy-ecological mode of production and consumption?

In solving many current pressing tasks pertaining to the energy supply of production and life of people it is necessary to have a clear idea on the long-term path how society will develop, about major outlines of the noospheric energy-ecological mode of production that will likely become prevailing by the mid—21st c. (provided that a favorable innovative-breakthrough scenario of the global dynamics is implemented). Now it is possible to determine only major features of the global energy-ecological future as a matter of course as well as major directions of the movement strategy along this main line.

1. Energy-saving and reduction of the energy consumption growth rates. Surmounting of the energy wastage of the industrial technologies and modern way of life, and significant reducing of the demand in primary energy resources are lying ahead.

The matter in question is not an absolute reduction of electricity energy consumption. Production (and consequently consumption) of electric energy is going at the priority rates (*Table 4*) and underlies the increase in the labor productivity and improvement of quality of life of population. It is especially important for the countries with low income; one should not forget that about one fifth of the population on the Earth has no access to electricity at all.

Electric energy production is growing at the highest rates in China (the base of the record economic growth rates) and in the countries with a low level of income where electrification is evolving. In the countries with high income where such process is mainly completed the increase rates of electric energy production are not high. The prevailing sources of electric energy are coal (40% on average in the world) and gas (20%). The Russian structure of the fuel balance is contrasting to the world sharply where significant reserves and a relative low price for gas (45%) is leading, and coal makes less than 17%. After a predictable increase in internal price for gas by 2011 nearly three times this competitive advantage of Russia will be in the past, a share of gas in production of electric energy will significantly fall, and a share of coal will grow thus causing an increase in the emission of greenhouse gases.

It should be taken into account that under the systems of centralized electricity and heat supply formed a significant part of electricity and heat is wasted in the networks or heats 'space'. In future, a share of independent co-generation plants will increase directly with consumers, at the residential quarters and small localities, optimization of temperature will be ensured in apartments. The establishment of the sixth technological order will result in the structural shifts in economy, reduction of a share of energy-intensive industries that will relatively (and in future absolutely) reduce the production consumption of energy.

Radical shifts will also be needed in the structure and volume of personal energy consumption. Nowadays information revolution and spread of Internet everywhere permits to convert to electronic townhouses and offices, electronic trade, and distance learning. This will enable to reduce the flows of people using transport to go to work, shopping, studying and permit to solve the issue of traffic jams in mega cities and reduce unreasonably high energy spending of population for trips.

Consequently, the first identifying feature of the post-industrial energy-ecological mode of production and use — ***energy saving*** as an ecological imperative for production and everyday life, efficiency promotion and restriction of society's needs in energy.

2. A conversion from the absolute (up to 85%) prevalence of fossil fuel to alternative ecologically clean sources of energy. This is the main line obvious to everybody. But it is still unclear what alternative source of energy will take the leading positions. ***Atomic energy*** claims such leadership. But uranium is also fossil fuel, and its reserves are non-renewable and gradually depletes and this is a very capital-intensive industry. Furthermore, accidents are not excluded theoretically. Another applicant — ***hydrogen energy*** — hydrogen and hydrogen fuel cells not giving harmful emission into the atmosphere [12]. Hydrogen and fuel cells are still expensive but their relative efficiency is growing as fossil fuel becomes more expensive, and the prime cost and price for hydrogen will be reducing fast with conversion to large-scale production and consumption. Attention increases to renewable sources of energy — hydro energy (mini water power plants), solar and wind energy, subsurface heat of the earth, etc. Significance of biomass will grow up.

In any case, the numerosity of energy resources will persist in the context of the capabilities of various countries worldwide

Table 4. ELECTRIC ENERGY PRODUCTION GROWTH RATES AND ITS SOURCES

Countries	Electric Energy Production					
	Bln kW		% of growth	% of increase	Oil	
	1990	2004			1990	2004
World	11 788	17 374	147	2,8	10,3	6,46
Countries with low - income	518	1028	217	5,7	7,0	6
Including India	289	668	172	4,3	4,3	5,4
Countries with medium income	3843	6259	163	3,6	14,7	7,6
Including China	621	2200	354	9,4	7,9	3,3
Including Russia	1200	930	92	0,6	9,9	2,7
Countries with high income	7427	10 087	136	2,2	5,4	5,6
Including Euro zone	3203	4142	127	1,7	4,1	3,4
Including USA	1667	2227	134	2,1	9,4	4,9

Source: 2007 World Development Indicators. Washington: The World Bank, 2006. P.162—164.

and territories, diversity of elements of the fuel and energy balance. In the near decades an active selection of most efficient, ecologically clean promising sources of energy will be taking place in terms of economy and ecology.

3. A transition from monopolization of the energy sector to its demonopolization, deconcentration and decentralization. In the 20th c. the tendency to concentration, centralization prevailed and monopolization of the energy sector arising out of it. Increasingly larger

Source of Electric Energy Production, %							
Gas		Coal		Atomic Energy		Hydro Energy	
1990	2004	1990	2004	1990	2004	1990	2004
13,8	19,7	38,1	39,8	18,1	16,0	17,1	15,8
15	19,9	40,9	47,1	1,2	1,9	34,8	23,4
3,4	4,5	65,3	69,1	2,1	2,5	24,8	12,7
19,5	20,6	35,8	42,7	7,4	6,7	21,6	21,5
0,5	0,4	71,2	77,9	0,2	2,3	20,4	16,1
45,7	45,8	15,3	17,3	11,91	15,6	17,0	18,9
10,7	19,1	39,1	37,3	23,2	22,8	15,2	11,9
11,9	17,6	53,1	50,4	19,1	19,6	8,5	6,5
8,6	8,3	34,5	27,0	35,4	34,0	11,8	10,0

mines, electric power plants, factories were built, the land became belted with pipelines, electrical lines, heat pipes, utilities, national and cross-state energy grids were established. Both state and private monopolies of the energy sector and transnational corporation dictated their terms and prices to consumers relying on the governmental support.

New tendencies are taking shape in production, location and consumption of energy. Major heat power plants, atomic power plants, water power plants and power systems are completed by a large number of distributed sources of energy and independent energy plants thus reducing losses in networks. This process is accompanied with a computer-based control over energy consumption in apartments, offices, hospitals, schools, and also creation of energy-efficient houses of new generations. Small business gets access to energy supply, competitive bases expand, and monopolism is undermined. Governmental regulation of energy supply to population strengthens.

4. Radical transformation in a civilizational aspect of the global energy sector functioning. Now two poles have formed here. The first pole is major energy suppliers to the world market — Moslem, Eurasian, Latin American, Oceanic and African civilizations which have the main world reserves of fossil fuel, and also OPEC that produces a significant influence on production and prices for fuel (negotiations are underway to establish a similar mega monopoly between states in the gas industry). The next pole is North American, Western European, Eastern European, Japanese, Chinese, Indian civilizations that consume a larger portion of world energy resources and can't function without importing their significant volumes.

Due to their monopoly position and opportunity to influence the level of prices for major oil and gas export countries (including Russia) appropriate enormous volumes of world oil and gas rent in the periods of high world prices that are paid by buyers of such resources. However, as a result of the energy-ecological revolution the monopolists will significantly lose such opportunities. Competition from the alternative, including high-tech (hydrogen) types of energy will increase, the position of the states and civilizations will strengthen which will be able to implement a technological overturn in the energy sector (this first of all is oil and gas importers). In prospect, it may be anticipated that energy will become cheaper on the world market, increase in stability and predictability of prices. Total mass of energy rent will reduce but a share of high-tech civilizations will increase in its appropriation.

Consequently, the energy-ecological revolution will transform not only a technological base of production, transmission and consumption of energy but also establish favorable conditions for competitive market economy on a global scale.

It is clear that the establishment of the noospheric energy-ecological mode of production and way of life planet-wide will take long — at least half a century.

3. SCENARIOS OF ENERGY-ECOLOGICAL DYNAMICS OF CIVILIZATIONS FOR A PERIOD UP TO 2050

3.1. Global Energy-Ecological Imperative

Let's begin our forecast of the global energy-ecological dynamics not traditionally — from production and consumption of energy but from the end ecological result — dynamics of atmospheric pollution with greenhouse gases. According to many experts and politicians it is exactly such pollution leads to adverse changes in climate. It is more so relevant that at the meeting of G-8 leaders in Germany in 2007 the European Union, Japan and Canada brought forward a quantified ecological imperative for the first time — reduce double the greenhouse emission into the atmosphere by 2050. In actual fact, this is a global normative ecological forecast. To what extent is it real?

Let's examine scenarios of dynamics of greenhouse gas emissions into the atmosphere first on the global level by giving an example of carbon dioxide CO_2. This is the major pollutant. According to the World Bank in 2003 CO_2 emissions made

26,751 mln t (an average increase for 1990—2003 — 1.2%), in 2000 methane emission made 5,894 mln t (an average annual reduce for 1990—2000 — 0.6%) and nitrogen oxide — 3,454 mln t (an average annual increase for 1990—2000 — 0.3%). We'll found our forecast of the greenhouse gas emission on the figures of the UN demographic forecast of population size dynamics on the planet (medium variant and the figures of the World Bank on consumption dynamics of energy and emission of CO_2 per capita. Let's base our estimations on two scenarios: inertia-based (persistence of emissions per capita on the level of 2003 that corresponds to the tendency formed in 1990—2003) and innovative-breakthrough (implementation of the normative requirement to reduce the emission by 50% in general on the planet by 2050 brought forward at the G-8 summit in Germany in 2007). The estimation results are given in *Table 5.*

Under the inertia-based scenario the level of CO_2 emissions per capita by 2050 will remain on the level of 2003. However, due to a population growth for such period by 41% (under a slowdown of its increase from 1.28% of the average year increase in 2001—2005 to 0.9% in 2026—2030 and 0.5% in 2045—2050) and persistence of growth rates formed of energy consumption per capita (0.3%) an average annual volume of energy consumption by 2050 will increase by 62%, and CO_2 emission — by 41%. It will mean a further pollution of the planetary atmosphere with greenhouse gases, strengthening of unfavorable changes in climate, approximation to a global eco-catastrophe (if not its beginning).

Awareness of such remote but quite real threat made a number of the G-8 leaders to bring forward the demand to reduce double the atmospheric pollution by 2050. This demand (normative global forecast) means a decisive turn of the world political elite (and respectively scientific elite and global civil society) to the noospheric civilization, to the implementation of the global energy-ecological revolution.

Table 5. SCENARIOS OF DYNAMICS OF ENERGY CONSUMPTION AND CO_2 EMISSIONS IN THE WORLD FOR A PERIOD UP TO 2050

A — inertia-based scenario, B — innovative-breakthrough scenario

Indicators	Scenarios	2005	2030	2050	% of growth
Population, mln persons		6438	8199	9076	141
Average rates of increase for the previous quinquennium, %		1,28	0,90	0,50	39
		2004			
Energy consumption, mln t Oil equivalent	A	11026	15185	17902	162
	B		13635	9675	88
Per capita, kg	A	1793	1938	2064	115
	B		1663	1066	54
		1990–2004	**2004–2030**	**2030–2050**	
Average rates of increase, %: Energy consumption	A	1,7	1,2	0,8	47
	B		1,05	-1,7	
Per capita	A	0,3	0,3	0,3	100
	B		-0,3	-2,2	
		2003			
CO_2 emission, mln t	A	26751	34081	37727	141
	B		30068	13755	50
Per capita, t	A	4,3	4,3	4,3	100
	B		3,7	1,52	35
Per 1 t of energy consumption, t	A	2,43	2,43	2,43	100
	B		2,2	1,42	59
		1990–2004	**2004–2030**	**2030–2050**	
Average increase rates, %: CO_2 emission	A	1,2	0,9	0,5	39
	B		0,45	-3,75	
Per capita	A	0,0	0,0	0,0	100
	B		-0,6	-4,35	
Per 1 t of energy consumption	A	-0,55	-0,55	-0,55	100
	B		-0,4	-2,2	

For developing an **innovative-breakthrough scenario** let's take as the end result a reduction of 50% of the global CO_2 emissions by 2050. One should take into account that such result may be reached using two ways: energy-saving, i.e. considerably reduction in energy consumption per capita; change in the structure of energy sources, i.e. a transition to alternative, ecologically pure sources. At the various stages of development relation of such two ways inherent to the noospheric energy-ecological mode of production and sixth technological order will be different. It should also be taken into account that the world economy and a prevailing mode of energy consumption are remarkable for their high inertance (in the period before 2030 it will be prevailing, although in a less pronounced form) and in the next two decades the emission has to be reduced not only double, but compensate for its increase for the preceding three decades.

For estimation of the innovative-breakthrough scenario let's assume that in the period before 2003 the annual increase rates of CO_2 emission will be double less than under the inertia-based scenario (0.45%) and the volume of emission will increase by 2030 by 12.4% — up to 30,068 mln t (instead of 34,081 mln t under the inertia-based scenario) and emissions per capita will drop up to 3.7 t — by 15% (0.6% of average annual). But in such case within the next 20 years in order to achieve the normative total indicator (a double reduction of emission by 2050 against 2003) one will have to reduce the total volume of emissions 2.2 times (3.75% of an average annual drop) and the volume of emissions per capita — up to 1.52 t (41% by 2030 or 4.35% of an average annual drop).

It is clear that such reverse in tendencies may be reached only based on the drastic ***global energy-ecological revolution***. A reduction of the energy consumption by such rates under traditional energy technologies would result in degradation of economy and society in general, to the collapse of the global civilization. The question is whether or not such results of the energy-ecological revolution are attainable in practice? Or should one await them for a much longer time — to the end of 12th century?

3.2. Ways to Implement the Energy-Ecological Imperative

There are two major directions in the achievement of the desirable level (to reduce double greenhouse gas emission into the atmosphere by 2050 against 2003) based on the energy-ecological revolution:

➠ Reduction of energy demands and its consumption based on conversion to the energy-conservative mode of production and way of life. In the periods of the deep-seated economic crises such tendency was observed in Russia and other post-Soviet countries, in some countries of Western Europe; German experience indicates that it is possible under regular conditions of an economic growth, although on a lesser scale;

➠ A conversion from fossil fuel to the prevalence of alternative ecologically clean sources of energy. Such conversion is taking shape but it requires a long time and billion investments in the in-depth transformation of the global energy sector.

For our estimation let's take the starting assumption that a half of reduction of emissions under the innovative-breakthrough scenario against the inertia-based one will be reached through the first direction and a half — through the second. In such case an average annual reduction of energy consumption will turn out approximately double less that would be required for reaching the same result due to reduction of energy consumption under recent energy technologies. Total volume of energy consumption in such case by 2030 will increase by 24%, and at the second stage it will fall by 29%; totally for 45 years the level of energy consumption will fall by 12% as a result of the energy-ecological revolution under an increase in population for the same period by 41%. The prospect is quite tough but seemingly attainable using the structural shifts in economy (a drop of share or ousting of a number of energy intensive industries), conversion to energy-saving technologies in production and private consumption and using a significant replacement of fossil fuel with ecologically clean alternative sources of energy. In this regard it should be taken into account that in 2004 a share of renewable sources of energy made 10.8% in the world and increased by 0.5% only for 14 years; in Africa to the south of the Sahara it made 59.7%; in South Asia — 38%; in general by countries with low level of income — 47.8% (mainly for burning wood and animal production waste); in Brazil — 26.5% (mainly due to ethanol).

However, the prospects that such normative forecast in question will be implemented by the middle of the century, becomes considerably complicated if such problem is viewed by group of countries (countries with high, medium and low income of population and by civilizations (*Table 6*).

Although a share in the world energy consumption of the countries with low income where 36.5% of the world population resided in 2005 increased from 9.0% in 1990 to 10.2% in 2004, and energy consumption per capita grew from 484 to 513 kg, their lagging behind the countries with high income increased from 10.4 to 10.7 times by the last indicator. A gap in the installed power per employee is one of major reasons underlying polarization in GDP level per capita that made 61.2 times in 2005 at the current exchange rate and 13.1 times by PPP. It also should be taken into account that a gap in the level of installed power per employee is even more significant — in 2004 5.9% only of electricity of the world produced in the countries with low income (a considerable part of the population had no access to electricity at all). While a share of the countries with high income made 58%. Energy efficiency is 65% lower in the countries with low income and their share in the world GDP made 3.2% only in the world GDP.

It may be anticipated that in the countries with low income energy consumption and CO_2 emission in the first half of the 21st c. (which was 16 times lower in 2003 than in the countries with high income) will grow at the priority rates that will permit bridging up at least double the existing gap in energy consumption and labor productivity by 2050. Hence, three primary conclusions follow:

First, the major burden to reduce emissions of greenhouse gases, conversion to alternative sources of energy and reduction of energy consumption should be undertaken by the countries with high level of income.

Second, countries with low level income where energy consumption will be growing in prospect, should take the energy-saving and ecological clean type of growth of the energy sector from the very beginning adequate to the noospheric ecological mode of production.

Third, as the countries with low level of income have no sufficient own resources — either financial or personnel — for assimilating the achievements of the energy ecological revolution the countries with high level of income (and first of all the G-8 countries and European Union) have to assume an additional and significant portion of burden of the innovative upgrading the energy sector in the countries with low income, transfer of technologies and personnel training. Sizes, directions and forms of such support may be determined after drawing a global forecast of the energy ecological future by groups of countries and civilizations.

3.3. Prospects of Energy-Ecological Dynamics: Civilizational Aspect

Even more differentiated picture of the forthcoming global energy-ecological overturn is taking shape when estimating

Table 6. DYNAMICS OF ENERGY INDICATORS BY GROUPS OF COUNTRIES

Indicators	Years	Countries with low income	Countries with medium income	Countries with high income	World
Population, mln persons in % of the world population	2005 2005	2352 36,5	3024 42,7	1011 15,7	6438 100
Energy consumption, mln t of oil equivalent (o.e.)	1990 2004	723 1137	3503 4431	4369 5513	8610 11026
% of the world	1990 2004	8.4 10,2	40,7 40,2	50,7 50,0	100 100
per capita, kg o.e.	1990 2004	484 513	1349 1451	4842 551	1685 1793
% of the world	1990 2004	2,8 2,5	80,1 80,9	2871 307	100 100
Energy efficiency GDP 2000 by PPP* per 1 t of energy consumption in oil equivalent	1990 2004	3,5 4,4	3,0 4,2	4,7 5,2	3,9 4,8
% of the world	1990 2004	90 92	77 88	121 108	100 100
Energy supply Net energy import, % of energy consumption	1990 2004	-2 -3	-25 -27	16 19	-2 -2
CO_2 emission Mln t	1990 2003	1337 1893	8320 10754	10652 12738	22501 26751 100
% of the world	1990 2003	5,9 7,1	36,4 40,2	47,3 47,8	100
per capita, kg o.e.	1990 2003	0,8 0.8	3,5 3,6	11,8 12,8	4,3 4,3
% of the world	1990 2003	18,6 18.6	81,4 83,7	274,4 297,2	100 100

*PPP — purchasing power parity

the dynamics of the energy sector in a civilizational aspect. 12 local civilizations of the fifth generation have been divided into two groups based on an energy supply criteria (relation of net import to energy consumption): energy deficient (North American, Western European, Eastern European, Japanese, Chinese and Indian) and energy excessive (Moslem, Eurasian, Latin American, Oceanic, Buddhist and African). Although both energy deficient and energy excessive countries exist in many civilizations, we are taking as a base the type of energy supply prevailing in such civilization. Some civilizations are represented by one or an absolutely dominating country (Japanese — Japan, Indian — India, Oceanic — Australia, North American — USA, Eurasian — Russia) or by group of countries (Moslem — countries of the Middle East and North Africa, western European — Euro zone); countries — representatives are taken for other civilizations (Eastern European is represented by Poland, Buddhist — Viet Nam). Such choice is determined by statistical data published in the yearbook of the World Bank 2007 World Development Indicators. Production and consumption of energy is quoted in tons of oil equivalent (o.e.).

Such estimation results are given in *Table 7*, *Fig. 4* and *5*.

What conclusions may be made?

First, the level of electricity consumption differs from civilization to civilization many times. It is highest in the USA — 7,921 kg per capita; the lowest one in the African civilization — 452 kg. — i.e. 17.5 less. Although such gap will be reducing with the lapse of time (in 1990, it made 24.4 times) but it remains significant showing polarization in the technological and economic level of development of civilizations. The group of leaders includes Australia (5,672), Russia (4,460), Japan (4,173) and Euro zone (3,990). It indicates that energy wasteful economy has formed in such countries and major reserves for energy saving are obvious.

Civilizations with a lower level of use per capita are at the other pole: African (452), Indian (531), Buddhist (691), Latin American (1,187), Near East and North Africa (1,189). The coming together by the level of energy consumption should be from the two poles: lowering of the overall level of consumption in the countries with high income and increase in the lagging countries while the general world trend of energy consumption per capita should be going down (mainly at the vanguard countries).

Second, many civilizations with a high level of energy consumption are energy deficient (except Australia) and covers a growing part of energy consumption from import. The worst position is with Japan (96%) and Euro zone (63%). An accelerated economic growth aggravated energy dependence of China (5%) and India (19%) although there is no that high share of import in the energy consumption. At the same time civilizations with a relatively low GDP level per capita are the major suppliers of energy to the world market: for Near East and North Africa — energy export makes 131% of consumption, in Russia — 81%, in the African civilizations — 58%.

As a result of the energy-ecological revolution the situation will radically change on the world market. The vanguard civilizations after mastering energy saving and ecologically clean sources of energy and reducing the consumption of primary energy resources will be dominating on the world market. They will supply technologies and high-tech equipment appropriating a technological quasi-rent. Fast developing civilizations now (Chinese, Indian) may take the same path reducing pressure on the world fuel market. Positions of the today's major exporters to the world energy market will weaken. The sizes of world fuel rent appropriated by them will significantly reduce, especially in the periods when oil and gas prices are going down (although no return to the prior level of the 80—90s is possible).

Table 7. DYNAMICS OF MAJOR INDICATORS OF THE ENERGY SECTOR BY CIVILIZATIONS

Civilizations	Years	Energy Production, mln t o.e.	Energy Consumption, o.e.		Energy Efficiency d/t, o.e.
			total, mln t	Per capita, kg	
Energy deficient civilizations North-American – USA	1990 2004 increase rate, %	1650 1641	1938 2326 1,4	7722 7921 0,2	3,7 4,6
Western European — Euro zone	1990 2004 increase rate, %	471 4,63	1053 1245 1,3	3958 3990 0,9	5,8 6,5
Japanese — Japan	1990 2004 increase rate, %	77 97	446 532 1,2	3610 4173 1,0	6,5 6,4
Eastern European– Poland	1990 2004 increase rate, %	99 79	100 92 -0,19	2620 2403 -0,18	2,9 5,1
Chinese — China	1990 2004 increase rate, %	889 1537	866 1609 3,6	763 1242 2,6	2,1 4,4
Indian– India	1990 2004 increase rate, %	333 467	362 573 3,3	426 531 1,5	4,0 1,5
Energy excessive civilizations Moslem (Middle East and North Africa)	1990 2004 increase rate, %	602 624	194 357 4,3	661 1189 2,3	4,6 4,2
Eurasian — Russia	1990 2004 increase rate, %	1119 1158	775 641 -1,2	5211 4460 -0,9	1,6 2,0
Latin American	1990 2004 increase rate, %	618 910	460 645 215	1050 1167 0,9	6,0 6,2
Oceanic (Australia)	1990 2004 increase rate, %	158 262	88 116 2,2	5130 5762 1,1	4,0 4,8
Buddhist (Viet Nam)	1990 2004 increase rate, %	25 65	24 50 5,1	367 611 3,5	3,3 4,2
African (to the south Sahara)	1990 2004 increase rate, %	482 715	317 452 4,4	693 703 0,0	2,8 2,8 0,0

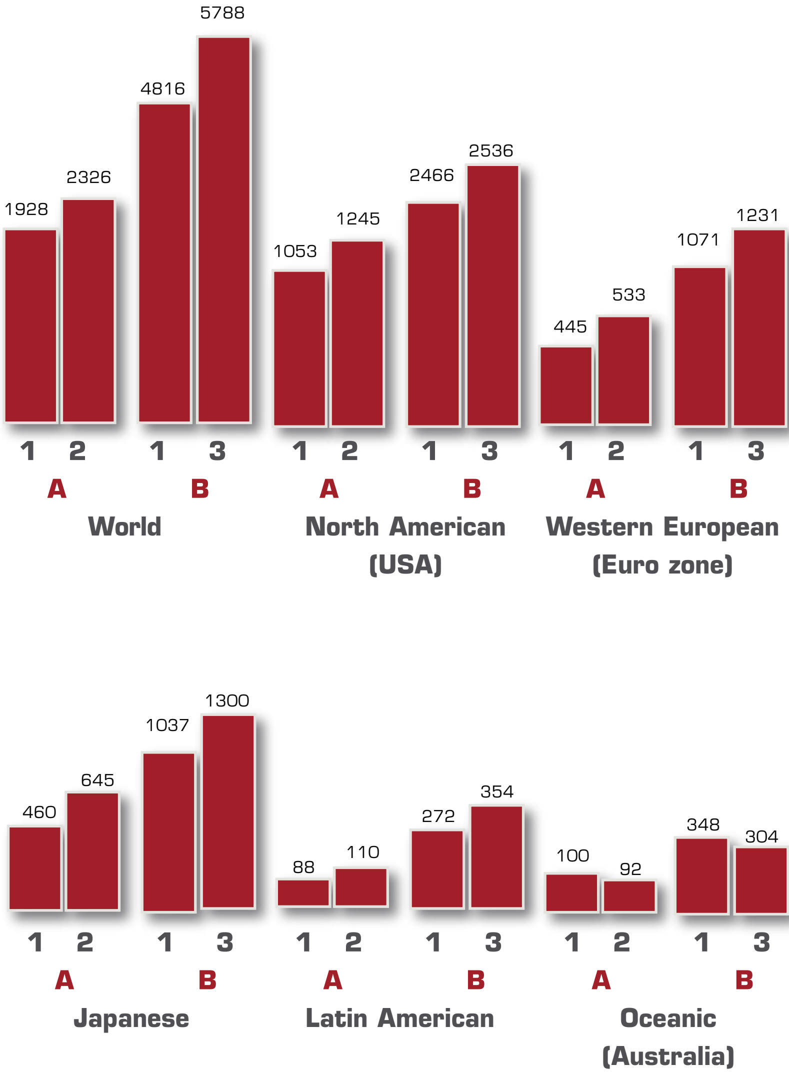
Net Import in % of consumption	CO_2 Emission	
	Per capita, t	in % of the world
14 29	4816 5788 1,7	19,3 19,9
65 63	2466 2536	8,3 8,2
45 96	1070 1231 1,0	8,7 9,6
2,2 5,0	348 304 -1,3	9,1 8,0
3 5	398 4144 2,5	21 3,2
8 19	578 1273 4,9	0,8 1,2
-210 -131	575 1012 4,5	2,5 3,4
-44 -81	2262 1493 -3,3	15,3 10,3
-34 -41	1037 1300 2,0	2,4 2,4
-80 -126	272 354 2,7	15,9 17,8
-2 -30	21 76 11,5	0,3 0,9
-52 -58	418 532 1,6	0,8 0,8 0,0

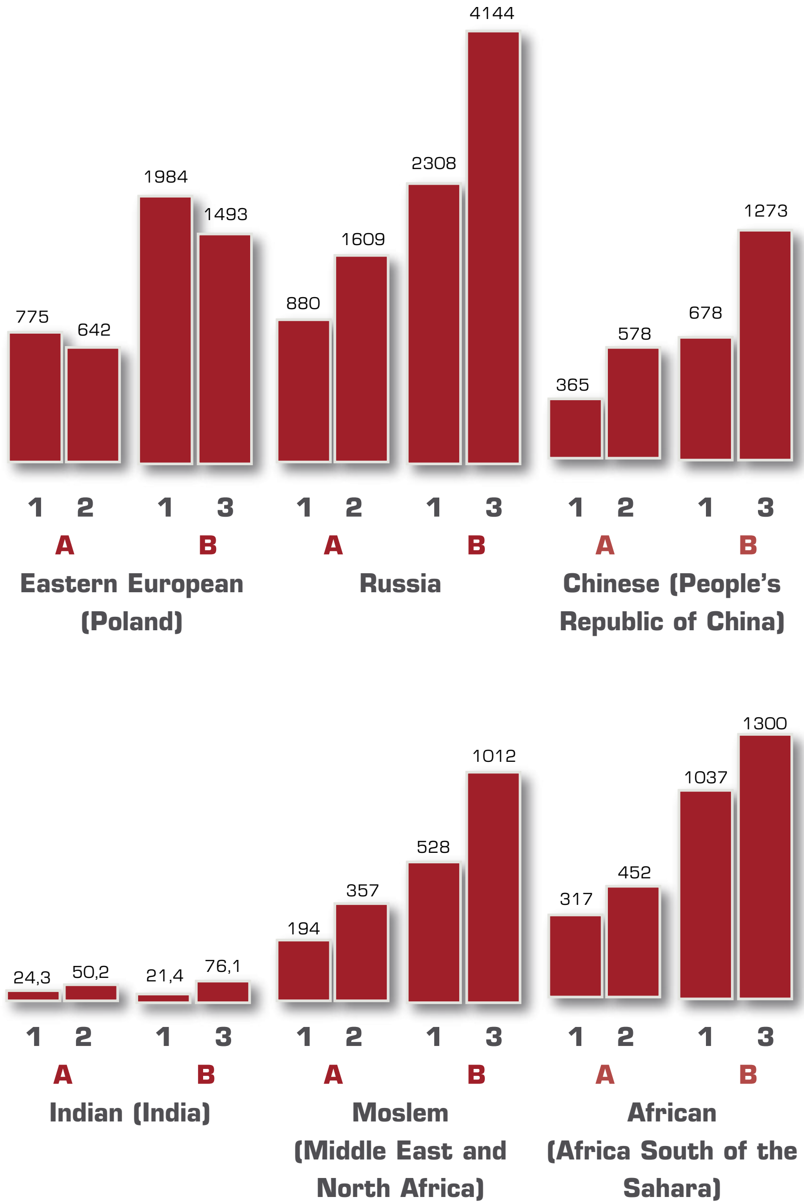
From 1970 to 2006 the world prices for oil grew 13.8 times, for natural gas in the USA — 8 times-while prices for non-energy commodities reduced by 12% (including for agricultural products — by 29.4%). It is unlikely that such tendency leading to re-distribution of resources and income in favor of the oil and gas complex and putting brakes on the economic growth of energy consumers will persist in future. Replacement of fossil fuel with alternative sources of energy will finally lead to the diminution in demand for hydrocarbon fuel, stabilization and then to a drop in price for it. Further growing prices for fuel are turning to the major impetus to assimilation and widening of alternative sources of energy and cost reduction and prices for them in the scale production and use make such resources are even more competitive.

Third, alternative energy largely belongs to high-tech, science intensive products and is organically included in the technological revolution. The result of such revolution will be assimilation and diffusion of the sixth technological order in

Figure 4. DYNAMICS OF ENERGY CONSUMPTION AND CO_2 EMISSIONS BY CIVILIZATIONS

1 — 1990; 2 — 2004; 3 — 2003.
A — energy consumption, mln t oil equivalent
B — CO_2 emission, mln t





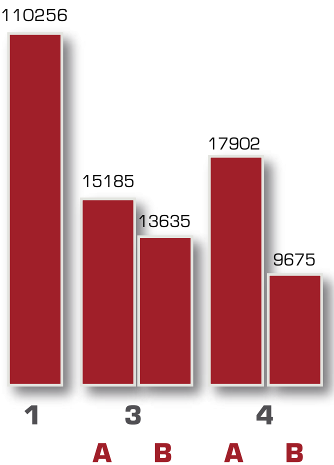
Source: The 2007 World Development Indicators. Washington: The World Bank, 2007. P. 150—156.

Figure 5. DYNAMICS FORECAST OF ENERGY CONSUMPTION AND CO_2 EMISSION IN THE WORLD

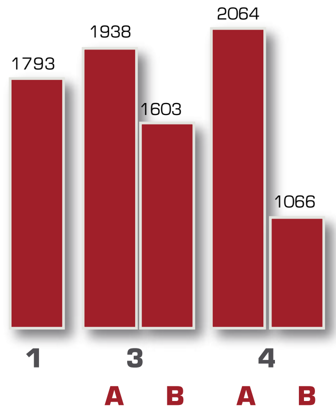
1 — 2004; 2 — 2003; 3 — 2030; 4 — 2050.
A — inertia-based scenario; B — normative innovative-breakthrough scenario

Energy consumption

Mln t of oil equivalent

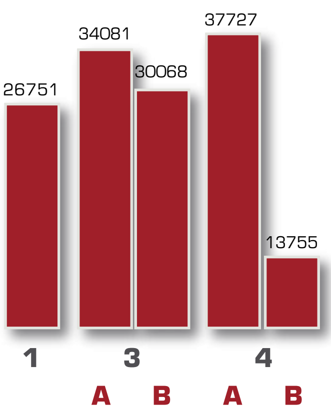


Per capita, kg

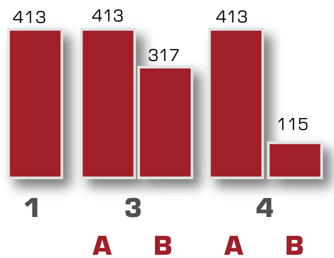


CO_2 emission

Mln t of oil equivalent



Per capita, kg



the vanguard countries, and then world wide as well as the establishment of the new structure of economy. In such structure today's energy-intensive productions will efface and the leading positions will be taken by new energy-saving industry that assimilated nanotechnologies, biotechnologies and information technologies. The energy-ecological revolution is becoming an indissoluble component of the global technological revolution and transformation of the global energy factor — a decisive factor in reducing the consumption of primary energy resources and a considerable reduction of greenhouse gas emissions.

The problem is that such deep transformation of the global techno-sphere and energy sphere will require many trillion dollars and the lagging civilizations have not relevant funds for it. The countries with low level of development where more than one third of the world's population resides the gross domestic income per capita at the prevailing exchange rate is 60.3 times and PPP 13.1. times less than in the countries with high income where 16% of the population on the planet lives ('Golden Billion'). A lagging in mastering of achievements offered by the energy-ecological revolution will lead to losses in the competitiveness of the countries with low and medium income and an increase in the gap between reach and poor civilizations that has already reached the critical level.

A strategic objective of the world community represented by the United Nations is to take all steps to bridge up such gap, drawing closer the technological (and economic) level of development of civilizations. In order to do so significant adjustments should be introduced in the prevailing neo-liberal model of globalization, direct the flows of investments and new technologies to the lagging countries thus allowing them assimilating the fundamentals of the post-industrial technological and noospheric energy-ecological modes of production. At the round table session of the Johannesburg summit (2002) we suggested that the Global Technological Fund under the UN aegis should be created for account of deductions from export of high-tech products and weapons. Such fund would become a step towards the establishment of a new model of globalization and world order based on the principle of partnership among civilizations.

A more radical alternative to establish the Global Energy-Ecological Fund is possible on deductions at the fixed rates of excesses over the standard quotas (reducing by years) of CO_2 emissions into the atmosphere i.e. taking the world energy-ecological anti-rent in favor of the world community. These funds might be directed to the financing of energy-saving projects and assimilating ecologically alternative sources of power in the countries not having sufficient own funds and also for the arrangement of the global monitoring for atmospheric pollution. Such mechanism is able to replace the effective Kyoto Protocol (as the practices show its application does not give strong impetuses to reduce greenhouse gas emissions) and will become an efficient tool for the implementation of the global energy-ecological imperative, speeded diffusion of achievements of the energy-ecological revolution in all civilizations.

Certainly, building up such mechanism will require a great deal of efforts and long time for surmounting the resistance of the countries that are today's largest 'contributors' to the pollution of the planet and to establish the payment mechanisms and efficient use of the fund being formed. But we do not see another way to implement the ecological imperative and establishment of the noospheric energy-ecological mode of production on the global civilization scale.

Fourth, a double reduction of the greenhouse gas emission, implementation of the global energy-ecological revolution and building up the noospheric energy-ecological mode of production will become the reality only as a result of radical changes in the way of life and structure of the end consumption, especially in the developed countries. One should clearly understand that recent tendencies of wasteful energy consumption — seas of advertising, race for the leading-edge car models, private aircrafts, an extreme growth of residential space per each person, etc. lead to a dead-end. It is necessary to build up the culture of energy-saving and the model of thrifty energy consumption, differentiated for various climatic conditions. The development of e-commerce, e-offices, distance learning etc. will promote a drop in demand for energy. A healthy, reasonable, thrifty style of life is required for population of various civilizations in the context of their specifics. This is a primary strategic task of governments, civil society and mass media. A new, rational and economical noospheric ethics is required, the one that dispraises excesses, bravery, and spendthrifting. Efforts of global community will be required for developing and extending the noospheric way of life and energy-saving ecological, noospheric ethics.

Thus, a long-term forecast shows:

➠ The solution of the strategic task set at the G-8 summit in 2007 — to reduce double the level of atmospheric pollution is possible only under a large scale mastering and diffusion of achievements of the energy-ecological revolution, building up the noospheric energy-ecological mode of production, radical change in the prevailing model of globalization;

➠ A need for a considerable bridging up the gap between civilizations in the level of energy-ecological, technological and economic development; a need for the vanguard civilizations and world community to ensure the priority growth of lagging civilizations;

➠ A need for consolidation of intellectual, economic and political forces of humanity to work out and implement on the principles of partnership among civilizations the Global Energy-Ecological Strategy and effectual and efficient vehicle for its implementation.

4. RUSSIA IN THE ENERGY-ECOLOGICAL REVOLUTION OF THE 21ST CENTURY

4.1. Russia in the Global Energy Sector

Position of Russia in the modern world hit by the global energy-ecological crisis and standing at the threshold of the energy-ecological revolution is dual and contradictory.

On the one hand as the possessor of a considerable part of proved oil and gas reserves and supplier to the world market of a growing share of its production Russia takes advantages filling its bags with money (reserves of the Central Bank, Stabilization Fund, currency accounts of oil and gas companies) and is ready for possible unfavorable fluctuations in the conditions of the world market.

On the other hand, signs of the 'Dutch Illness' arises: why efforts and means should be spent for costly and risky innovative transformation of economy, energy-saving technologies, alternative energy sources, improvement of competitiveness of local finished products if it is enough to lay new pipes and direct additional flows of oil and gas through them, deposit the accumulated rent with the reputable banks and live in the sun?

Currency flows of 'oil money' in Russia are putting brakes on the entrepreneurial and innovative initiative. The main concern of the RF Ministry of Finance becomes to 'how sterilize' 'excessive' money, how don't let them to the internal turnover so that not to speed up inflation.

However, Russia can't sit passively on the shore of a furious stream of the energy-ecological revolution through a number of reasons.

First, the reserves of 'black and blue gold' are not boundless. Oil production in a couple of decades and gas production in three-four decades will begin to fall drastically. What will be Russia using to satisfy internal demands of economy and meet export obligations undertaken? What will be left for next generations of Russians?

Second, by the measure of energy efficiency (GDP per unit of consuming energy resources) Russia falls 2.5 times behind the average world level and 2.7 times — the level of the countries with high income. Energy facilities of the country are extremely outdated, shortage and growing prices for energy are putting breaks on the economic growth, bring about a growing discontent of population.

Third, outdated fixed assets of the Russian energy sector (including public energy) need radical innovative upgrade that will require hundreds of billions of US dollar investments in the fixed capital. Such contributions should be made on a fundamentally new basis, not to rob the belly to cover the back and assimilate consistently energy-saving, ecological clean sixth technological order.

Fourth, the population size is falling in Russia, its share in the population of the world dropped from 3.2% in 1980 and 2.9% in 1990 to 2.2% in 2005. According to the UN medium variant of forecast it will drop by 1.3% by the middle of the century. The population density of the country is low making only 18.5% of the average density in the world, and it will drop by 10% by 2050 with its considerable part living in unfavorable climate conditions, in the Far North or the like regions. In the long-term prospect the population size of the country will reduce by 2050, according to the UN medium scenario by 22%, and according to a favorable scenario — by 6%. A shortage of manpower resources will be considerable.

Fifth, a share of Russia in the world's GDP (by PPP) is minor and dropped significantly in the period of crisis– from 5.6% in 1990 to 2.6% in 2000 and by 2.5% in 2005. This limits the resources that might be used for modernization and ecologization of the energy sector. While Russia exceeded nearly double the world economic before the crisis of the 90s (GDP per capita) then this indicator made 32% only of the world level at the prevailing currency rate in 2000, and in 2005 — 64%. It is unlikely that a share of Russia will considerably increase in the world's GDP in the long term.

Sixth, Russia remains one of the major energy producers in the world, more and more working to meet the demands of the world energy market: while a share reduced in the world energy consumption from 11% in 1990 to 8.6% in 2005, percentage of Russia in the world energy production has increased from 10.8% to 12.7%, and the relation of export and own energy consumption — from 44% to 81%. A share of fuel in the country's structure of export in 2005 made 49% as compared with the world average indicator — 10%. This means that Russia is turning more and more to the energy donor for the countries of Western and Eastern Europe, China, and Japan. In doing so the economic growth of the country is encumbered as fuel prices and energy shortage are growing.

Such tendency can't persist long, first of all because of depletion of oil and gas reserves at the rich working deposits in the developed regions. According to experts a reduction in oil production will already begin by 2020, and a fall in the gas production will occur after 2030 from the deposits on land. Rich deposits remain on the sea shelf and in some areas of the Far East but their development will require major investments in the production and development of fields and transport infrastructure. A demand for fossil fuel may reduce on the world market by that time, and the world prices may drop that will question the return on such investments.

Seventh, energy efficiency is extremely low in Russia (in 2005 — all in all 42% of average world), and CO_2 emission per capita and GDP unit is 2.4 times higher the average world indicators. This indicates a low energy and ecological efficiency of the energy sector. It could also be hardly explained by worsening climatic conditions only. Such wasteful manner of use of energy consumption has no future. Therefore a conversion to ecologically clean alternative sources of energy, energy saving production practices and style of life is a pressing imperative.

Eighth, the fuel-energy complex in Russia is a major initiator and inflation engine in the country, a brake on the improvement of the level of life of population. In the inflation explosion of the 90s the fuel industry and energy were leading. This tendency still persists. For 2001—2005 the price index in the production of fuel-energy raw material increased 3.5 times, in production, transmission and consumption of electric energy — 3.3 times under a growth of prices in general in the industry of 2.8 times and consumer price index — 2.3 times. Envisaged (upon the insistent request of the European negotiators for accessing the WTO) a three-time increase of prices for natural gas will result in the knock-on effect of growing prices throughout the energy sector and will extremely impede the task of reduction of emissions of the greenhouse gases. The matter is that in Russia a share of gas in the energy sources of electric energy production made 45.3% in 2004 against 19.7 on average world and 19.1% for the countries with high income. An increase in the coal firing (mainly brown) at the electric plants will result in the increase of greenhouse gas emissions into the atmosphere.

4.2. Strategy of Transition to Alternative Energy

The central link of a long-term energy-ecological strategy of Russia as well as other countries is a large-scale transition to the alternative, ecologically clean sources of energy — and fixed plants (first of all, production of heat and electric energy) and in transport. The matter in question is both renewable sources of energy already used (water energy) and fundamentally new (hydrogen with fuel cells, ethanol, solar, tidal energy etc.). A share of energy from renewable sources in the general consumption of energy is inconsiderable in Russia and has a tendency towards reducing from 1.6% in 1990 to 1.1% in 2004 while it made 10.3% in the world. A share of water energy made 18.9% (average world indicator — 16%) in the sources of electric energy production in 2004, nuclear energy — 15.6% (average world indicator — 15.8%).

A considerable reduction of greenhouse gas emissions into the atmosphere of Russia may be achieved by 2030, according to the normative innovative-breakthrough forecast, only for the intensive use of the following factors:

- A considerable reduction of the overall level of energy consumption based on a conversion to the energy saving technologies in production and household; a reduction of losses in transportation of energy and in heating of houses; structural shifts in economy (a reduction of share of energy intensive productions), etc. According to estimations a half of required reduction in greenhouse gas emissions may be achieved through a conversion to energy saving economy;
- An increase in 3-4 times a share of renewable sources of energy (water energy, wind energy, tidal, geo-thermal sources, sun etc.); development of small hydro energy is promising here;
- An increase of a share of nuclear energy from the present-day 16% to 25—30%; however, this is an extremely capital intensive factor (in the context of large investments both in construction of atomic power plants and ensuring their safety operation and decommissioning and storing of atomic power plants and agents out of use);
- Assimilation and arrangement of a large scale use of the fundamentally new sources of energy related to the sixth technological order; this first of all refers to hydrogen with fuel cells and ethanol.

Let's expound on the prospects of conversion to **hydrogen energy** as one of the prime high-tech alternative sources of energy. This is more so topical as many countries and regions of the world (USA, European Union and Japan) have approved long-term hydrogen programs and supported through allocation of billions of dollars of governmental and private investments. A strategy of conversion of Russia to hydrogen energy is validated in the treatise [12] and in the project of the national scientific-innovative program 'Hydrogen Energy' for a period up to 2050 [12, Supplement 1].

An impetus to launching researches in hydrogen energy was given by the world energy crisis of the beginning of the 70s. But long-term hydrogen programs appeared in the vanguard countries only in 2003, after the summit meeting in Johannesburg (2002), and also due to a leaping growth of world prices for fuel and entry into force of the Kyoto Protocol.

In Russia, researches in hydrogen energy were conducted on the world level up to the 1990s. In the course of neo-liberal market reforms the governmental support of such promising efforts were nearly ceased. Only from the end of 2003 after signing the agreement between the Russian Academy of Sciences and mining and metallurgical company Norilsk Nickel and approval of the Comprehensive Program for pilot, research and engineering efforts in hydrogen energy and fuel cells, the researches were resumed and being worked at extensively. However, the governmental support of such researches is insufficient; and a technological lagging of Russia from the vanguard countries in hydrogen energy is wiping up slowly.

In order to wipe up such lagging and increase the role of the state in the implementation of the contemporary scientific-technological overturn the Institute for Economic Strategies, P. Sorokin — N. Kondratieff International Institute, the hair of the theory and practice of governmental regulation of the market economy of the Russian Academy of Public Service under the RF President have made a scientific report and concept for building up the National Scientific-Innovative Program 'Hydrogen Energy' for a period up to 2050. The report was published and discussed at the 19th Cross-Disciplinary discussion at the RAGS on March 30, 2005.

At the G-8 summit in Saint Petersburg in July 2006 the issue on global energy security was discussed and the Saint Petersburg Plan of Action Global Energy Security was approved. Two items in this plan has a direct relation to hydrogen energy. Item 26 reads: 'We support the transition to the Hydrogen Economy, including in the framework of the International Partnership for the Hydrogen Economy (IPHE). A critical part of this effort is to develop common international standards in the field of commercial development of hydrogen power, infrastructure and security requirements.' And part of item 21 covering the efficiency and energy saving on transport reads: 'To increase research to develop vehicles using gasoline/hydrogen fuel and hydrogen fuel cells to promote the "hydrogen economy". Thus hydrogen energy and hydrogen economy has gained the higher international recognition as long-range directions in the development of global energy in the 21st century.

At the summit an increasing demand for energy resources (according to the estimates it will increase by 2030 one and a half time where approximately 80% will be satisfied from fossil fuel with limited reserves) was mentioned among global energy problems as well as high and unstable prices for oil; a growing dependence of many countries on import of energy sources; demand for huge investments in all links of the energy chain; a need in environmental protection and solution of the climate changes. The summit also pointed out at the need for making medium-average and long-range forecasts of demand for energy resources.

In 2005, the National Innovative Company 'New Energy Projects' (N.I.C. N.E.P.) was established. In actual fact it has become the managing company of the Hydrogen Energy Program and acts in close cooperation with Nornickel Co. and the Russian

Academy of Sciences. The company started the evaluation, selection and implementation of promising scientific-research and engineering projects in hydrogen and hydrogen fuel cells, took part in several international exhibitions, established contacts with a number of foreign companies operating in this area.

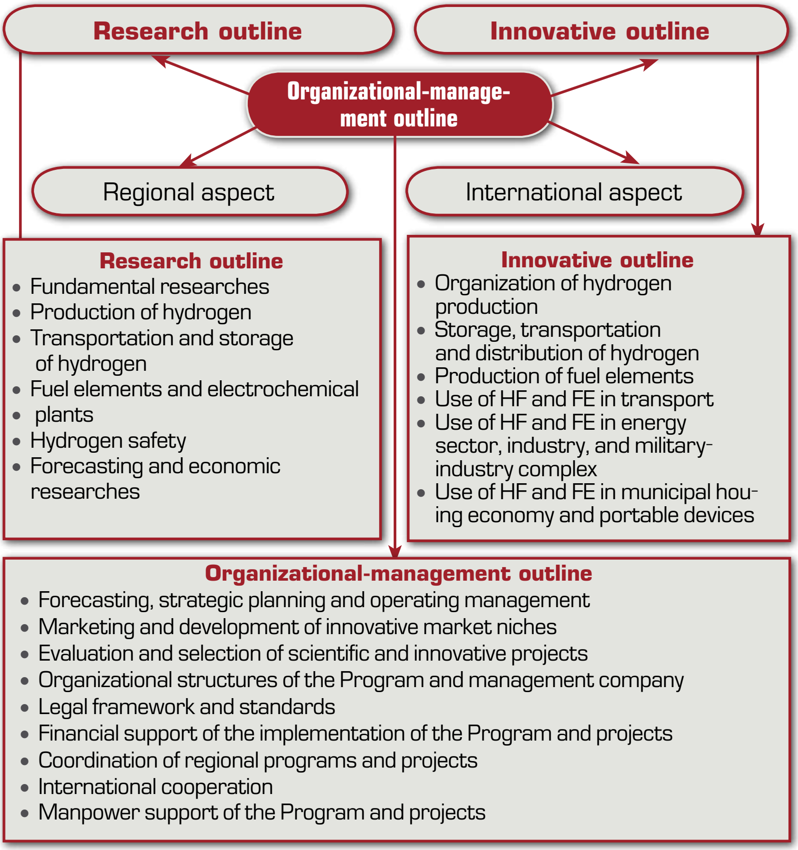
The activities connected with the establishment of personnel and information support of the establishment of hydrogen energy pursued by the Moscow State Institute of Radio Engineering, Electronic Engineering and Automatic (Engineering University) (M.I.R.E.A.) together with the chemistry faculty of the M.V. Lomonosov, other higher educational establishments in cooperation with the National Association of Hydrogen Energy and Russian Academy of Public Service under the RF President intensified. Scientific conferences on these problems are held on a regular basis, youth hydrogen club was established, they publish the journal Hydrogen General Education.

What are attributes and specifics of the national hydrogen energy program?

1. ***The object of the national program is a technological base and economy of the country in general***, prime directions in their transfer to a qualitatively new state at the next stage of the life cycle. The matter in question is a global transformation of the national energy sector, radical restructuring of its all links — from sources of energy and power engineering industry to the varied directions in energy saving — stationary conditions (including electric public utilities), transport and in portable electronic devices.

A conversion to hydrogen energy — a part of the energy ecological revolution means replacement of exhaustible fossil fuel causing damage to the environment with reproducible ecologically clean sources of energy. This is shown in the objectives of a program: to increase a share of hydrogen in the structure of the energy consumption balance up to 30%, saving

Figure 6. STRUCTURE OF THE NATIONAL INNOVATIVE PROGRAM 'HYDROGEN ENERGY'



of fossil fuel and reducing the volumes of CO_2 emissions into the atmosphere by 25% (along with the use of ethanol and other ecologically clean energy sources).

2. ***The national program for the hydrogen energy covers all stages of mastering and diffusion of the epochal innovation:*** all fundamental and applied research effort, and development efforts, organization of production, realization and

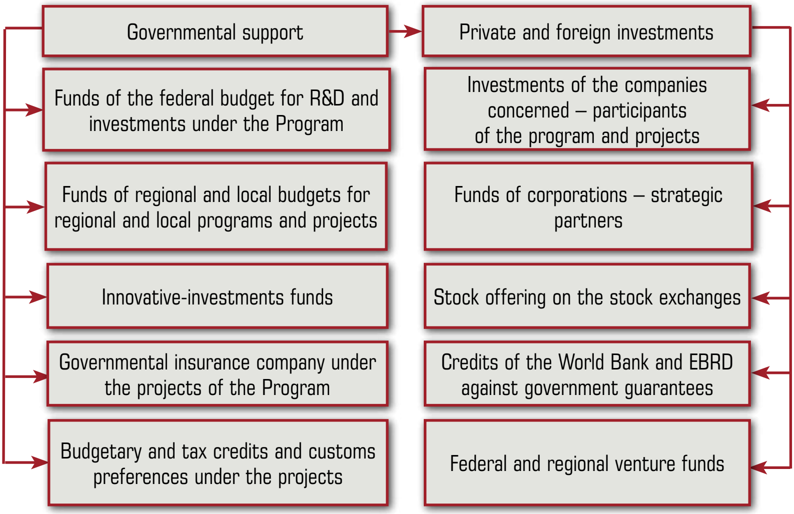
use of a new source of energy. Such approach allows determining the nature of the hydrogen program as scientific-innovative. Hence the envisaged structure of the programs is stemmed (*Fig. 6*) that includes three major outlines: research (scientific base and necessary scope of research and development efforts — from fundamental and pre-discovery to design efforts, preparing tests of pilot samples and demonstration models); innovative-production (mastering, diffusion, organization of a large scale production); organizational-management integrating the activity of all links at all stages of implementation of programs.

3. *The national program 'Hydrogen Energy' has a half century horizon*. 5—10 years will be required for a scientific development, testing and selection of the most efficient samples of equipment and technologies, preparing the spheres of production and use of hydrogen and fuel cells. Even larger period is required for an innovative mastering and diffusion of a fundamentally new high-tech source of energy in various spheres, including production and personal consumption. It is not by coincidence the US hydrogen program and hydrogen platform of the Eurasian Union have the same horizon — 2050, and the normative forecast of G-8 members of double reducing the greenhouse gas emissions is also envisaged for the same period. Therefore the energy-ecological strategy shall cover the period up to 2050 and has quantified parameters (indicators) at all its stages.

But such long-term horizon of the program predetermines its flexibility, mandatory regular (at least once within a decade, and if necessary — also in five years) update and partial adjustment of the items on the program in the context of the outputs and new opportunities (scientific discoveries, major inventions, and efficient base innovations).

4. National program ***is of a cross-disciplinary, cross-sectoral***, cross-regional and cross-state nature, embracing a wide range of related scientific, innovative-production, economic, ecological, social problems that meets the requirements of

Figure 7. SOURCES OF FINANCING OF THE NATIONAL SCIENTIFIC-INNOVATIVE PROGRAM 'HYDROGEN ENERGY'



national and globalized world economy. Therefore the depth of transformation of the reproduction structure and spheres of production, circulation and consumption of the national program are deeper and longer.

5. ***Sources of financing*** of the national program (*Fig.* 7) are varied and change in time. The budgetary investments prevail as a rule in the starting period and primary mastering of base innovations. At the stage of diffusion of innovative technologies the center of gravity is transferred to the private investment and attraction of foreign capital. High-tech stock exchange may be used for it (in Russia — the sector under way of innovative and fast developing companies of the Moscow Interbank Currency Exchange). The specific of Russia is that the function of the starting investments has been assumed by the mining and metallurgical company Nornickel at the initial stage which allocated $40 mln annually for a scientific debugging of future innovative projects.

Another situation is being formed in the nanotechnologies where the budgetary investments are envisaged from the very beginning amounting to $7 bln as well as tax exemptions.

6. The national program has an ***organizational-management outline***. Its customer should be the government representing national, supra-departmental interests. In view of multiple executing parties the management company is necessary for the implementation of the program. The national innovative company 'New Energy Projects' established in 2005 exercises the management company functions of the national program 'Hydrogen Energy'.

The organizational-management outline of the national program should ensure the implementation of the principle of **innovative partnership** of the state, business, education and science. Each partner exercises its respective functions. **Science** makes forecast for such scientific-technological direction, conducts fundamental, applied researches and development efforts, grants inventions, and performs author's innovative projects. Based on the forecast the **state** draws up programs and projects, ensures its legal framework, allocates budget for the implementation of programs and projects (especially at the starting period), grants tax preferences, establishes favorable innovative climate. **Business** undertakes the implementation of innovative-investment projects and supports them with resources, develops market niches on the national and international markets. **Education** trains scientists, specialists, civil servants, qualified workers necessary for the implementation of the national program, frames information support, participate in researches, and publishes educational programs.

The national program 'Hydrogen Energy' will require tens of billions of dollars of governmental and private investments at all stages — from R&D to the innovative updating of fixed capital of all links of the energy sector but in return the effect received by the country will be significant and lasting. It will be in the following forms (*Fig. 8*):

Figure 8. EFFECT OF THE IMPLEMENTATION OF THE NATIONAL SCIENTIFIC-INNOVATIVE PROGRAM 'HYDROGEN ENERGY'

Innovative-technological effect →
- Improvement of competitiveness of national products
- Mastering of the sixth technological order
- Modernization of a scientific-innovative potential
- Bridging a technological lagging with the vanguard countries

Economic effect →
- Reducing energy content in GDP 2 times by 2050
- Cheapening power supply of economy
- Reducing payoff period of investments
- A share in GDP growth from energy in 2050 20%

Ecological effect →
- Extension of the mineral fuel field development periods
- A reduction of 25% of fossil fuel by 2050
- A reduction of 25% of the greenhouse gas emissions by 2050

Foreign economic effect →
- A reduction of 20% of a share of fuel in export by 2050
- An expansion of 5% of a share in high-tech export in 2050
- Reintegration of the CIS countries in the energy industry
- Strengthening of positions in world economy

Social effect →
- A growth of demands for scientists, specialists, skilled workers
- Increase in the real income of population
- Ensuring steady operations of the municipal housing economy
- Favorable climate for scientific creation, inventions and innovations

State-political effect →
- Strengthening the role of the state in the innovative breakthrough
- Ensuring socio-political stability
- Strengthening of geo-political positions of Russia

➠ ***Innovative-technological*** effect as a result of mastering of one of base directions of the sixth technological order, long-term improvement of competitive capacity of national products on national and world markets, demand and development of a scientific-technological potential of Russia, bridging a technological lagging with the vanguard countries;

➠ ***Economic*** effect reducing energy content in GDP (energy efficient improvement), cheapening energy sources and power supply of economy, increase of the energy-technological quasi-rent, speeding the GDP growth rates;

➠ ***Ecological*** effect significant reduction of greenhouse gas into the atmosphere, reduction of waste after production and mineral fuel enrichment, extension of the mineral fuel field development periods;

➠ ***Foreign economic*** effect determined by a reduction of raw material hypertrophy of export, increase in innovative energy rent in export of high-tech products and energy technologies, diminishing dependence on the fluctuation of the world fuel market conditions, strengthening of integration tendencies within CIS;

➠ ***Social effect*** determined by an increase in demand for highly skilled manpower and improvement of training quality, radical improvement of housing and utilities operation conditions, increase of real income of population, establishment of favorable climate for creative activity of the youth;

➠ ***State-political*** effect determined by an increase of the role of the state in the implementation of the strategy of the innovative breakthrough and a growing confidence from the population (that is a significant factor of social-political stability) and strengthening of geopolitical positions of Russia that may act as one of the originators of the working out the UN global energy-ecological strategy and its discussion at the World Summit.

Thus, the strategy of innovative breakthrough in hydrogen energy is not only of practical-specific significance for the solution of the most pressing problems of the country. Like once the GOELRO plan it may become the core for solving a package of economic, ecological and social problems of the 21st c. in Russia, an example of the innovative partnership among various institutes and social forces inside the country and partnership of civilizations in the world arena and establishment of a humanistic noospheric post-industrial society.

5. ANALYSIS AND FORECAST OF DYNAMICS OF ENERGY-ECOLOGICAL EFFICIENCY BASED ON THE ENERGY-ECOLOGICAL MATRIX

5.1. Methodology of Defining the Energy-Ecological Matrix

Let's apply the energy-ecological matrix for analysis and forecasting of dynamics of emissions into the environment. This tool is a development of the methodology of the strategic [14] and geo-civilizational [15] matrix used in our prior researches and forecasts.

Let's take for the end, summary indicator of the energy-ecological efficiency the level of CO_2 emissions into the atmosphere taking its limiting value under ideal relation of all major factors for 100 points. Let's also determine the major factors (indicators) defining the level of atmospheric pollution with greenhouse gases:

- ***primary*** factors — population size and energy consumption per capita. Let's estimate each factor in 25 points, total — 50;

➠ ***secondary*** factors directly influencing the level of atmospheric pollution — the structure of energy consumption (a share of alternative, ecologically clean sources of energy) and energy efficiency (consumption of energy per GDP unit). Let's estimate each factor as 15 points, total — 30 points;

➠ ***tertiary*** factors rending an indirect effect — energy-saving and ecological policy of the state and energy-ecological ethics (desire for saving energy and environment). Let's estimate each factor as 10 points, total — 20 points.

Let's take two scenarios as a base for estimation of the forecast scenarios: ***inertia-based*** — formed at the beginning of the 21st c. tendencies will persist but be somewhat changing in the context of dynamics and mutual influence of individual factors;

Innovative-breakthrough — based on the introduction of energy-saving technologies and replacement of fossil fuel with alternative sources by the end of the forecast period the level of the normative forecast will be reached — CO_2 emissions into the atmosphere will be reduced double.

The energy-ecological matrix takes account of the influence of a ***cyclical factor***. Medium-term cycles and crises phases accompanying them are evened within the decade interval. But a deep-seated civilization crisis of the 90s hit the Eurasian and Eastern-European civilizations and also a forthcoming crisis in the 20s in change of the fifth Kondratieff cycle by the sixth in the vanguard countries will result in slowing down the economic growth and reduction of energy consumption. The energy-ecological revolution of the 30—40s will be accompanied in the innovative-breakthrough scenario (under conditions of falling rates of increase in the population size) by a significant improvement of the energy-ecological efficiency.

Specifics of the energy-ecological matrix is that the leading indicators — volumes of CO_2 emission, growth rates of the population size and energy consumption per capita are of irreversible nature: an increase in CO_2 emission, energy consumption and growth rates of population reduce the global energy-ecological effectiveness. Other indicators have a direct nature: an increase in the share of alternative sources, GDP increase per unit of energy used, active energy-policy of the state and energy saving ethics influences favorably the dynamics of the summary indicator.

For making the energy-ecological matrix the following ***time frames*** are taken: 1980, 1990, 2000, 2005, 2010, 2020, 2030, 2040 and 2050. These frames reflect various stages of the cycles: the 80s — stable path of the mature fifth Kondratieff cycle and energy-ecological order adequate to it; the 1990s — the stage of the turning point in the path of the cycle, transition from the up to down stage that told especially notably on the Eurasian, Eastern-European, Japanese civilizations and new industrial countries; first two decades of the 21st c. — the down stage of a long-term cycle; the twenties of the 21st c. — stabilization of the indicators on the low level, large-scale assimilation of base innovations of the sixth Kondratieff cycle and new technological and energy-ecological orders; the 30—40s years — the stage of a considerable improvement in the indicators based on deepening and diffusion of the energy-ecological revolution on the planet.

5.2. Estimation of Energy-Ecological Efficiency Dynamics of the Global Civilization

In view of the original data given above let's define the energy-ecological matrix for the global civilization (*Table 8, Fig. 9*).

For a quarter of the century (1980—2005) the summary indicators of global energy-ecological efficiency dropped from 64 to 50 points — by 27% — mainly due to increase in population size and per capita consumption. Other indicators also declined a little. This indicates the aggravation of a threat of the global ecological catastrophe.

Under the inertia-based scenario energy efficiency will be stable during the first two decades, and then it will grow a little mainly because of strengthening ecological policy and ethics. But there are no sufficient grounds to anticipate a global energy-ecological catastrophe even under the inertia-based scenario.

The implementation of the innovative-breakthrough scenario will change the picture of dynamics of energy-ecological efficiency.

Energy-saving and a share of ecologically clean alternative sources of energy will grow significantly, especially during the energy-ecological revolution of the 30—40s, the impact of the states on energy saving and energy indicators will be gaining momentum, energy-ecological ethics and support of positive tendencies in this sphere by civil society will gain currency. It is hardly that the summary indicator will reach to 2005 the required level of the global normative forecast — double reduction of total greenhouse gas emissions into the atmosphere of the planet; it may be reached some decades later.

5.3. Forecast of Energy-Ecological Efficiency Dynamics in Russia

After defining the energy-ecological matrix for Russia one can compare energy-ecological outlooks of the countries with the indicators of the global civilization (*Table 9*).

Depopulation has become a favorable factor for Russia in terms of energy-ecological efficiency (in 2005 — 19 points against 15 average world points). Other indicators are worse than world, therefore the summary indicator of energy-ecological efficiency changed inconsiderably for 1980—2005.

In prospect energy-ecological efficiency of Russia will be growing (especially in the period of the energy-ecological revolution and diffusion of a noospheric energy-ecological

Table 8. ESTIMATION OF DYNAMICS OF THE GLOBAL ON THE ENERGY-ECOLOGICAL MATRIX

A — inertia-based scenario; B — innovative-breakthrough scenario

Indicators	Limiting values of indicator	1980	1990	2000
Population size	25	20	18	16
Energy consumption per capita	25	18	16	15
Share of alternative sources	15	7	6	6
Energy-efficiency	15	9	9	8
Energy-ecological policy	10	5	5	4
Energy-ecological ethics	10	5	5	4
Value of the summary indicator of energy-ecological efficiency	100	64	59	53

mode of production) both under inertia-based and innovative-breakthrough scenario — up to 66 and 82 points respectively exceeding the average world estimations. Under the inertia-based scenario the excess of the average world summary indicator is mainly reached due to a demographic factor. Under the innovative-breakthrough scenario energy-ecological efficiency of the country with respect to the level of 1980 will significantly grow. Implementing this scenario Russia has a chance to become one of the leaders of the global energy-ecological revolution.

What are ***the prerequisites and conditions for the implementation of the innovative-breakthrough scenario*** of energy-ecological development of Russia?

1. ***Population size*** will be falling in the long-term run: under the UN medium variant of forecast by 22% by 2050 against 2005; under the high variant of forecast — by 6%. Measures of

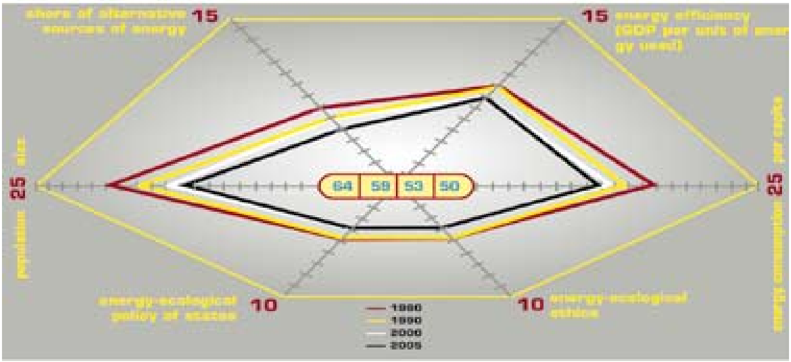
ENERGY-ECOLOGICAL EFFICIENCY BASED

2005	Scenarios	2010	2020	2030	2040	2050
15	A	14	13	12	11	11
	B	14	14	13	14	15
14	A	13	12	11	11	9
	B	14	13	13	15	16
5	A	5	6	7	8	8
	B	6	7	8	9	10
8	A	9	9	10	10	11
	B	9	9	11	12	13
4	A	4	5	5	6	7
	B	4	6	7	8	9
4	A	4	4	5	5	6
	B	4	5	6	7	8
50	A	49	49	50	51	52
	B	51	54	58	65	71

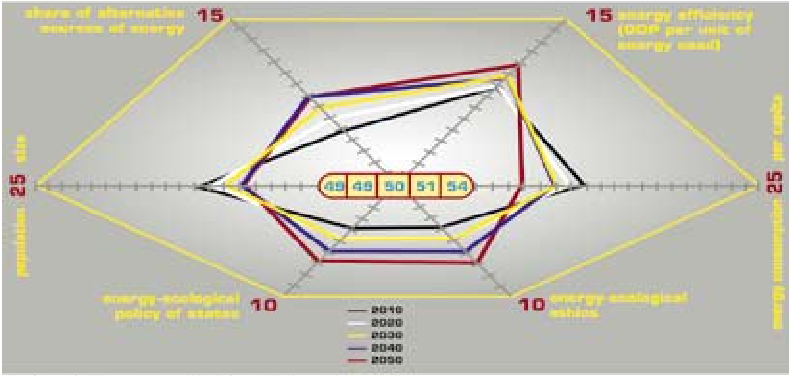
demographic policy being pursued and social national project in public health will increase the probability that the high variant of the forecast will be implemented that however will mean a somewhat higher demand for energy supply against the inertia-based scenario. Large investments projects to be implemented in the Far East and Siberia will reduce the outflow of population from the regions with more severe climatic conditions where energy inputs for energy supply are higher and will require additional energy costs to implement such projects.

Reduction of the population and its aging will become the major factor for reducing the number of the employed by 2050 by 25—30% holding back the economic growth and limiting the scale of investments necessary for innovative transformation of the energy sector of the country. Migration may surmount the operation of such factor. Therefore the significance of improv-

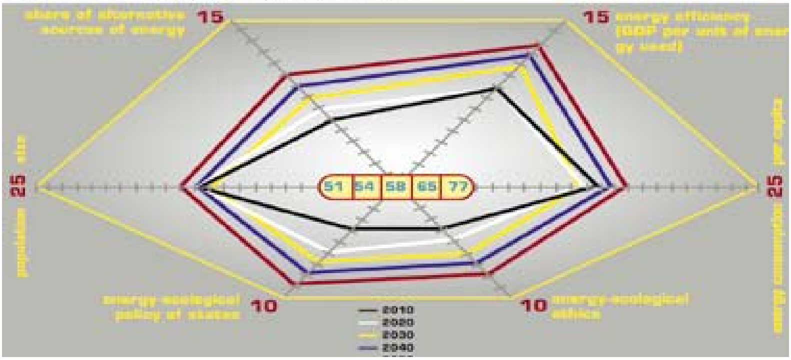
Figure 9. DYNAMICS OF ENERGY-ECOLOGICAL EFFICIENCY OF THE WORLD ECONOMY BASED ON THE ENERGY-ECOLOGICAL MATRIX



2010—2050 inertia-based scenario



2010—2050 rr - innovative-breakthrough scenario



Indicators: 1 — population size; 2 — energy consumption per capita; 3 — share of alternative sources of energy; 4 — energy efficiency (GDP per unit of energy used); 5 — energy-ecological policy of states; 6 — energy-ecological ethics

ing the quality of manpower will increase as well as its efficient use based on the radical improvement of vocational education and redistribution of working resources between reproduction sectors and industries. It is anticipated that the mass and share of the employed in the energy sector will be increasing in the period of its innovative upgrade but in the 30—40s as a result of the energy-ecological revolution it will begin reducing.

2. ***Energy consumption*** is the major reserve for an intensive increase of the energy-ecological efficiency. The following major directions in energy-saving may be distinguished:

➠ Reduction of costs and losses of energy in its transportation by pipelines and energy grids, and also in the housing and utilities as a result of the spread of self-contained co-generation plants reducing the need in far and medium transport of energy (this will additionally reduce a demand for production of energy intensive pipes and metal for them); construction of energy-saving homes and regulation of energy spending;

➠ Reduction of extreme expense for trade-intermediary services and illumination advertisement. According to the input-output balance for 2002 the trade-intermediary services made 129.1 bln rbls in the cost of electric and heat energy — 17.7% of the output of products in basis prices and 49.1% of gross added value of the sector [16];

➠ Stopping the 'race for cars', especially elite foreign make cars, increase in the share of public transport in carriage of people in large cities and intercity carriages;

➠ Structural shifts in economy related with the increase of a share of energy efficient industries and services and reduction of a share of energy intensive industries, first of all, metallurgy;

Table 9. DYNAMICS OF ENERGY-ECOLOGICAL EFFICIENCY OF RUSSIA

Indicators	Limiting values of indicators	1980	1990	2000
Population	25	17	17	18
Average per capita energy consumption	25	13	12	14
Share of alternative sources	15	5	5	6
Energy-efficiency	15	6	6	4
State energy-ecological policy	10	5	6	3
Energy-ecological ethics	10	4	4	3
Value of the summary indicator of energy-ecological efficiency	100	50	50	48

➠ Mastering energy-saving technologies of the sixth technological order in all spheres and industries of the energy sector that will become an additional factor of an absolute reduction of energy consumption.

In 2004, energy consumption per capita in Russia made 4,490 kg — 2.5 times more than the average world indicator. The reduction of such excess is possible using energy saving, although certainly more severe climatic conditions will require a relatively higher level of energy consumption under all other conditions being equal.

3. ***Share of alternative sources*** of energy is a major source of growth of energy-ecological efficiency. In 2004, a share of renewable sources of energy and waste in the use of energy made 1.1% in Russia (1.6% in 1990) — against 10.3% on average in the world and 3.1% in the developed countries. A share of water energy made 18.9% (against 16% on average in the world) in the same year, nuclear energy — 15.6% (against 15.6% on average

A — inertia-based scenario, B — innovative-breakthrough scenario

2005	Scenarios	2010	2020	2030	2040	2050
19	A	20	21	22	23	23
	B	21	22	23	23	24
13	A	13	12	13	14	15
	B	12	13	14	15	16
5	A	6	7	7	8	8
	B	6	8	9	11	12
6	A	5	6	7	8	9
	B	6	8	9	11	12
3	A	3	4	4	4	5
	B	4	4	6	8	9
3	A	3	4	4	5	6
	B	4	5	6	8	9
49	A	50	54	57	62	66
	B	53	60	67	76	82

in the world, 22.8% in the countries with a higher income and 34% in the Euro zone). A wide assimilation of mini water power plants and envisaged increase in the production of nuclear energy will permit significantly reducing the emissions of CO_2 into the atmosphere.

4. ***Energy efficiency*** in Russia (GDP by PPP in prices of 2000 per unit of energy used) is 2.4 times less than on average in the world. It is possible to achieve the improvement of such indicator using two major ways: energy saving, reduction of energy consumption (it has been addressed above) and the priority GDP growth rates. In 2004—2005, GDP growth rates in Russia made 6.4% under average world of 3.5%, GDP growth rates per capita — 6.9% under average world — 2.3%. However, in the long-term run such advance will be hard to support related to a shortage of manpower resources, high wear of fixed capital and a falling competitive capacity of products of manufacturing industries on the national and international markets. Such

reserve may be activated only based on the technological revolution and conversion to the prevailing energy-saving sixth technological order in general in economy.

5. ***State energy-ecological policy*** determines the efficiency of energy sphere in many ways. It should be noted that the major direction of such policy — conversion from extension of production and export of fuel to alternative ecologically clear sources of energy, reduction of greenhouse gas emissions, saving of energy resources for future generations. A significant share of energy rent being concentrated with the state should be directed to modernization and innovative upgrade of the energy sector.

6. ***Energy-ecological*** ethics should take one of the central places in the upbringing of young generations and economic activity. Once the dissemination of Protestantism, especially Calvinism and Anglican Church in the western civilization oriented people to moderate, thrifty style of life. Modern Russian religious confessions — Orthodoxy, Islam, Buddhism and Judaism could orient the believers to thrifty, energy-saving way of life and activity for interests of future generations. Such motives should become determinative in family and school upbringing, activities of youth and public organizations, political parties, in the performance of mass media.

The involvement of all referred reserves and establishment of conditions for the implementation of the innovative-breakthrough scenario of the energy-ecological development of Russia will render real a significant increase in energy-ecological efficiency of economy of the countries by the mid—21st c.

AFTERWORD

About the Global Energy-Ecological Strategy

The 21st century has confronted humanity with a new challenge — a global energy-ecological crisis that threatens the future of humanity. The global civilization and its major institute — United Nations Organization should provide a worthy response in a timely manner to such new challenge by working out a long-term global energy-ecological strategy and mobilizing sound forces and human resources of all the planet, all local civilizations to pursue such strategy.

The UN has already undertaken steps in such direction. In 1992, at the summit in Rio-de-Janeiro the strategy of sustainable development oriented at efficient use of the planetary resources in the context of a harmonious combination of interests of the present and future generations was offered. In 2002, at the summit in Johannesburg a special focus was paid to energy, electric energy supply of developing countries, and reduction of greenhouse gas emissions. The key points of ensuring global energy security worked out at the G-8 summit in Saint Petersburg, 2006 are of significant importance.

At the G-8 summit in Germany in June 2007 proposal was brought forward to reduce double CO_2 emissions and other greenhouse gas emissions by 2050. The decision of this strategic task is accentuated by the fact that in the countries with fast developing economy (China, India) the growth rates of CO_2

emissions into the atmosphere significantly exceed average world. A growth in energy consumption and emissions of greenhouse gases will also continue in these countries in near future. Therefore a major burden of reducing emissions falls to the developed countries and Russia. It is obvious that such task is impossible to solve without the energy-ecological revolution, conversion to alternative, ecologically clean sources of energy. The vanguard countries should render assistance to the countries with a low level of energy consumption in the large-scale assimilation of energy-saving technologies of the sixth technological order. It is necessary to master energy-saving style of life on the path to the noospheric energy-ecological mode of production.

Time has come to make a new step so that ensure security and flourishing future of all humanity, surmounting a growing global energy-ecological crisis — to adopt the **UN Global Energy-Ecological Strategy** at the summit of all states and civilizations of the planet envisaged for a long period up to 2050 and with validated quantitative objectives of development and time fences for their achievement.

It is impossible now to consider separately ecological and energy future of the world community. It is evident that a fast growing consumption of fossil fuel makes a decisive contribution to the heat pollution and worsening of the climate on the planet and only based on a conversion to alternative, ecologically clean sources of energy and consistent pursuance of energy-saving policy it is possible to solve the major ecological problems. Another thing is also evident: a gap in the level of energy supply and energy efficiency has created the gulf between rich and poor countries and civilizations, generates international conflicts and armed clashes. These sores of the world community may be cured only based on the global energy-ecological revolution pursued by the world community under the UN coordinating role.

It appears reasonable the following steps in such directions.

1. The international group of scientists (Russia, Kazakhstan and other countries) is drawing up a ***long-term forecast 'Energy-Ecological Future of Civilizations'*** for a period to 2050 where the scenarios for surmounting the global energy-ecological crisis are addressed as well as ways of radical reduction of heat pollution of atmosphere. This forecast is to be discussed at the Energy Forum of the Shanghai Cooperation Organization and submitted to the UN General Assembly in autumn 2008 together with the proposals on the UN Global Energy-Ecological Strategy.

2. The UN General Assembly in the context of recommendations of the G-8 summits will adopt a ***resolution on holding the World Summit on the Global Energy-Ecological Strategy in 2012 (RIO-20)*** and working out a long-term energy-ecological strategy by 2011. Russia, Kazakhstan and other countries concerned may be originators of such draft resolution. Summit may be hold in the centre of Asia — in Astana, the new capital of Kazakhstan.

3. Based on a long-term forecast one should enter upon preparing the draft **Global Energy-Ecological Strategy** for a long-term prospect. In doing so it appears reasonable to establish the Energy-Ecological Council of major political figures, scientists, businessmen, ecologists, public figures of all 12 civilizations of the fifth generation by the UN Secretary General upon approval by the UN Security Council. Such council will draft, discuss, publish and place on the Internet the draft Global Strategy to discuss it at the session of the UN General Assembly in autumn 2011 and table at the World Summit in 2012.

4. Specialized UN organs — Economic and Social Council (demographic forecast), UNEP (ecological forecast), UNDP (technological forecast), UN regional organs should be involved to making the draft of the Global Strategy, and also the World Bank, and other international organizations concerned.

The financing of such activities will require solution by the UN, Global Ecological Fund, other organizations and sponsors.

Russia has all preconditions to take the leading place in making such forecast and drafting a Global Strategy. Russia chaired at the G-8 summit in Saint Petersburg and prepared a draft document on global energy security together with other countries. Russian scientists published in Russian and English the two volume book 'Civilizations: Theory, History, Dialogue and the Future' where the issues of energy-ecological future are addressed. The issues and problems of energy-ecological future are also dealt with in the works 'Russia — 2050 — Strategy of Innovative Breakthrough' (2005), 'Integral Macro Forecast of Innovative-Technological and Structural Dynamics of Economy of Russia for a Period up to 2030' (2006), 'Russia: Strategy of Transition to Hydrogen Energy' (2007), discussed at the Internet sites: www.kuzyk.ru, www.energy.newparadigm.ru.

At the meeting of the round table session in New York on the issues of global forecasting on 10.10.2006 dedicated to the 100th anniversary of the birth of Wassily Leontieff, Nobelist in Economy a proposal endorsed by RF Ministry of Foreign Affairs S.V. Lavrov was made by the Russian scientists on renewal within the UN the activities on long-term global forecasting. The international team drafted a concept for making the UN Global Forecast 'Future of Civilizations. Forecast of Socio-Demographic, Energy-Ecological, Technological and Geopolitical Development of Civilizations for a Period up to 2050' and scientists of Russia, Kazakhstan and other countries began to realize it.

Thus, time has come to work out the global energy-ecological long-term strategy by the best intellectual, business and political forces of the planet which would allow the world community surmounting the present-day crisis state and transit to sustainable development in the interests of present and future generations, implement the noospheric principle of harmonious co-evolution of society and nature.

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SUPPLEMENT 1

G7/G8 Summit Meetings St. Petersburg Summit Documents Global Energy Security

St Petersburg, July 16, 2006

St Petersburg Plan of Action on Global Energy Security

Global Energy Challenges

1. Energy is essential to improving the quality of life and opportunities in developed and developing nations. Therefore, ensuring sufficient, reliable and environmentally responsible supplies of energy at prices reflecting market fundamentals is a challenge for our countries and for mankind as a whole.

2. To tackle this overarching goal we have to deal with serious and linked challenges such as:

- high and volatile oil prices;
- growing demand for energy (estimated to rise by more than 50% by the year 2030, approximately 80% of which would still be met by fossil fuels, which are limited resources);
- increasing import dependence in many countries;

- enormous investment requirements along the entire energy chain;
- the need to protect the environment and to tackle climate change;
- the vulnerability of the critical energy infrastructure;
- political instability, natural disasters and other threats.

The global nature of these challenges and the growing interdependence between producing, consuming and transiting countries require strengthened partnership between all stakeholders to enhance global energy security. We agree that development of transparent, efficient and competitive global energy markets is the best way to achieve our objectives on this score. We recognize that governments and relevant international organizations also play an important role in addressing global energy challenges.

3. Neither global energy security, nor the Millennium Development Goals can be fully achieved without sustainable access to fuels for the 2.4 billion people and to electricity for the 1.6 billion people currently without such access in developing countries. They cannot be forgotten or marginalized.

Response of the International Community

4. Given political will, the international community can effectively address three interrelated issues: energy security, economic growth and environmental protection (the "3Es"). Applying fair and competitive market-based responses to the global energy challenges will help preclude potentially disruptive actions affecting energy sources, supplies and transit, and create a secure basis for dynamic and sustainable development of our civilization over the long term.

5. We will pursue energy security through a comprehensive and concerted approach consistent with our common environmental goals. Last year in Gleneagles, we agreed to enhance our work under the Plan of Action for Climate Change, Clean Energy and Sustainable Development and resolved to take forward the dialogue on these issues whose results will be reported at the 2008 G8 Summit in Japan. We reaffirm this commitment.

We also reaffirm our commitment to the United Nations Framework Convention on Climate Change (UNFCCC) and to meet our shared multiple objectives of reducing greenhouse gas emissions, improving the global environment, enhancing energy security, and cutting air pollution in conjunction with our vigorous efforts to reduce energy poverty. We also agree to work to improve access to energy in developing countries.

Statement on Global Energy Security Principles

6. Recognizing the shared interest of energy producing and consuming countries in promoting global energy security, we, the Leaders of the G8, commit to:

➠strong global economic growth, effective market access, and investment in all stages of the energy supply chain;

➠open, transparent, efficient and competitive markets for energy production, supply, use, transmission and transit services as a key to global energy security;

➠transparent, equitable, stable and effective legal and regulatory frameworks, including the obligation to uphold contracts, to generate sufficient, sustainable international investments upstream and downstream;

➠enhanced dialogue on relevant stakeholders' perspectives on growing interdependence, security of supply and demand issues;

➠diversification of energy supply and demand, energy sources, geographical and sectoral markets, transportation routes and means of transport;

➠promotion of energy saving and energy efficiency measures through initiatives on both national and international levels;

➠environmentally sound development and use of energy, and deployment and transfer of clean energy technologies which help to tackle climate change;

➠promotion of transparency and good governance in the energy sector to discourage corruption;

➠cooperative energy emergency response, including coordinated planning of strategic stocks;

➠safeguarding critical energy infrastructure; and

➠addressing the energy challenges for the poorest populations in developing countries.

7. Based on the above objectives, principles and approaches, we will implement our common global energy security strategy through the following Plan of Action. We invite other states, relevant international organizations and other stakeholders to join us in these efforts.

ST. PETERSBURG PLAN OF ACTION GLOBAL ENERGY SECURITY

1. We reaffirm our commitment to implement and build upon the agreements related to energy reached at previous G8 summits. We will enhance global energy security through actions in the following key areas:

- increasing transparency, predictability and stability of global energy markets;
- improving the investment climate in the energy sector;
- enhancing energy efficiency and energy saving;
- diversifying energy mix;
- ensuring physical security of critical energy infrastructure;
- reducing energy poverty;
- addressing climate change and sustainable development.

I. Increasing Transparency, Predictability and Stability of Global Energy Markets

2. Free, competitive and open markets are essential to the efficient functioning of the global energy system. Efforts to advance transparency; to deepen and spread the rule of law; to establish and strengthen predictable, efficient fiscal and regulatory regimes; and to encourage sound energy supply and demand policies all play significant roles in maintaining global energy security. By reducing uncertainty these efforts improve understanding of energy market developments, and therefore sound investment decisions and competitiveness. Regular exchanges of timely and reliable information among all market participants are also essential for the smooth functioning of world energy markets. Transparent, predictable national energy policies and regulatory environments facilitate development of efficient energy markets. We invite the International Energy Forum (IEF) to study ways of broadening the dialogue between energy producing and consuming countries on these issues including information exchange on their medium- and long-term respective policy plans and programs.

3. We welcome the beginning of implementation of the Joint Oil Data Initiative (JODI) and will take further action to improve and enhance the collection and reporting of market data on oil and other energy sources by all countries including through development of a global common standard for reporting oil and other energy reserves. In this respect, we will invite the IEF to work on the expansion of JODI membership and to continue to improve the quality and timeliness of data.

4. As a critical tool in the fight against corruption, we will also take forward efforts to make management of public revenues from energy exports more transparent, including in the context of the Extractive Industries Transparency Initiative (EITI) and the IMF Guide on Resource Revenue Transparency (GRRT).

5. Clear, stable and predictable national regulatory frameworks significantly contribute to global energy security, and multilateral arrangements can further enhance these frameworks. We support the principles of the Energy Charter and the efforts of participating countries to improve international energy cooperation.

6. Concerted actions of energy producers and consumers are of critical importance in times of supply crises. We encourage further efforts under the IEA aegis to promote international best practices related to emergency response measures, including establishment, coordination and release of strategic stocks, where appropriate, as well as measures to implement demand restraint and fuel-switching. We note constructive steps by major producing countries to increase oil output in response to recent tight market conditions and support additional actions.

II. Improving the Investment Climate in the Energy Sector

7. Ensuring an adequate global energy supply will require trillions of USD in investment through the entire energy chain by 2030, a substantial share of which will be needed by developing countries. We will create and maintain the conditions to attract these funds into the energy sector through competitive, open, equitable and transparent markets. We understand that governments' environmental and energy policies are critical for investment decisions. In producing, consuming and transit states, therefore, we will promote predictable regulatory regimes, including stable, market-based legal frameworks for investments, medium and long-term forecasts of energy demand, clear and consistent tax regulation, removal of unjustified administrative barriers, timely and effective contract enforcement and access to effective dispute settlement procedures.

8. We shall take national and international measures to facilitate investments into a sustainable global energy value chain to:

➠further save energy through demand-side measures as well as introduce advanced energy-efficient technologies;

➠introduce cleaner, more efficient technologies and practices including carbon capture and storage;

➠promote wider use of renewable and alternative energy sources;

➠expand the hydrocarbon proven reserves in a way that would outpace their depletion and increase the recovery of energy resources;

➠increase the efficiency of oil and gas production, and develop resources on the continental shelf;

➠establish, expand and improve the efficiency of oil-refining, petrochemical and gas processing industries' capacity;

➠develop global LNG market;

➠establish or upgrade infrastructure for energy transport and storage;

➠develop efficient power generating facilities; and

➠expand and improve the efficiency, safety and reliability of electricity transmission facilities and power grids and their international connectivity including, where appropriate, in developing countries.

9. We encourage construction and development of hydrocarbon-processing facilities to increase energy market flexibility and confidence, as well as expansion, where economically viable, of trade in hydrocarbon products. We will work with all stakeholders to improve energy regulatory regimes, inter alia, through feasible technical standards harmonization. We will ask the International Standards Organization to study ways and means of harmonizing relevant standards in this context.

10. We consider it important to facilitate capital flows into power generation, including to build new, more efficient power plants, upgrading existing plants to include wider use of renewables, and to construct transmission lines, develop interregional energy infrastructure and facilitate exchange of electrical power, including trans-border and transit arrangements. We encourage the development of competitive power markets, interregional energy infrastructure and exchange of electrical power.

11. Rapidly growing LNG trade is gradually supplementing the existing regional systems of pipeline gas supplies. To reduce huge investment risks and facilitate smooth functioning of the emerging global LNG market, we will seek to create appropriate investment conditions.

12. High and increasing investment exposure calls for better risks sharing between all stakeholders in energy supply chain which will ensure reliable and sustainable energy flows. Economically sound diversification between different types of contracts, including market-based long-term and spot contracts, could contribute to such risks mitigation, as would timely decision-making and appropriate adherence and enforcement of contractual agreements.

13. We will work to reduce barriers to energy investment and trade. It is especially important that companies from energy producing and consuming countries can invest in and acquire upstream and downstream assets internationally in a mutually beneficial way and respecting competition rules to improve the global efficiency of energy production and consumption. Market-based investment flows between and among nations will also enhance energy security by increasing confidence in access to markets or sources of supply.

14. Ensuring the long-term availability of skilled workforce throughout the energy sector is critical to energy security. We encourage institutions of higher learning and the private sector to take the necessary steps in providing appropriate training to adequately develop human resources in the energy sector, including new and innovative energy sources and technologies needed for ensuring longer-term energy security.

III. Enhancing Energy Efficiency and Energy Saving

15. Energy saved is energy produced and is often a more affordable and environmentally responsible option to meet the growing energy demand. Efforts to improve energy efficiency and energy saving contribute greatly to lowering the energy intensity of economic development thus strengthening global energy security. Increased energy efficiency and conservation reduce stress on infrastructure and contribute to a healthier environment through decreased emission of greenhouse gases and pollutants.

16. We will move forward with timely implementation of the Gleneagles Plan of Action. We have instructed our relevant ministers to continue the Dialogue on Climate Change, Clean Energy and Sustainable Development and report its outcomes to the G8 Summit in 2008. We call upon other states, especially fast-growing developing economies, to join the corresponding G8 initiatives. These outcomes can also be relevant to the dialogue on long-term cooperation to address climate change under the UNFCCC. Those of us who have ratified the Kyoto Protocol recognize the role of its flexibility mechanisms in promoting energy efficiency. It is important to engage the private sector and other stakeholders in achieving these ends.

17. A comprehensive approach within the international community to energy saving, energy efficiency and the extension of relevant efforts, including sharing best practices, to the entire energy value chain are important in this respect. For this purpose, we shall undertake to:

- strengthen and elaborate the system of national and multilateral energy efficiency statistics;
- consider national goals for reducing energy intensity of economic development to be reported by the end of the year;

➠for energy intensive products, encourage the development, extension and deployment of best practice energy efficiency labeling programs, and increase efforts to adopt the most stringent energy efficiency standards that are technically feasible and economically justified. Individual countries should set these standards taking into account national conditions. In this context the IEA initiatives on standby power ("1 Watt" initiative), minimum efficiency standards for television set-top boxes and digital television appliances, energy efficient lighting and fuel-efficient tire program are promising and should be examined in more detail;

➠take necessary measures, including financial and tax incentives at home for the promotion of energy-efficient technologies, and the actual use of those available technologies on a wide-scale basis;

➠demonstrate leadership at the national level by incorporating energy efficient technologies and practices in government buildings and drawing upon alternative energy resources to help power them;

➠raise public awareness about the importance and benefits of energy efficiency and energy saving.

➠encourage relevant actions taken by multilateral development banks (MDBs), including EBRD and the World Bank;

➠increase the Global Environment Facility's involvement in energy efficiency projects.

18. We will invite the World Bank, the IEA, and other organizations as appropriate to work on improvement of internationally accepted standards, labeling and best practices, and public awareness campaigns, in accordance with their respective mandates and comparative advantages.

19. As part of an integrated approach to the entire resource cycle we reaffirm our commitment to comprehensive measures to optimize the resource cycle within the 3Rs Initiative (Reduce, Reuse, Recycle). In furthering these efforts, we will set targets as appropriate taking account of resource productivity. We will also raise awareness of the importance of energy efficiency and environmental protection through national as well as international efforts.

20. Increasing energy saving and efficiency we will pay more attention to the energy sector itself, which can contribute significantly to this end by reducing losses in production and transportation. Our priority measures in this area will include:

➠raising the environmental and efficiency levels for processing hydrocarbons;

➠reducing gas flaring to minimal levels and promoting utilization of associated gas;

➠improving energy infrastructure, including minimizing oil and oil products losses in transportation and gas emissions from gas systems;

➠using methane otherwise released in the atmosphere from coal mining, landfills, and agricultural operations.

21. Since 2/3 of world oil is consumed by the transportation sector and its fuel consumption is outpacing general energy consumption we will pay special attention to this sector of energy demand. For making transportation more energy efficient and environmentally advanced we shall:

➠share best practices to promote energy efficiency in the transportation sector;

➠develop programs in our respective countries, consistent with national circumstances, to provide incentives for consumers to adopt efficient vehicles, including clean diesels and hybrids; and introduce on a large scale efficient public hybrid and/or clean diesel transportation systems, where appropriate;

➠promote diversification of vehicle energy systems based on new technologies, including significant sourcing from biofuels for motor vehicles, as well as greater use of compressed and liquefied natural gas, liquefied petroleum gas and synthetic liquid fuels;

- promote wider use of modern technologies, materials and devices on traditional vehicles, leading to lighter, more aerodynamic and more efficient engines and other transport components such as transmission and steering systems, tires, etc.;
- increase research to develop vehicles using gasoline/hydrogen fuel and hydrogen fuel cells to promote the "hydrogen economy";
- facilitate the development of trans-modal and trans-border transportation, where appropriate;
- study further the Blue Corridor project by the UN Economic Commission for Europe;
- continue to consider the impact of the air transport sector on energy consumption and greenhouse gas emissions noting international cooperation on these issues.

22. We call upon all countries to offer incentives to increase energy efficiency and to promote energy conservation.

IV. Diversifying Energy Mix

23. Diversification of the energy mix reduces global energy security risks. We will work to develop low-carbon and alternative energy, to make wider use of renewables and to develop and introduce innovative technologies throughout the entire energy sector.

Alternative, Cleaner Low-Carbon Energy

24. We shall further encourage the activities of the Carbon Sequestration Leadership Forum (CSLF) aimed at preparing and implementing demonstration projects on CO_2 capture and storage and on the development of zero emission power plants. In this context we will facilitate development and introduction of clean coal technologies wherever appropriate.

25. We encourage all oil producing states and private sector stakeholders to reduce to minimal levels natural gas venting or flaring by facilitating the use of associated gas, including its refining and processing into fuels and petrochemical products. In this respect we support the efforts of Global Gas Flaring Reduction Partnership (GGFR) and Methane-to-Markets Partnership (M2M) to implement projects on the production of marketable methane from landfills, agriculture waste and coal-bed methane, particularly in developing countries.

26. We support the transition to the Hydrogen Economy, including in the framework of the International Partnership for the Hydrogen Economy (IPHE). A critical part of this effort is to develop common international standards in the field of commercial development of hydrogen power, infrastructure and security requirements.

Nuclear Energy

27. We recognize that G8 members pursue different ways to achieve energy security and climate protection goals.

28. As we meet on the 20th anniversary of the Chernobyl accident, we reiterate the commitments made during the 1996 Moscow Summit on Nuclear Safety and Security, and the paramount importance of safety, security and non-proliferation.

29. Those of us who have or are considering plans relating to the use and/or development of safe and secure nuclear energy believe that its development will contribute to global energy security, while simultaneously reducing harmful air pollution and addressing the climate change challenge:

The development of innovative nuclear power systems is considered an important element for efficient and safe nuclear energy development. In this respect, we acknowledge the efforts made in the complementary frameworks of the INPRO project and the Generation IV International Forum.

Until advanced systems are in place, appropriate interim solutions could be pursued to address back-end fuel cycle issues in accordance with national choices and non-proliferation objectives.

Benefits will stem from improving the economic viability of nuclear power. We recognize that independent effective regulation of nuclear installations is essential for the development of infrastructure supporting safe and secure nuclear energy.

30. We are committed to:

- further reduce the risks associated with the safe use of nuclear energy. It must be based on a robust regime for assuring nuclear non-proliferation and a reliable safety and security system for nuclear materials and facilities;
- ensure full implementation of the international conventions and treaties in force today which are a prerequisite for a high level of safety and a basis to achieve a peaceful and proliferation-resistant nuclear energy use. The responsibility of all nations to support the work of the IAEA and all measures to implement these conventions and treaties in these fields is emphasized;
- continue to consider nuclear safety and security issues in the Nuclear Safety and Security Group (NSSG).

31. We reaffirm the objective set out in the 2004 G8 Action Plan on Non-Proliferation to allow reliable access of all countries to nuclear energy on a competitive basis, consistent with non-proliferation commitment and standards. Building on that plan, we intend to make additional joint efforts to ensure reliable access to low enriched uranium for power reactor fuel and spent fuel recycling, including, as appropriate, through a multilateral mechanisms provided that the countries adhere to all relevant international non-proliferation commitments and comply with their obligations.

32. In this respect, we take note of recent potentially complementary initiatives put forward in the IAEA framework regarding multilateral fuel supply assurances, as well as the proposals made by Russia and the U.S., aimed at further development of peaceful nuclear energy, in a manner that promotes proliferation resistance of the nuclear fuel cycle, including preventing the spread of sensitive nuclear technologies.

Renewables

33. A large-scale use of renewable energy will make a significant contribution to long-term energy supply without adverse impact on climate. The renewable solar, wind, hydro, biomass and geothermal energy resources are becoming increasingly cost competitive with conventional fuels, and a wide variety of current applications are already cost-effective. Therefore, we reaffirm our commitment to implement measures set out in the Gleneagles Plan of Action.

34. We welcome the work of interested parties in international mechanisms and programs dealing with renewable energy, including the Renewable Energy and Energy Efficiency Program (REEEP), the Renewable Energy Policy Network for the 21st Century (REN21) and the Mediterranean Renewable Energy Partnership (MEDREP). We welcome the establishment of the Global Bio-Energy Partnership (GBEP). We will work in partnership with developing countries to foster the use of renewable energy.

35. We will continue enhancing international cooperation in using the potential of biomass, advanced sustainable forest management practices. Both help to diversify local energy consumption, make an important contribution to carbon sequestration, as furthering a wide range of economic and environmental benefits.

36. We shall promote international cooperation in the area of forest management, primarily in addressing deforestation and forest degradation, the trade in illegally harvested timber and forest fires. We note that deforestation has a significant impact on climate change (resulting, according to the Food and Agriculture Organization of the United Nations (FAO), in an actual 25% increase in yearly greenhouse gas emissions). We reaffirm the importance of tackling illegal logging and agree to take further action, with each country taking steps where it can contribute most effectively. This should include the promotion of sustainable forest management and the incorporation of appropriate measures to address illegal logging in relevant national policies of both timber-producing and consuming countries. We welcome recent international forest-related policy initiatives including the St. Petersburg Ministerial Conference Declaration on Forest Law Enforcement and Governance in Europe and North Asia, and initiatives of the United Nation Forum on Forests (UNFF), UNFCCC, the International Tropical Timber Organization (ITTO) and Asia Forest Partnership (AFP).

Innovative Energy Technologies

37. We will work in partnership with the private sector to accelerate market entry and utilization of innovative energy technologies by supporting market-led policies that encourage investments in this area.

38. Despite the increased role of alternative sources in the energy mix, hydrocarbons are expected to continue to play a leading role in total energy consumption well into this century. Therefore we will work with the private sector to accelerate utilization of innovative technologies that advance more efficient hydrocarbon production and reduce the environmental impact of its production and use. These include technologies for deep-sea oil and gas production, oil production from bitumen sands, clean coal technologies, including carbon capture and storage, extraction of gas from gas-hydrates and production of synthetic fuel.

39. We will take measures to develop other promising technologies including construction of advanced electricity networks, superconductivity, nanotechnology, including nanobiotech etc. We welcome recent initialing ITER agreement by the participating countries and take this opportunity to encourage R&D programs on fusion energy within its framework.

40. We shall facilitate closer ties between fundamental and applied research to promote the earliest economically viable market entry of these technologies.

V. Securing Critical Energy Infrastructure

41. The security of the world's energy infrastructure is connected and mutually dependent. Given the global nature of the energy infrastructure, we recognize that no country can insulate itself from danger elsewhere. Hence, we are committed to ensuring the security of the global energy network, and will work to gain a better understanding of its vulnerabilities and ways to improve our efforts to prevent disruptions by deliberate attack. We support a coordinated, international process to assess risks to energy infrastructures, and a more effective means of sharing energy infrastructure security best practices and expertise.

42. We commit ourselves to address threats and vulnerabilities to critical energy infrastructures, and to promote international cooperation in this regard. We instruct our experts to meet as necessary to examine and make recommendations on addressing the many challenges in securing energy infrastructure and deliver to the Russian Presidency at the end of this year a comprehensive report on:

- defining and prioritizing the most important vulnerabilities among energy infrastructure sites, and share methodologies for assessing and mitigating them;
- assessing potential risks of terrorist attacks;
- developing a compendium of effective security response best practices across all energy sectors within our countries;
- developing, implementing, and providing to other countries a checklist for the physical security of critical energy infrastructure;
- encouraging international cooperation on R&D for technologies to enhance critical infrastructure protection;
- establishing points of contact for coordination of technical assistance in this area;
- continuing to advocate the adoption of export controls on radioactive sources and new initiatives to prevent terrorists' access to radioactive sources.

43. We call upon governments to fully implement the International Ships and Ports Facility Security Code and encourage attention to the management of maritime security.

VI. Reducing Energy Poverty

44. We confirm our commitment to the UN Millennium Development Goals, including through facilitating a better access to energy. It is impossible to drastically reduce general poverty, support health services, provide clean drinking water and sanitation, promote more productive agriculture and food yields, and secure investment in job-creating enterprises in developing countries without addressing the challenge of energy poverty. We will help vulnerable countries overcome the macroeconomic shocks related to energy prices, and the longer term challenge of facilitating access to energy for the poorest populations.

45. A sound strategy to address energy poverty should be linked with:

- development of national and local institutional capacities and management improvements in the area of energy policy and related infrastructure needs, including training of local staff;
- facilitation of public participation in and public understanding of, energy policies and practices;
- national energy investment and access targets linked to poverty reduction policies;
- expansion of existing frameworks, such as the EU Energy Initiative (EUEI), the MEDREP, GBEP, the Global Village Energy Partnership (GVEP); the Renewable Energy and Energy Efficiency Partnership (REEEP), for private-public partnerships to foster investment that increases access to affordable energy services;
- establishment of an energy efficiency program and development of decentralized technologies, where economically justified, and geared toward reducing the cost of energy for the poor;
- a targeted and transparent social safety net system that can help poor and vulnerable customers pay for energy.

46. The majority of energy investment will need to come from the private sector. Assistance programs for developing countries should work towards promoting the improved policy and regulatory structures necessary to attract that capital.

47. The international financial institutions (IFIs) have an important role to play in tackling these challenges. We welcome the progress of the multilateral development banks to re-invigorate their efforts to promote investment in alternative energy sources, increased energy efficiency and adaptation in developing countries. We also welcome the launching of the International Monetary Fund's Exogenous Shocks Facility, and invite other non-G8 countries to contribute to it. We call upon other countries and IFIs to facilitate access to energy in the poorest countries by promoting private-public partnerships.

48. To improve access to reliable, modern, and sustainable energy services to the populations of energy poor developing countries, we will enhance existing bilateral and multilateral development mechanisms. We welcome the EU's Energy Facility, which will use grants to co-finance projects aimed at filling the energy gap, especially in Africa, as well as activities by Japan in partnership with AfDB to promote the "Enhanced Private Sector Assistance" (EPSA) for Africa. We look forward to the outcome of the UN Commission on Sustainable Development's two-year cycle of work (2006-2007) devoted to the review/policy discussion of the Energy for Sustainable Development issue.

49. We will facilitate development of local energy resources, including those based on core generation technologies and on renewable energy, such as hydropower, wind power, geothermal power, biomass, and the effective use of solar energy, to contribute to poverty reduction and long-term energy sustainability in developing countries. These measures include developing energy infrastructure capable, inter alia, of reducing vulnerability to energy shocks.

50. We instructed our experts to work together with other countries, international and regional financial institutions

(World Bank, Regional Development Banks, UN agencies etc.), the private sector and other stakeholders to facilitate technology transfer in the areas of energy efficiency, energy saving, renewable energy and decentralized local sources to reduce energy poverty thereby improving energy access and enhancing energy efficiency in developing countries. Building on the Gleneagles Plan of Action, such concerted efforts may help improve energy efficiency and promote energy conservation in developing countries through the following actions:

➠supporting the development of infrastructure to improve energy access tailored to specific needs and targeted towards energy efficiency;

➠assisting in policy and institutional capacity building for improving energy access, enhancing energy efficiency and promoting energy conservation and diversification of energy sources;

➠promoting renewable energy;

➠encouraging rural electrification, using both grid and non-grid connected solutions;

➠developing human resources in cooperation with the private sector.

51. We look forward to the completion and implementation of the World Bank Clean Energy Investment Framework and underline that it should give increased attention to improving access to energy services.

52. We share the view that strengthening national financial management and accounting systems, making government budgets, procurement procedures and concessions more transparent, taking specific measures to combat corruption, ensuring good governance, mobilizing domestic resources and progressively improving the business climate for private entrepreneurs and investors are essential for resolving effectively the above mentioned challenges in developing countries. In this context we also refer to the Gleneagles decision concerning Africa.

VII. Addressing Climate Change and Sustainable Development

53. We reaffirm our intention to deliver on commitments made in Gleneagles in order to meet our shared and multiple objectives of reducing greenhouse gas emissions, improving the global environment, enhancing energy security and cutting air pollution in conjunction with our vigorous efforts to reduce poverty. We also affirm our commitment to the UNFCCC's ultimate objective of stabilizing greenhouse gas concentrations in the atmosphere at a level that prevents dangerous anthropogenic interference with the climate system.

We will continue to work to reduce greenhouse gas and deal effectively with the challenge of climate change.

We are undertaking a number of approaches to deal with the interrelated challenges of energy security, air pollution control, and reducing greenhouse gas associated with long-term global climate change. With respect to climate change, we reaffirm our shared commitment under the UNFCCC and its related mechanisms.

Those of us committed to making the Kyoto Protocol a success underline the importance we attach to it, view Clean Development Mechanism and the Joint Implementation Mechanism as central elements of this, and look forward to the process to develop it further.

Some or all of us are participating in the following other initiatives to address these challenges: Asia-Pacific Partnership on Clean Development and Climate, the Methane to Markets Partnership, the International Partnership for the Hydrogen Economy, the Carbon Sequestration Leadership Forum, the

Renewable Energy and Energy Efficiency Partnership and the Global Bio-Energy Partnership.

We welcome the progress made at the XI Conference of the Parties to the UNFCCC (Montreal, December 2005) where we committed to engage in a dialogue on long-term cooperative action to address climate change by enhancing implementation of the convention; and the progress made at the UN Climate Change meeting last May in Bonn.

We reaffirm the importance of the work of the Inter-governmental Panel on Climate Change (IPCC) and look forward to its 2007 report.

All these undertakings are the foundation of our current efforts to address climate change, and will form the basis of an inclusive dialogue on further action in the future, including the period beyond 2012.

54. We welcome the progress made by the World Bank and the IEA on developing a framework for clean energy and sustainable development and on identifying alternative energy scenarios and strategies to support and implement elements of the Gleneagles Plan of Action.

55. We welcome the progress made at the first meeting of the Gleneagles Dialogue on Climate Change, Clean Energy and Sustainable Development, held on 1 November last year. We look forward to the next Ministerial meeting in Mexico in October 2006, where we will continue to identify opportunities for greater collaboration to tackle climate change, while pursuing energy security and sustainable development through deployment of cleaner, more efficient and low-carbon energy technologies, finance and market mechanisms, including, as appropriate, Clean Development Mechanism, Joint Implementation, emissions trade and adaptation.

Source: Official website of the Russian G8 presidency — http://en.g8russia.ru/

SUPPLEMENT 2

Institute for Economic Strategies (INES)
National Innovative Company
New Energy Projects (NIC NEP)
P. Sorokin – N. Kondratieff International Institute (SKII)
Russian Academy of Public Service
Under the President of the RF (RAPS)

National Scientific-Innovative Program 'Hydrogen Energy' for a Period up to 2050

(Draft)

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Yu.V. Yakovets, SKII President, RANS Academician, Ph.D. (Economics), RAPS Professor
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The concept of the Program was formulated by INES, SKII and RAPS in 2005, discussed and endorsed at the 19th Cross-disciplinary Discussion at RAPS in March 2005. The concept and the draft Program was discussed at the meeting of the NIC NEP Science and Engineering Research Council, endorsed and updated in the context of comments and proposals of the National Association of Energy and MIREA – Moscow State Institute of Radio engineering, Electronics and Automatics (Engineering University).

Summary of the Draft National Scientific-Innovative Program 'Hydrogen Energy' for a period up to 2050

Name of the draft Program – National Scientific-Innovative Program 'Hydrogen Energy' for a period up to 2050.

Name, number and date of decision-making to work out the Program. The draft Program was worked out as an initiative by the Institute for Economic Strategies, National Innovation Company 'New Energy Projects', Pitirim Sorokin – Nikolai Kondratieff International Institute, Russian Academy of Public Service under the RF President and further completed in association with the National Association of Hydrogen Energy and Moscow State Institute of Radio engineering, Electronics and Automatics (Engineering University). The project is a continuation and further development of the Integrated Program of exploration, scientific-research and development efforts in hydrogen energy and fuel elements endorsed by the RAS Presidium and the Board of Norilsk Nickel JSC on December 9, 2003. The project is targeted at the implementation of the Plan of Action Global Energy Security for Conversion to Hydrogen Energy (items 21 and 26 of the Action Plan) approved at the G-8 summit in Saint Petersburg on July 16, 2006.

Program Coordinator – the Government of the Russian Federation.

Government customers of the Program — Ministry of Economic Development and Trade of the Russian Federation, Ministry of Education and Science of the Russian Federation, Ministry of Industry and Energy of the Russian Federation, Ministry of Transport of the Russian Federation, Ministry of Regional Development of the Russian Federation, Ministry of Defense of the Russian Federation.

Major executing agencies of the Program – Russian Academy of Sciences, Ministry of Education and Science of the Russian Federation, Ministry of Industry and Energy of the Russian Federation, Ministry of Transport of the Russian Federation, Ministry of Regional Development of the Russian Federation, National Innovation Company 'New Energy Projects'.

The objective of the Program is working out large-scale mastering, development of production of hydrogen fuel and fuel elements and their use as an alternative, ecologically clean source of energy that will promote the energy efficiency of the Russian economy, reliability of energy supply to population and production, reduction of air pollution, strengthening energy and ecological security of the country and improvement of the structure of foreign trade.

The Program is of a scientific-innovative nature uniting research and development efforts, basic innovations in production, transportation, storage, use and ensuring safety of hydrogen fuel with the innovative-investment use of fuel elements in transport, energy, industry, municipal housing economy and other spheres of economy, development of innovative niches on the national and external energy markets.

Tasks of the Programs:

- To ensure an accelerated and large-scale mastering and development of hydrogen energy in Russia as one of the basic directions of the sixth technological order and conditions for ensuring energy security of the country;

- To develop and master efficient technologies of production, storage, use and ensuring safety of hydrogen fuel;
- To work out and master innovatively the systems of fuel elements and power plants ensuring efficient employment of hydrogen technologies in transport, industry, municipal housing economy and other sectors of economy;
- To identify the regions of the Russian Federation for complex mastering of hydrogen energy, to establish innovative-energy zones therein;
- To arrange cooperation in hydrogen energy with the CIS countries concerned, states of the East and the West;
- To improve the technological level and competitiveness of the sectors related to hydrogen energy, to increase a share of Russia on the world high-tech market;
- To mature the vehicle for making and implementation of the national program of the highest level based on the principles of partnership of the state, science, business and education, cooperation between states, integration of national and foreign capital in the implementation of an innovative breakthrough in energy;
- To arrange training and retraining of the manpower for all links of hydrogen energy, information support for its mastering and development.

Program implementation period — 2006—2050.

Major activities under the Program:

- Research and development efforts for efficient technologies of hydrogen fuel production, storage, processing and use, establishment of the system of fuel elements of various types;
- Marketing researches and arrangement of large-scale mastering of the fundamentally new competitive technologies for the use of hydrogen fuel and fuel elements in transport, energy, metallurgy, municipal housing economy, portable units, conquering space, military-industrial complex and other sectors of economy;

➠Arrangement of production of new materials (including nanomaterials) and equipment for various spheres of production, transportation and use of hydrogen fuel;

➠Joint researches, research and development efforts, implementation of integrated innovative projects with the CIS countries concerned and states of far abroad for mastering niches on the world market;

➠Training, retraining and advanced training of manpower for hydrogen energy, arrangement of general education in hydrogen, informing population on the outlooks and advantages of hydrogen energy;

➠Working out and mastering of the organizational-economic framework for the implementation of the Program that is adequate to the conditions of globalization and directed market economy and based on the principles of partnership of state, science, education and business, establishment of the management company and international innovative strategic alliance in hydrogen energy.

Sizes and sources of financing of the Program at four stages (2006—2010, 2011—2020, 2021—2030, 2031—2050) are determined preliminary and be updated as the Program is being implemented and evaluation of the outputs.

At the first stage the size of financing is estimated in USD 600 mln, where at least 300 mln – contributed by the state.

At the second stage the size of investments will grow to USD 8 bln, where 900 mln will be allocated by the state. At the third stage a possible size of investments, mainly in the innovative development of the fundamentally new technologies, will make about USD 5 bln, where a share of the state will make about 900 mln. At the fourth stage the size of investments in production and use of hydrogen fuel and fuel elements may reach USD 10 bln, including state – 800 mln. Only projects that will pass the innovative-technological evaluation will be financed. The expenses on the nuclear-hydrogen complex are not taken into account in this estimation.

Anticipated results after the implementation of the Program:

➠Russia will overcome lagging formed in the 1990s and enters the number of the countries – world leaders in development of hydrogen energy – one of the key directions in the energy-ecological revolution in the 21st century;

➠A large-scale production and use of hydrogen fuel and fuel elements will begin, thus ensuring energy security of the country under conditions when the reserves of the best deposits of fossil fuel are being depleted and it becomes more expensive;

➠The activities under the Program will promote the development of allied industries (production of nanomaterials, power equipment etc.), will become one of the leading directions in the high-tech complex of the country, innovative path of economic development;

➠Cooperation with the CIS countries and states of far abroad will strengthen, thus permitting to strengthen positions of Russia on the world energy market and to expand its presence on the world high-tech market in general;

➠Ecological situation in the country will alter for the better; the volumes of greenhouse gas emissions will reduce drastically as well as pollution of atmospheric air, water and lands. This will contribute to the surmounting negative changes in climate, improve quality of life of people, especially in large cities and industrial centers, will promote the growth of a well-aware support of hydrogen economy by population;

➠An efficient framework of partnership between state, business, science and education will be worked out in the implementation of an innovative breakthrough, fulfillment of national innovative programs and projects, coordination of scientific and innovative projects on the federal, regional and international levels.

The payoff period of the projects under the Programs will be changed at its various stages. When technologies are being mastered, it will be long, however at the next stages when production and use of hydrogen fuel and fuel elements will reach the industrial scale and they will become much cheaper, the payoff period of the projects will reduce considerably.

The effect of each project will be determined after evaluation of the projects under the Program and will be updated at each stage of its implementation in the context of the results already reached, inflation rates and conditions of the world energy market.

1. Need to Make a National Program

1.1. The Leading Link of the Global Energy-Ecological Revolution

1.1.1. Global Scientific-Technological Overturn of the 21st century

In the first half of the 21st c. the world economy has entered a period of a global scientific-technological overturn. Its contents is a scientific revolution and a transition from industrial to the post-industrial technological mode of production based on a cluster of epochal and basis innovations that are transforming all sides of society's life. The first stage of such transformations will be the mastering and spreading of the sixth technological order that will be prevailing in the 2020-2040s in the vanguard countries determining the competitiveness of products on the world and national markets, economic growth rates, level and quality of life of population.

1.1.2. Energy-ecological Revolution is the Pivot of a Global Technological Overturn

Each technological overturn has its own specific structure, its leading, basic directions. The pivot of the technological overturn of the first half of the 21st c. is a global energy-ecological revolution that is based on the use not fossil fuel prevailed in the industrial period as a major source of energy but alternative and renewable; ecologically clean sources of energy where hydrogen fuel will take the leading position among them.

The impending global energy-ecological revolution is dictated by a number of factors.

First, the population numbers of the world are increasing continuously: it will increase one and a half time against present by 2050. Energy consumption is rapidly growing, especially in the developing countries.

Second, in the foreseeable future major approachable and rich deposits of fossil fuel will be depleted, its reserves are distributed quite unevenly by countries and civilizations, costs of its production and prices will increase many times.

Third, energy causes more and more damage to the environment with each year: the volume of harmful substances emission into the atmosphere is only increasing that leads to irreversible changes in climate and threatens to the planet with an ecological catastrophe.

Fourth, current and capital costs for ensuring energy needs of society and preservation of environment are increasing fast that brakes economic growth of all countries and do not allow satisfying the needs of population to a necessary extent.

Fifth, economic and ecological potential of technologies of industrial type used in the energy sector is reducing. An innovative breakthrough is necessary, and the launching site for it will be the mastering and distribution of fundamentally new resource-saving, ecologically clean technologies in the

21st c., and first of all science-intensive hydrogen energy of the post-industrial type that will make the major contents of the developing energy-ecological revolution in the vanguard countries.

1.1.3. A Conversion to Hydrogen Energy is the Core of a Global Energy-Ecological Revolution

Hydrogen fuel has decisive **advantages** among alternative sources of energy due to a number of reasons:

➠Its reserves are nearly inexhaustible – hydrogen may be manufactured from water, methane, fossil fuel and biomass;

➠Hydrogen has a high energy intensity – its combustion value in oxygen is 2.6 times higher than with gasoline;

➠This is an ecologically clean product – ordinary water is its waste when using;

➠Hydrogen may be manufactured in the off-peak running regimes of the atomic power plants and hydroelectric power plant that enhances the efficiency of their performance and reduces production costs;

➠This type of fuel may be used (as fuel elements, autonomous energy generators, and also portable household appliances) in all sectors of economy.

In production and use of hydrogen fuel some restrictions exist:

➠Technologies of manufacturing, storing, transportation and use in large scale of hydrogen fuel has not been worked out well enough;

➠Hydrogen is explosive therefore rigorous standards of safety shall be applied in hydrogen energy as well as the system of information support of the Program should make such standards known to all producers and consumers;

➠The cost and sale price of hydrogen fuel and hydrogen elements are high now that limits the spheres of efficient use of these types of fuel.

However, these problems may be solved within one-two decades as an increasing number of scientists, inventors, designers and engineer from many countries are dealing with these issues and if the investments increase many times and scales of production of hydrogen fuel the costs and price will drop as a matter of course.

1.1.4. A Global Innovative Breakthrough in Hydrogen Energy

Although the idea to use hydrogen as fuel had already been proposed in the 19th c., complex research works in hydrogen energy began only in the mid-1970s, in the depth of the world energy crisis. In 1974 the International Association of Hydrogen Energy was established, it holds regularly international conferences and shows. In the 1980-1990s experimental works of the use of hydrogen and fuel elements in the industry, in conquering space, motor car and air transport were launched in a number of countries.

However, only the beginning of the 21st c. has witnessed a real breakthrough in hydrogen energy and fuel elements when such issues were promoted to the level of state and interstate promising innovative policy, when long-term national hydrogen programs (initiatives) were adopted in the USA, Japan and other countries, and in the European Union – similar interstate program. In the near years the scales of researches and innovations will increase in this field in geometric progression in the vanguard countries, and it means that soon notable practicable results may be got soon.

Hydrogen energy belongs to a number of high-tech productions and is one of the basic directions of the sixth technological order that will become prevailing in the 20-40s of the 19th c. and will determine the competitiveness of goods and services.

1.2. Hydrogen Energy is an Engine of an Innovative Breakthrough in Russia

1.2.1 A Lagging of Russia in the Innovative-Technological Overturn

Today Russia is behind the vanguard countries that are mastering fast and efficiently the achievements of the global energy-ecological revolution based on hydrogen and fuel elements. There are several reasons for that:

First, Russia is one of few countries of the world with enormous reserves of fossil fuel that permits it not only to satisfy own energy needs in it but to export millions of tons of fuel getting a huge world oil-gas rent from its sale under high world prices. Therefore neither the state nor the private business demonstrates a due interest to alternative sources of energy.

Second, as a result of crisis of the 1990s scientific-engineering and innovative potential of the country was undermined, a series of promising directions of scientific efforts, including in the sphere of alternative energy were wound up, and unregulated market economy has turned out to be nearly not receptive to promising basic innovations.

Third, neo-liberal market reforms are based on the postulate that the state should leave the sphere of economy, and state support to science and innovations should be reduced to minimum. However, in such situation an innovative breakthrough is impossible that is indicated by experience of foreign countries with the developed market economy.

Fourth, the energy sector of Russia is distinguished by low efficiency (*Fig. 1*). Producing 4.6 times higher energy per capita (in terms of oil equivalent) and consuming 2.6 times more per capita Russia's energy efficiency (GDP per unit of energy used) is 2.5 times lower world average and CO2 emissions per capita is 2.5 times higher. A share of fuel in the structure of export of goods is 6.2 times higher than the world average level. Modern Russia is fast depleting proven reserves of fossil fuel inherited from the previous generations and does not use huge sizes of the world oil-gas rent for modernization, innovative renovation and enhancement of competitiveness of economy.

If recent tendencies of development of energy sector under conditions of developing scientific-technological overturn in the world (including global energy revolution) persist, Russia will turn into the innovative-technological backwoods with the lapse of time and become only a supplier of fuel and raw materials and sales market of finished goods for developed countries and transnational corporations. It is already now when Russia begins to feel a growing shortage of electric power that brakes economic growth.

When approachable rich reserves of oil and gas are mainly depleted, their production processes and transportation become considerably expensive and fuel price drops on the world market as the developed countries will be mainly using hydrogen and other alternative sources of energy, energy-ecological and economic crisis is impending in Russia.

1.2.2 Status of Work in Hydrogen Energy

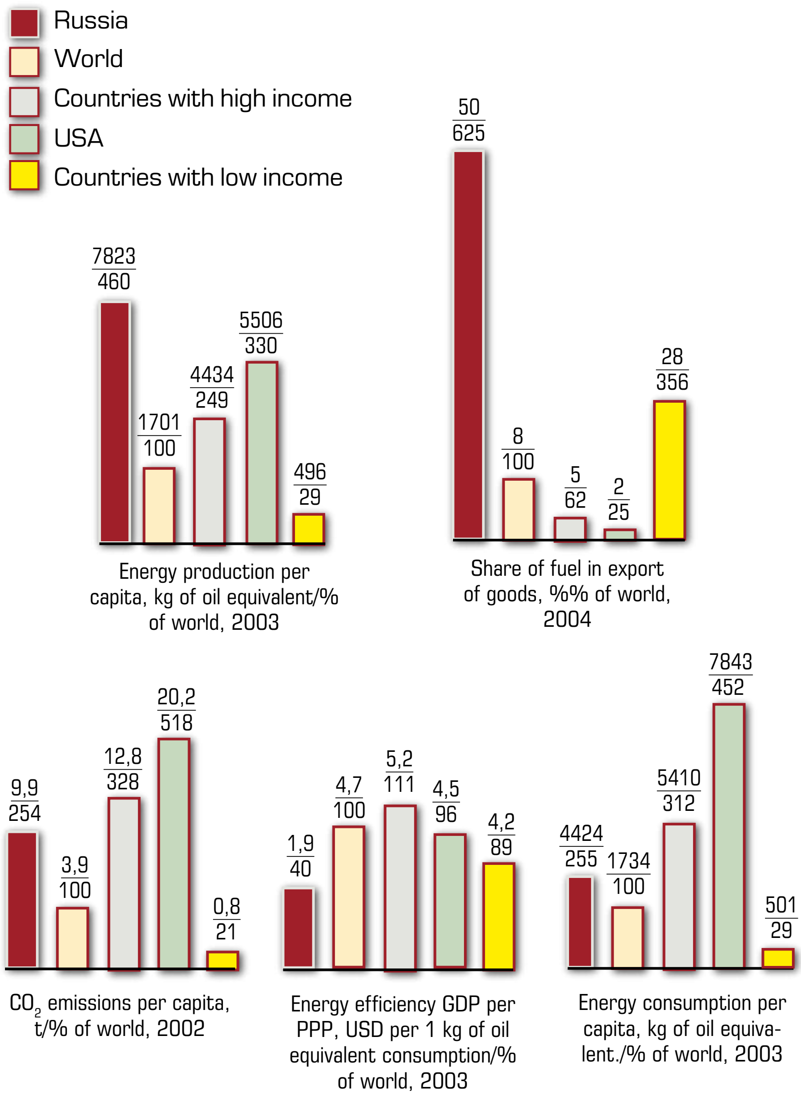
Already in September 1941 in besieged Leningrad there was created and registered a device to use hydrogen as motor car fuel and its scale use began for the first time in the world. In World War II about 700 cars supporting hydrogen balloons of the air defense of Leningrad and Moscow were operated on hydrogen.

From the mid—1970s the USSR actively joint the researches in hydrogen energy: they were conducted by specialists of several academic institutes, and the task laboratory of hydrogen technologies was opened in the Donetsk Polytechnic Institute. Hydrogen was used in several production processes as fuel, in conquering space, air transport. However, in the 1990s these efforts were wound up.

Only from the end of 2003 when the RAS presidium and the mining and metallurgical company Norilsk Nickel entered into the agreement and the Integrated Program of exploration, scientific-research and development efforts in hydrogen energy and fuel elements was approved (Nornickel GMK allocates USD 40 mln per year for the program), researches and practical activities into this subject were renewed. A number of academic and sectoral institutes and higher educational institutions of Russia took part in them, the National Association of Hydrogen Energy (NAHE). However, the state did not nearly render support to the prime direction of an innovative-technological breakthrough while the vanguard countries earmark huge funds for its development. Thus, the US Senate adopted a resolution that USD 1.7 bln from the budget will be channeled to this sphere within five years, and investments of private companies will make about 5—6 bln more. The European Union will spend EUR 2 bln for such purpose; in Japan – USD 4 bln (during 20 years).

From 2005 the researches in hydrogen energy in Russia considerably expanded. A number of projects have been prepared, exhibitions were held, there was established and successfully operating the national innovative company 'New Energy Projects'. The cross-disciplinary discussion was held and the work was published 'On the Path to Hydrogen Energy'. The NAHE has launched the formulation of the concept of the National Program of Hydrogen Economy that includes the involvement the most active social strata in the problems of energy-ecological security, giving hydrogen education. The MIREA and the Lomonosov Moscow University have established a scientific-educational center 'Sokolinaya Gora' furthering the development of hydrogen economy. The youth organization of a new type sprang up here – international hydrogen club comprising young scientists, post-graduates, students and schoolchildren.

Figure 1. RUSSIA IN GLOBAL ENERGY SECTOR



Source: 2006 World Development Indicators. Washington. The World Bank, 2006. Pp. 156, 160, 268

The government of the country set the strategic tasks of innovative transformation of energy industry, including based on hydrogen energy.

1.2.3 Scenarios of the Development of Hydrogen Economy in Russia

Two possible scenarios of Russia's involvement in the global energy-ecological revolution are clearly taking shape.

Inertia-based scenario: if the state does not still support the projects furthering an innovative breakthrough in hydrogen energy, Russia will eminently turn out on the periphery of the global energy-ecological revolution, and ecological and economic crises are impending in future when all the best oil and gas fields will be depleted and world prices for oil fuel will drop.

Scenario of innovative-energy-ecological breakthrough is based on the united efforts of the state, research organization, powerful industrial and financial corporation directed at a speeded up development and mastering in large scale of the key directions in production, transportation, storage, ensuring safety of hydrogen fuel and fuel elements, their efficient use in various sectors of economy, developing innovative market niches based on the innovative partnership of state, business, science and education. It is necessary to cooperate actively with the CIS countries concerned and other states so that to become one of the leaders of the global energy-ecological revolution in future. A strategic instrument to implement such scenario is to make and to implement consistently of the national scientific-innovative program 'Hydrogen Energy' under an active support of civil society.

1.3. Need and Advantages of the National Scientific-Innovative Program 'Hydrogen Energy'

1.3.1. Need of the National Program

It has already become a tradition that strategic socio-economic, scientific-technical, innovative, ecological and other problems are decided in Russia using federal special purpose programs. The list of the programs financed from the federal budget is annually adopted and published as one of appendices to the federal budget. However, the federal special purpose programs have several essential drawbacks: the size of financing is not enough and is revised annually, they are mainly of departmental (or regional) nature, no well-defined system of management and responsibility of executing agencies has been established for final result.

Historic experience of the USSR and Russia (the GOELRO plan, programs for the creation of missile nuclear shield, conquering space, implementation of national projects of social nature in modern Russia) and other leading countries of the world (the Apollo program and Soyuz-Apollo in the USA, modern hydrogen programs in the USA and the European Union) indicate: an innovative breakthrough is possible only based on the scale programs implemented on the initiative and with the immediate involvement of the state under active furtherance of private business and wide involvement of the scientific community, practical engineers, talented youth, and system of occupational education.

The energy-ecological revolution permeates nearly all sectors of economy. In order to implement it is necessary to concentrate considerable intellectual, financial and material resources both the state and business. It is exactly the target of the national innovative program 'Hydrogen Energy'.

1.3.2. Specifics and Advantages of National Programs and Projects

National programs and projects have indisputable advantages against federal special purpose scientific-technological and innovative programs.

First, if the object of the special purpose program is any direction of equipment (technology), sector or region, then a national program is oriented at transformation of economy in general at a certain angle of view. Thus, the object of the program 'Hydrogen Energy' is all energy sector of the sector, its connections with other sectors of economy and with the global energy sector: the structure of production and consumption of energy, technologies of energy supply and energy saving, energy market, production of relevant equipment, manpower training, legal framework of the energy sector, information support of an innovative breakthrough. Basically, the matter in question is building up hydrogen economy as it has been noted in the document of the G8 summit in Saint Petersburg.

Second, federal special purpose programs are usually made for 5—10 years ahead while national – for a longer period. It is impossible to transform fast all spheres of energy production and energy consumption, and a change of generation of equipment (technologies) and technological orders is extended for years and decades. Therefore a horizon of the National Program 'Hydrogen Energy' covers a period up to 2050 (as it is provided for by hydrogen technological platform of the European Union).

Third, unlike special purpose programs of one level (federal or regional), the national program 'Hydrogen Energy' is of a hierarchical nature. It ensures smooth cooperation of production and science, innovative mastering of achievements of the latter not only nationwide level but regional, and also permits to enter into cooperation with the CIS countries and far abroad that are introducing the same scientific-innovative programs.

Fourth, federal special purpose programs are more often financed from the budget, and the national program of hydrogen energy is founded on the partnership, uniting efforts of the state, science, education and business. While at the launching stage the state still remains the major investor, then financial participation of private corporations and investors then steadily increases in the programs (and hence responsibility for its implementation). Not least important condition is that the funds should be earmarked not for one year, but all period the projects are underway.

Fifth, unlike special purpose programs that as a rule has an amorphous structure of management and do not ensure a real responsibility for the result either government customer (of federal or regional body) or the master executing agency, the national program is based on well-defined modern and efficient system of management. The program is oriented at the final result and includes three mandatory elements:

- *Customers* (the Government of the RF, for individual sub-programs – ministries, agencies, regional bodies and also corporations by individual specific projects) in charge of making such orders, allocation of the funds, evaluation of the performance results and their practical application;
- *Research supervisors* of the Program proper, its sub-program, projects. Scientists bear responsibility for development of technologies and accompanying projects, for a scientific-technological level of results; they also exercise follow-on when technologies are being implemented;
- *Management company for the program and executing agencies* (directors) of sub-programs, projects. The executing agencies get an order and resources for its implementation, arrange all activities and deliver them to the interdepartmental commission in general and by stages (sub-programs, projects).

In this regard all elements oriented at the final result are included in the single information network that will ensure efficient control from civil society for the implementation of the Program, its ecological and socio-economic effect.

Sixth, the result of the performance of the target program is economic, social, ecological effect in one branch, sector or region, and the national program – in all country. Furthermore, it is often the case when the state acceptance of the target programs completed is not performed, and their results are not evaluated that establishes conditions for inappropriate use or stealing of the earmarked funds. On the contrary, the quality of the performance of the stages of the National Program and individual projects may be evaluated according to clear parameters, comparing with figures predetermined when making a governmental order: a share of hydrogen fuel in the energy balance of the country, volumes of hazardous emissions into the environment, level of energy saving, increase in labor efficiency and GDP output etc.

The analog for working out the framework to implement a National Program may serve the framework for the performance of four national projects of social nature adopted on the initiative of the RF President the hydrogen program is connected with each of them through the subject.

2. Objectives, Tasks and Milestones in the Implementation of the Program 'Hydrogen Energy'

2.1. Objectives of the National Program

2.1.1. Requirements for the System of Objectives of the National Program

The final and intermediate objectives of the Program should be articulated clearly, determined in quantity and mutually agreed. It is necessary to build up the tree of objectives of the Program proceeding from the following requirements:

➠Major parameters (indices) of the implementation of the Program showing in large its general objective should not be many; they can't contradict each other internally and show final national economic results of the Program implemented;

➠In view of the performance period of the Program, such final parameters should be broken down into several time lengths (milestones of the implementation of the Program) so that it could be possible to control its performance and adjust it, if necessary;

➠As the Program has a complicated and multi-level nature, final parameters should be determined by each sub-program, each project weighing and approving them with the parameters of the general objective;

➠The implementation of the Program and its individual stages should be controlled strictly and how efficient the funds allocated are used should be monitored; if internal and external conditions of the implementation of the Program change, to adjust the system of its objectives and structure or terminate activities at all over individual projects if it is established that they have no prospects.

2.1.2. General Objective of the Program 'Hydrogen Energy' in a first approximation may be formulated as follows: '*To elaborate and to master innovatively the fundamentally new technologies of production, safety storing, transportation and use of hydrogen fuel and fuel elements in various sectors of national economy so that to increase a share of such type of fuel in the energy consumption balance of Russia up to 3% by 2020, 10% — by 2030 and 30% — by 2050*'. On this basis to ensure a relative saving of fossil fuel and reducing the volumes of greenhouse gases emissions into the atmosphere from stationary and mobile sources by 3% by 2020, 10% — by 2030 and 25% — by 2050.

To increase a share of the annual average GDP increased due to the implementation of the Program by 0.5% by 2020, 10% — by 2030 and 20% — by 2050.

One should be clearly aware that the implementation of the Program can't bring essential results before 2010, but a benefit from its implementation will become obvious already by 2020.

2.1.3 Interim Objectives of the Program follow from their general objective. It is necessary within framework of the Program:

➠ *To reach the industrial level of production* of hydrogen fuel at the atomic power plants and water power plants. Involving these and other sources for production of hydrogen fuel in volumes sufficient to conduct experimental works and to increase its share in the energy consumption balance up to the indices specified in the general objective of the Program;

➠ To develop *storage and transportation systems* of hydrogen fuel from its producers to consumers. To set the output of self-contained electric power plants and filling stations in quantity sufficient to supply vehicles operated on hydrogen fuel with it (cars, scooters, vessels, aircrafts etc.) and electric public utilities in remote regions;

➠ To work out and to arrange *industrial production of fuel elements* for self-contained electric power plants and mobile and stationery mechanisms operated on hydrogen fuel and being used in various sectors of economy, first of all in electric public utilities;

➠ *To bring the level of consumption* of hydrogen fuel and fuel elements:

– in cars: to 0.5% by 2010, 5% — by 2020, 20% — by 2030 and 45% — by 2050;

– in river and sea vessels: 1% of deadweight by 2020, 5% — by 2030, 15% — by 2050;

– in aircrafts: to 2% by 2030 and 15% — by 2050;

– in electric power plants for municipal housing economy: to 10% by 2020, 25% — by 2030 and 40% — by 2050.

– In portable energy sources: to 5% by 2020, 20% — by 2030 and 45% — by 2050;

➠To *solve the issue of safe production*, storage, filling, use, to establish the system of standards and specifications, control mechanism for compliance;

➠To reduce the cost of production of fuel elements against the level attained in 2005 2—3 times by 2010, 4—5 times by 2020, 6—7 times by 2030, 8—9 times by 2050, hydrogen – 1.3—1.5 times by 2010, 1.8 – 2 times by 2020, 2.5—2.8 times by 2030 and 3.2—3.5 times by 2050;

➠To ensure *training and retraining* on a necessary scale of researchers, instructors, engineers, production engineers, skilled workers, managers for production, mastering and operation of hydrogen fuel and fuel elements under the program and projects;

➠To put into effect the *system of general education in hydrogen* that includes mass training in the fundamentals underlying the use of ecologically clean types of energy, first of all hydrogen, in direct connection with the decision of the prime energy-ecological problems of municipalities, regions and all the country;

➠To work out and to put into effect an information network that would ensure efficient control from civil society over the implementation of the Program and its implications.

The tree of the Program objectives is given in *Fig, 2*.

2.2. Tasks of the National Program 'Hydrogen Energy'

2.2.1 A set of tasks of the National Program follows from the system of its objectives and ensures specific ways to achieve

Figure 2. TREE OF OBJECTIVES OF THE PROGRAM 'HYDROGEN ENERGY'

General Objective

Researches and basic innovations ensuring shaping of hydrogen economy for achieving the significance of parameters, %

Indices	2020	2030	2050
Share of hydrogen in the structure of energy consumption	3,0	10,0	30,0
Saving of fossil fuel and reduction of CO_2 emissions	3,0	10,0	25,0
Share of hydrogen energy in the GDP increase	0,5	10,0	20,0

First Level Objectives

Growth of hydrogen production for attaining the set objective

Growth of fuel elements production in the volumes for attaining a share in energy consumption

Bringing the hydrogen fuel consumption to the following level, %

Indices	2020	2030	2050
Cars	5,0	20,0	45,0
Vessels	1,0	5,0	15,0
Municipal housing economy	10,0	25,0	40,0
Portable devices	5,0	20,0	45,0

Resolving problems of transportation and storage of hydrogen

Resolving safety issues

Cost reduction as compared with 2005, times

Indices	2010	2020	2030	2050
Hydrogen fuel	1,3–1,5	1,8–2	2,5–2,8	3,2–3,5
Fuel elements	2–3	4–5	6–7	8–9

them based on the stages of the implementation of the Program. Objectives and tasks of the Program serve as guides in determining its functional and insuring structure.

2.2.2. ***System of tasks under the Program*** necessary for attaining its objectives, including three blocks connected with each other:

➠*Research* – a complex of fundamental and applied researches, development efforts and technical and economic assessments intended to solve problems of production, storage, transportation and use of hydrogen fuel, production and use of fuel elements and power plants in various sectors of economy. The first block is primary at the initial stages of the implementation of the program due to the depth of transformations and science-intensive technologies related to the sixth technological order;

➠*Innovative* – mastering production and use of hydrogen fuel and fuel elements based on basic innovations in all branches, sectors of economies and regions of the country fit for that (first of all in municipal energy, transport and portable electronic devices). The significance of this block and its share in investments will be increasing at further stages of the Program;

➠*Management* – making legal, organizational-economic and management framework for development and implementation of the National Program 'Hydrogen Energy', its sub-programs and projects, including the issues of establishment and functioning of the management company, training and retraining of manpower, information support, mastering hydrogen energy in the regions of Russia and international cooperation in this sphere. The tasks of this block should be begun to solve from the very start of its shaping, however, their structure and the performance will be changed at various stages as the Program is being fulfilled.

All three blocks of tasks (research, innovative and management) should be connected through a general information periphery (IP) working in general for the program from civil society. IP should reflect on the international, national, regional and municipal levels socio-economic, ecological and political-legal aspects of hydrogen development in Russia making a basis of social monitoring the implementation of the Program at all its stages.

2.3. Stages of the Implementation of the Program

2.3.1. ***A stage-by-stage approach to elaboration and implementation of the Program***. As the Program is envisaged for a long-term outlook, has a high level of uncertainty, its tasks are complicated, and research and innovative risks are high, it is necessary to envisage several stages in its implementation, and also an option to make adjustments as it advances.

2.3.2. ***The first stage (2006—2010)***. A major direction in the implementation of the Program is the projects of the first block – research, and also management. Fundamental and applied research works and development efforts should be done covering a wide range of directions and projects in production, transportation, storage, application of hydrogen fuel, and designing, manufacturing and efficient use of fuel elements. At the same time it is necessary to conduct marketing researches and technical and economic assessments so that to determine the most efficient methods of production and areas where hydrogen fuel and fuel elements will be used (innovative niches on the internal and external markets). The management company should outline a range of innovative projects of the 1st turn and solve the issues of its financing, to identify regions to be first master the achievements of hydrogen energy. At the first stages negotiations are conducted and agreements are entered into with Russian and foreign partners, legal and organizational-economic framework of the implementation of the Program is being built, the system of management is shaped, target training of manpower is launched. Demonstration copies of devices and plants are created and displayed at the international expositions. The concept of manpower training for hydrogen energy is formulated and launched.

Public opinion is formed to convert to hydrogen and other ecologically clean types of alternative energy. The concept of hydrogen general education and information periphery (IP) of the Program is worked out and tested. Information support of the first stage of the implementation of the Program is performed and development of general education in hydrogen connected with the implementation of priority national projects and decision of the most severe environmental problems.

2.3.3. ***Second stage (2011—2020)***. The major task of this period is innovative mastering of the results attained at the first stage. It is necessary to implement a complex of innovative-investment projects in the priority spheres and to ensure their scientific support, and also to continue a fundamental search in promising directions. At this stage the volume of investments will increase many times, production cost, transportation and use of hydrogen fuel, manufacturing and application of fuel elements will drop sharply. Economic, ecological, social and foreign economic effects from the development of hydrogen energy will increase, its contribution to the GDP increase will grow, new niches on the internal and external markets will be developed, cooperation with foreign partners expanded. Positions of Russia will noticeably strengthen in the global energy overturn.

A regular training and retraining of manpower should operated by the end of the stage in all links of hydrogen energy. A well-established public opinion will be formed that hydrogen energy is necessary as the core of energy-ecological security of the country. Information periphery (IP) os formed in general including public monitoring of the implementation of the Program and energy-ecological safety of municipalities, regions and all the country.

2.3.4. ***Third stage (2021—2030)*** – a phase of spreading of the energy component of the sixth technological order both on national and global scale. A complex of basic innovations is completed by a great number of improving innovations that ensure the expansion of spheres of production and application of hydrogen fuel and fuel elements. Innovative spreading of a new scientific-technological direction will bring a tangible result in the form of a major increase of a share of hydrogen fuel in the energy consumption balance, reduction of CO_2 emissions, and increase in GDP growth rates. This will permit to compensate reducing reserves, volumes of production and export of fossil fuel and its appreciation. A transformed energy sector of Russia will organically be included in the global energy sector modernized on the high-tech basis.

2.3.5. ***Fourth stage (2031—2050)***. Hydrogen energy as one of basic directions of the sixth technological order will enter the maturity phase. The improving innovations will be going as an extended front; a part of novelties will already become pseudo-innovations. Effect of mass distribution of hydrogen energy will reach its maximum; hydrogen fuel will become the main alternative source of energy. The volumes of production and consumption of fossil fuel and greenhouse gas emissions into the atmosphere will considerably reduce. The development of fundamental issues of the seventh technological order that will be prevailing in the second half of the 21st c. will begin.

A large mass of people of the country consuming or is ready to consume hydrogen or other ecologically clean energy in future will take it as an integral feature of the post-industrial way of life. Information periphery (IP) operating in an online mode using population actively supports the activity and energy-ecological security of the country.

3. Structure of the National Program 'Hydrogen Energy'

3.1. Major Principles and Outlines of the Structure of the National Program

3.1.1. Compliance of the Structure with the Objectives and Tasks of the Program

The structure of the Program shall ensure the fastest and efficient achievement of its objectives, and also be flexible enough, able to adapt to changes in objectives and tasks, to develop in time, by stages of the implementation of the Program.

3.1.2. Outlines of the Structure of the Program

In pursuance of the objectives stated in section 2 of the Program three outlines connected with each other may be defined in its structure (*Fig, 3*):

➠*Research* – conducting fundamental and applied researches and development efforts aimed at the development of efficient production technologies, storage, transportation and ensuring safety of hydrogen fuel; creation and modernization of fuel elements; use of hydrogen fuel and fuel elements in various branches and sectors of economy; building up efficient framework of innovative partnership of state, science, education and civil society for the implementation of the Program;

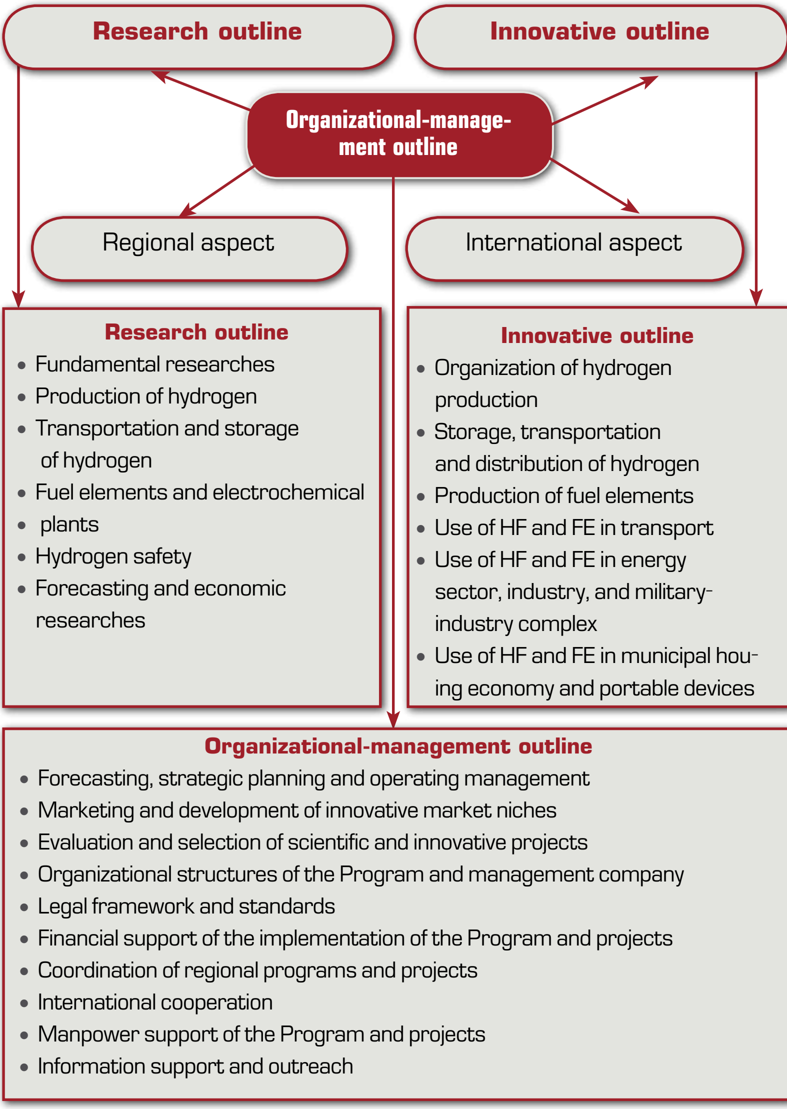
➠*Innovative* – use of the outputs of R&D and inventions for mastering and spreading of efficient innovative technologies and products in various sectors and spheres of economy, elaboration of business plans of innovative-investment projects, mastering of innovative niches on internal and world markets;

➠*Organizational-management* – building up special purpose organizational structures with respect to the projects, sub-programs and the Program in general; establishment of the management company under the Program (National Innovative Company 'New Energy Projects'); identification of customers, research supervisors, executive directors for the programs and sub-programs, establishment and arrangement of operations of the management company of the Program; shaping the organizational structures engaged in forecasting and strategic planning of development of the Program, innovative-technological and economic evaluation and selection of specific projects, management of financial flows; coordination of regional and international hydrogen energy projects, manpower training; information and technical support, public relations; building up information periphery (IP); social monitoring of energy ecological security of the country.

3.1.3. Projects

The basis of the implementation of the National Program is a specific project – research, innovative or organizational-management after the relevant evaluation. The project making a part of the sub-program and the Program becomes a basis for financing, gets a specific customer, research supervisor and executive director, research program (for research projects) and business plan (for innovative projects). Financing of the projects is determined for entire period of their implementation from all sources in accordance with the approved program of researches or business plan. Upon completion of the performance period the management of the Program and subprogram and management company will accept from the executing agencies and assess the results achieved by the same. It is possible the elaboration of complex projects covering both research and innovative and management activity as well as organizational-management projects.

Figure 3. STRUCTURE OF THE NATIONAL INNOVATIVE PROGRAM 'HYDROGEN ENERGY'



3.1.4. Subprograms

In the structure of the Program there are distinguished subprograms that have a nature of matrix and cover research, innovative and management activity ensuring connections and coordination of the projects at all stages until the final result is obtained – a market product or technologies with an optimal level of mastering. The subprogram helps to solve specific tasks of the Program – issues of production, storage, transportation, ensuring safety, distribution of hydrogen fuel, development and production of fuel elements and power plants, marketing and developing innovative niches on the internal and external markets.

3.1.5. Regional Aspect of the Program

In the elaboration of this or that project it is identified a territory where its primary mastering will occur, and also the decisions of coordination with individual regions where the complexes of the projects for fuel and fuel elements production will be introduced and their innovative mastering will occur. As the Program advances the number of such regions will be expanded, hydrogen energy will be more and more widely applied countrywide. Regional and interregional programs may be shaped that will determine a territorial aspect of the Program for hydrogen energy by the subjects of the Russian Federation and macro regions (federal districts).

The territorial aspects of the Program are shown in the monitoring of its implementation with the involvement of municipal population, regions and all the country, monitoring of public opinions, energy-ecological monitoring and general education in hydrogen within the complex program of information periphery (IP).

3.1.6. International Aspect of the Program

Under conditions of globalization of economy and energy industry it is advisable to work out and implement the National

Program 'Hydrogen Energy' within the innovative cooperation with foreign parties concerned and foreign companies. Such cooperation may be based on:

- Joint research and innovative projects;
- Acquisition of parcels of shares and joint business with the foreign companies engaged in hydrogen energy;
- Interstate treaties, programs and projects in hydrogen energy worked out and entered into within CIS and between individual countries of the Commonwealth;
- Coordination of activity and exchange of experience with the companies in the vanguard countries (USA, Japan, Germany etc.) and interstate unions (the European Union);
- Establishment of an international innovative strategic alliance in hydrogen energy;
- UNEP initiatives or UN international programs, UNDP etc.

The subsystem and projects intended for ensuring international cooperation and coordination of activities are distinguished in the organizational part of the Program respectively.

3.2. Research Outline of the Program

The research part includes the following subsystems and major problems to be solved in the implementation of the National Program.

3.2.1. Fundamental Researches

- Thermodynamics, kinetics and catalysis, structural mechanism and their influence, properties and efficiency of electrochemical fuel cells with various electrolytes.
- Hydrogen and fullerenes.
- Hydrogen and nanotechnologies.
- Hydrogen treatment of materials. Get powders. Hydrogen modification of semi-conducting and dielectric materials.

➟Microspheres for storing hydrogen.

➟Thermodynamics, kinetics, technological implementation means of photolytic processes of water decomposition.

3.2.2. Hydrogen Process

➟Establishment of large-scale hydrogen production complexes based on atomic power plants (atomic power plants and Atomic Power Technological Plants), in particular using high-temperature gas-cooled reactors of new generation MGR-GT.

➟Development of industrial methods and equipment for production of hydrogen using plasma technologies.

➟Creation of high temperature mobile and fixed plants for hydrogen production in thermo chemical cycles.

➟Development of technologies and equipment for hydrogen accumulation of energy in energy complexes with variable demand, including in the systems using renewable resources (solar and wind hydrogen plants energy complexes).

➟Creation of fixed and mobile complexes for hydrogen production and manufactured gas (H2+CO) using biomass gasification method and local mineral resources (coal, shale etc.)

3.2.3. Hydrogen Transportation and Storage Issues

➟Development of technologies and equipment for storing stocks of hydrogen (gaseous and hydrates) on the industrial scale in the land gas holders and underground space of man-made and natural origin.

➟Creation of dedicated hydrogen equipment (compressors, pipelines, safety systems) and adaptation of existing networks of gas pipeline and gas filling stations for transportation, distribution and filling with hydrogen of various mechanisms operating on this type of fuel.

➟Development of solid storage batteries of hydrogen based on intermetallic compounds and alloys, borohydrate of alkali metals and hydrides of light-weight metals.

➠Creation of small-size systems of storage of hydrogen for transport vehicles and systems of heat and electric supply.

➠Development of hydrogen bottles of composite materials rated at pressure up to 70 MPa with the weight content of hydrogen 10-12% of the bottle weight.

➠Development of cryogen vessels with the weight content of liquid hydrogen at least 25% of the vessel weight.

➠Establishment of industrial complexes for liquefying of hydrogen and cryogen tanks for storage and transportation of liquid hydrogen by road and air transport.

➠Development of equipment for filling stations of transport vehicles by gaseous and liquid hydrogen.

3.2.4. Issues of Production of Fuel Elements and Electrochemical Power Plants

➠Development of battery of hydrogen-air fuel elements with solid polymer electrolyte with the improved electro physical and cost performances (based on domestic ion conducting membranes of new generation).

➠Development of electrochemical generators (based on fuel elements batteries) with solid polymer electrolyte for automobile transport and systems of decentralized power supply.

➠Development of mini-fuel elements with solid polymer electrolyte designed for charging mobile electronic devices (telephone, notebook, computer, dedicated equipment).

➠Creation of batteries of hydrogen-air fuel elements with alkaline electrolyte and electrochemical generator with improved dimension and cost performances and intended for automobile transport power plants.

➠Development of electrochemical and hybrid (with turbine) power plants for systems of electric and heat supply (based on high temperature (solid oxide) fuel elements).

➠Development of co-regeneration self-contained power plants for supply with electric power and heat of residential buildings, quarters, small settlements, poultry farms, industrial livestock complexes, hospitals, and individual enterprises.

➟Creation of energy complexes using primary energy of renewable resources (wind, sun, tides etc.) based on electrolytic section-electrochemical generator' and applied for electric power supply of consumers in remote areas of the planet.

3.2.5. Safety Problems of Hydrogen Energy

➟Establishment of systems of monitoring and control of hydrogen content in gas mixtures and constructional materials.

➟Development of equipment and technologies to suppress processes of initiation of combustion and detonation in hydrogen mixtures.

➟Preparation of operation and legal documents pertaining to elementary rules and skills to handle hydrogen and hydrogen containing products at all stages of their production, storage, distribution and consumption.

3.2.6. Forecasting, Economic, Ecological and Social Researches

➟Making, regular extension and updating long-term (for 30—50 years) and medium-term (for 10—15 years) forecasts of dynamics of global and national energy sectors and development of hydrogen energy as one of basic directions of the sixth technological order.

➟Creation of global and national macro models of energy sector within reproduction-cyclical and geo-civilizational macro models for analysis, forecasting and assessment of economic implications of development of hydrogen economy and participation of Russia in the world energy sector.

➟Estimation of the influence that will render the implementation of the Program on the environmental situation and long-range balance of Russian energy resources.

➟Validation of the framework of innovative partnership between the state, business, science, education and civil society in the development of hydrogen energy, methods of governmental support in the implementation of the national program.

➠Research into social aspects in the implementation of the National Program 'Hydrogen Energy', its influence on the level and quality of life of population, especially in the remote northern regions of the country.

➠Research into information-educational aspects of the Program and general education in hydrogen, their impact on the state of public mind and energy-ecological security of the country.

3.3. Innovative Outline of the Program

The structure of innovative outline of the Program relies on the results of the research outline and targeted at a large-scale development of innovative niches on the national and world energy markets within the optimal period and with maximum possible effect.

3.3.1. Tasks pertaining to the Organization of Hydrogen Fuel Production

➠Mastering large-scale production of hydrogen by water electrolysis at the atomic and water power stations at the off-peaks.

➠Creation of capacities for hydrogen production from natural fuel, oil products, biomass and other sources.

➠Organization of production or import of equipment for hydrogen plants.

3.3.2. Problems of Hydrogen Fuel Storage, Transportation and Distribution

➠Mastering materials and technologies for storage of hydrogen by using gas bottles, cryogen and metal-hydride methods.

➠Development of systems of fuel transportation for industrial and energy purposes.

➠Establishment of distribution systems able to ensure demands of regions in hydrogen fuel.

➠Organization of production of equipment for storage, transportation and distribution of hydrogen fuel.

3.3.3. Production and Use of Fuel Elements

➠ Creation of capacities manufacturing various fuel elements.

➠Expansion of production output of metals and materials for fuel elements.

➠Establishment of logistics centers for sale and maintenance of fuel elements.

3.3.4. Use of Hydrogen Fuel and Fuel Elements in Transport

➠Mastering of batch, and then large-batch production of motor cars and trucks and buses on hydrogen fuel with hybrid gas-hydrogen engines, and also production of car filling stations.

➠Development of sea, river vessels and subsurface vessels with engines driven by hydrogen fuel.

➠Creation of winged vehicles and aircrafts with engines on hydrogen fuel.

➠Use of hydrogen fuel in the rocket-and-space industry.

3.3.5. Use of Hydrogen Fuel in Energy Sector, Industry and Military-Industrial Complex

➠Creation of self-contained energy generators on hydrogen fuel.

➠Development of systems on hydrogen fuel used in metallurgy, electronics, glass industry etc.

➠Active application of hydrogen fuel in the military-industrial complex.

3.3.6. Application of Hydrogen Fuel and Fuel Elements in Municipal Housing Economy, Agriculture and Household Appliances

➠Creation of self-contained system of power supply in the remote and northern districts, and also in energy smart housing estates of new generation.

➠Fitting with self-contained power plants with hydrogen fuel elements of poultry farms, industrial livestock complexes, farms, and small rural settlements.

➠Setting up production of portable energy accumulating units for household appliances.

The structure of management of the National Program given in *Fig. 4* ensures the performance of the following functions.

3.4. Organizational-management Outline of the National Program

3.4.1. Forecasting, Strategic and Operating Management of the Program

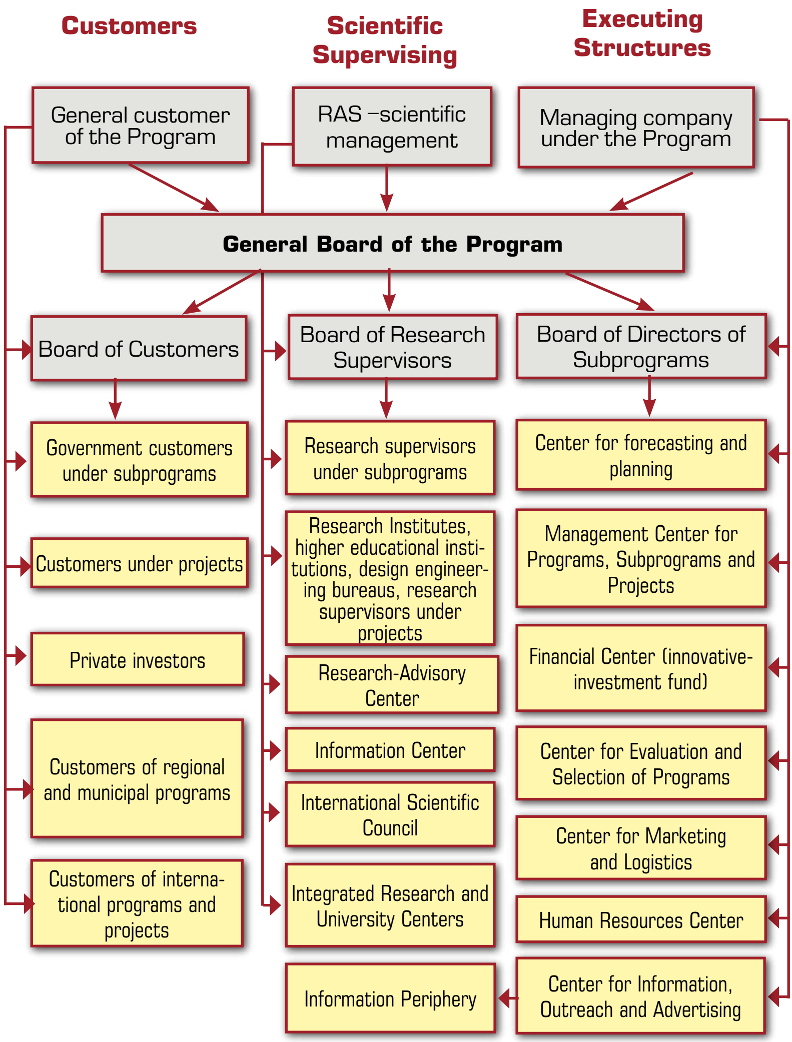
➠Analysis, making and evaluation of the energy sector and hydrogen energy development sector in the world and in the country.

➠Strategic planning of the implementation of the Program and development of hydrogen energy.

➠Scheduling of the nodal directions of development of hydrogen, their inclusion in the federal programs.

➠Operating management of the implementation of the Program, subprograms and projects.

Figure 4. THE STRUCTURE OF MANAGEMENT OF THE NATIONAL PROGRAM 'HYDROGEN ENERGY'



3.4.2 Evaluation, Selection and Appraisal of the Implementation of the Projects

➠Innovative-technological, economic and ecological evaluation of projects.

➠Patent examination of projects.

➠Appraisal of results of the implementation of the projects.

3.4.3. Marketing and Developing Market Niches

➠ Studying and forecasting of the conditions of national and world energy markets and development of hydrogen energy.

➠Marketing and promotion measures of innovative products of the Program on the internal and external markets.

➠Mapping out marketing strategy for entering the markets, development of market niches.

3.4.4 Activities of Organizational Structures Introducing the National Program

➠ Establishment of national, and in the long term – international strategic innovative alliance to implement the Program.

➠ Performance of the management company under the Program.

➠ Building up dedicated organizational structures for the subprograms and major projects.

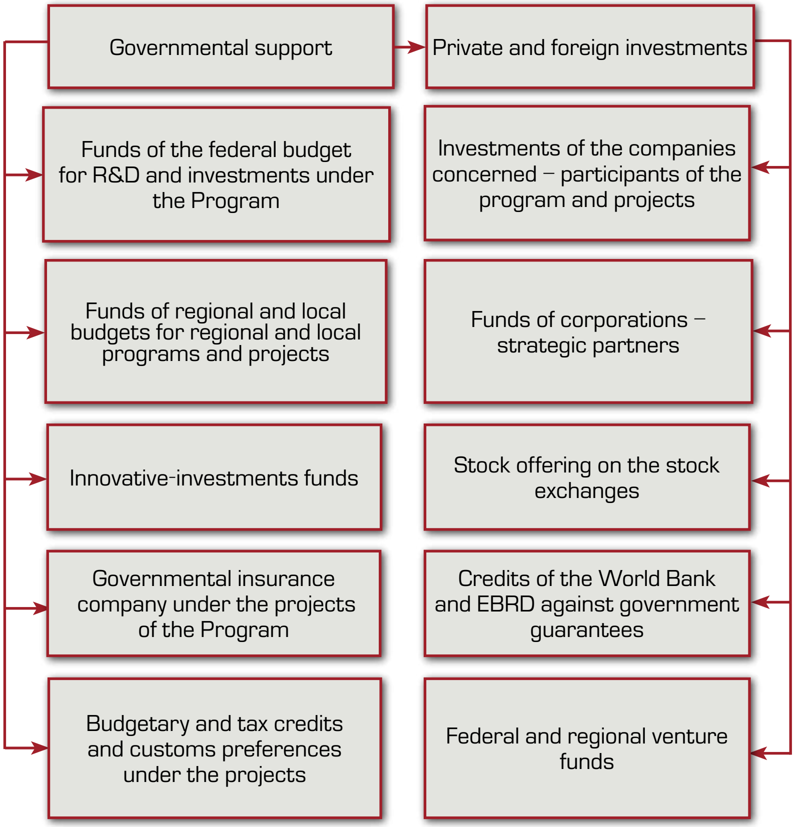
➠ Establishment of innovative-energy zones in the region of pioneer complex mastering of hydrogen energy.

➠ Support of small innovative enterprises operating in hydrogen energy, opening of business incubators for such companies in the innovative-energy zones.

➠ Performance of research-advisory council under the Program, evaluation and selection of projects.

➠ Arrangement of training and advance training of manpower, information support of the Program.

Figure 5. SOURCES OF FINANCING OF THE NATIONAL SCIENTIFIC-INNOVATIVE PROGRAM 'HYDROGEN ENERGY'



3.4.5. Financial Support of the Program

➠Establishment of the innovative fund for the implementation of projects, support of federal innovative and investment funds.

➠Entering equities market and dealings with investors for such purpose.

➠Establishment of regional venture funds in innovative-energy zones for support of small and medium business projects.

Financial support of the Program and projects is performed on the multi-channel basis (*Fig. 5*).

3.4.6. Legal Framework of the Program

➠Drafting federal laws on the National Program 'Hydrogen Energy' and innovative-energy zones.

➠Draft making of subordinate acts ensuring management of the Program.

➠Drafting the regulations on organizational structures necessary to implement the Program.

➠Making the system of standards and norms.

3.4.7. Coordination of Regional Programs and Projects

➠Coordination of activities related to the establishment and ensuring the operations of innovative-energy zones.

➠Coordination of the projects in hydrogen energy.

➠Approval of regional regulatory acts pertaining to the issues of hydrogen energy.

3.4.8. International Cooperation in Hydrogen Energy

➠Participation in the elaboration and implementation of joint programs and projects with the countries concerned – CIS members.

➠Joint projects with companies and states of far abroad concerned.

➠Establishment of joint ventures in individual projects, international strategic innovative alliance under the Program.

3.4.9. Information and Human Resources Support, Outreach

➠Publication of scientific, accounting and information literature on hydrogen energy.

➠Building and support of internet-portal for the National Program 'Hydrogen Energy'.

➠Regular delivering of conferences, trade shows pertaining to hydrogen energy.

➠Collecting and distribution of information related to development and implementation of the Program.

➠Manpower support of the Program, energy-ecological monitoring and general education in hydrogen.

➠Distance learning in the fundamentals of ecologically clean hydrogen and other types of energy.

➠Information on the state and outlooks for energy-ecological security of the country.

➠International information ties.

➠Development of general education in hydrogen and its infrastructure.

➠Creation of information periphery (IP) of the Program.

➠Support of active youth associations of hydrogen-ecological direction based on the international MIREA club – students union of a new type.

➠Arrangement of manpower training and traineeship abroad under the sub-programs and projects of the National Program, establishment of educational centers and projects similar to 'Sokolinaya Gora'.

➠Arrangement of PR actions under the Program and projects, outreach of the best achievements through mass media.

4. Preliminary Costs Estimation and Effect of the Implementation of the National Program

4.1. Expense for the Implementation of the Program

4.1.1. Structure of Expense

➠Expense for fundamental and applied researches, R&D (in accordance with the research outline of the Program).

➠Investments in innovative mastering of the projects (in accordance with the innovative outline of the Program).

➠Funds for the management of the Program, evaluation, selection and implementation of the projects, interregional and international cooperation (in accordance with its organizational-management outline).

➠Expense for training of manpower to carry out the projects, information support.

Volume of expense for each of the said directions will be periodically updated as the Program advances, selection and implementation of the programs.

4.1.2. Sources of financing of the Program

➠Funds of the federal budget earmarked as a separate line in accordance with the updated budgetary classification will be committed to the fundamental researches, starting mastering of new generations of hydrogen technologies, their use in social development, ecology, defense and administration. At the first stage these funds will make a major part of investments in the Program; however a share of budgetary contributions will reduce at the next stages.

➠Funds of federal investment-innovative funds and venture fund for financing of specific projects.

➠Funds of the budgets of the subjects of the Federation and municipalities in regions where the programs and projects in hydrogen energy will be introduced.

➠ Investments of private, mixed and government enterprises participating in the implementation of specific projects.

➠Foreign investments in projects jointly performed.

4.1.3. Preliminary Costs Estimation for the Program

➠At the first stage (2006—2010) – USD 600 mln, including from the federal budget – 300 mln;

➠At the second stage (2011—2020) – about USD 2 bln, including from the federal budget – 900 mln;

➠At the third stage (2021—2020) – USD 5 bln, including from the federal budget – 2,500 mln;

➠At the fourth stage (2030-2050) – for 20 years USD 10 bln, including from the federal budget – USD 800 mln (mainly for social and military-industrial complex).

According to a preliminary expert's estimation it will be required USD 17.6 bln, including from the federal budget – up to USD 2.7 bln, in a total for the implementation of three stages of the Program.

This estimation is of preliminary character and the expenses on the nuclear-hydrogen complex are not taken into account.

The volume and structure of expense will be detailed more in selection of the projects and updated at each stage of the implementation of the Program.

4.2. Effect of the Implementation of the National Program 'Hydrogen Energy'

4.2.1. Components of Effect after Implementation of the National Program (are given in *Fig. 6*)

Components of Effect:

- Innovative-technological – mastering of high-tech priority directions of the sixth technological order, bridging a technological lagging with the vanguard countries;
- Economic – a growth of the volume of value added cost and profit when the program products are being realized, reducing the payoff period of investments in specific projects;
- Budgetary – increase in the volume of additional expense of federal and local budgets from the implementation of the projects;
- Ecological – reducing emissions of harmful substances into the atmosphere, pollution of water basins and lands, saving of non-renewable resources of mineral fuel, enhancement of energy-ecological security;
- Foreign economic – diminishing dependence of the country on fluctuations in prices on the world fuel market, stepping up export of high technologies;
- Social – making tens of thousands of skilled jobs, increase in income of population, development of system of professional education; favorable conditions for intensification of intellectual potential of the youth, new way of life of population, growth of tolerance based on ideas of sustainable growth, speeding up social processes consolidating society;
- State-political – strengthening of stability and security of the country, enhance its role in civilizational space.

4.2.2. ***Economic effect*** will find its expression in the improvement of competitiveness of national products, and its energy content will reduce, fossil fuel becoming more and more expensive fast will be replaced with cheaper hydrogen and fuel

Figure 6. EFFECT OF THE IMPLEMENTATION OF THE NATIONAL SCIENTIFIC-INNOVATIVE PROGRAM 'HYDROGEN ENERGY'

Innovative-technological effect →

- Improvement of competitiveness of national products
- Mastering of the sixth technological order
- Modernization of a scientific-innovative potential
- Bridging a technological lagging with the vanguard countries

Economic effect →

- Reducing energy content in GDP 2 times by 2050
- Cheapening power supply of economy
- Reducing payoff period of investments
- A share in GDP growth from energy in 2050 20%

Ecological effect →

- Extension of the mineral fuel field development periods
- A reduction of 25% of fossil fuel by 2050
- A reduction of 25% of the greenhouse gas emissions by 2050

Foreign economic effect →

- A reduction of 20% of a share of fuel in export by 2050
- An expansion of 5% of a share in high-tech export in 2050
- Reintegration of the CIS countries in the energy industry
- Strengthening of positions in world economy

Social effect →

- A growth of demands for scientists, specialists, skilled workers
- Increase in the real income of population
- Ensuring steady operations of the municipal housing economy
- Favorable climate for scientific creation, inventions and innovations

State-political effect →

- Strengthening the role of the state in the innovative breakthrough
- Ensuring socio-political stability
- Strengthening of geo-political positions of Russia

elements with production costs considerably reducing as its scale expands. At the first stage (2006—2010) one should not expect considerable economic effect; many projects will turn out to be loss-making. However, at the second stage (2011—2020) expansion of scale of production and consumption of hydrogen and fuel elements will reduce many times costs and to enhance the return of the projects, especially against appreciation of fossil fuel and oil products. As a result the efficiency of products and the size of innovative energy rent will increase fast, and the investment payoff period will noticeably shorten. At the third stage (2021—2030) a growth rate of profits and energy rent will slow down, however their weight will be the largest that will give rise to GDP increase due to reducing in energy content of production and saving of fossil fuel, ensure a transition to an innovative type of development of economy.

4.2.3. Ecological effect

➠Extension of the field development period of non-renewable fossil fuel (first of all oil and has) and slowing down the rates of its appreciation being a major reason for inflation in the country;

➠Reducing growth rates, and then an absolute reduction of emissions of greenhouse gases and other deleterious gases, pollution of water basins and lands;

➠Enhancement of energy-ecological security of the country by a gradual ousting of ecological harmful energy from an every day use.

All this will permit to prevent unfavorable changes in climate, improve the state of environment in major industrial-transport centers and remote regions.

4.2.4. Foreign economic effect

➠ Dependence of Russian economy on conditions of the world fuel market and export of fuel will be reduced; resources will be released for maintaining within a longer period of the previous volume of export of fuel and proceeds from world oil-gas rent;

➠A share of Russia in the world export of high technologies will increase due to expansion of export of hydrogen technologies and fuel elements to the CIS countries and other states of the world concerned;

➠Expansion of cooperation in high technologies with the EC, USA and other countries fulfilling the programs in hydrogen energy.

4.2.5. Social effect

➠ Increase in the number of jobs requiring high skills, growth of income of the employed and resources for supporting non-workers (children, retired, physically challenged persons etc.);

➠Establishment of favorable climate in the country for scientific creation and innovative breakthrough that is especially important for the oncoming generations;

➠ A new way of life population established as a result of careful use of ecologically clean hydrogen and other alternative energy;

➠Improvement and enhancement of reliability of power supply of population;

➠Bringing the levels of socio-economic development and conditions of life of population in various regions of Russia that is especially important for northern and eastern areas and will contribute to reducing depopulation rates.

4.2.6. State-political effect

➠Strengthening of the role of the state and civil society in ensuring of the innovative breakthrough;

➠Furtherance of achievement of social and political stability in the country;

➠Consolidation of federal, regional and municipal authorities and public associations based on joint decision-making on energy-ecological problems vital for everybody;

➠A growth in the awareness of citizens on energy-ecological policy of the state, strengthening of social cohesion of population;

➠Strengthening of energy-ecological and geo-political positions of Russia in the world.

SUPPLEMENT 3

Program for Making the UN Global Forecast 'Energy-Ecological Future of Civilizations'

1. Necessity, Objectives and Methodology for Making a Global Energy-Ecological Forecast

Basis for making a forecast: Concept for making the UN global forecast 'Future of Civilizations. Forecast of Socio-Demographic, Innovative-Technological, Energy-Ecological and Geo-Political Development of Civilizations for a Period Up to 2050' endorsed by the RF Ministry of Foreign Affairs; documents of the G-8 summits in Russia (2006) and in Germany (2007) on energy-ecological security and climate warming control.

1.2. Relevancy of such forecast is determined by the fact that the first decades of the 21st c. are characterized by the evolvement of a global energy-ecological crisis. It manifests itself in a growing shortage of fossil fuel and its appreciation, dangerous increase of heat pollution of the environment and a threat of irreversible changes in climate, aggravation of contradictions among civilizations on the world energy market. Surmounting the crisis is possible based on the global energy-ecological revolution based on conversion to alternative ecologically clean sources of power. Major landmarks of such conversion is outlined in the G-8 document on global energy security in Saint Petersburg (2006) and reducing emissions of greenhouse gases in Germany (2007) in a number of additional international and national forecasts made by the International Energy Agency, UNEP, International Institute for Applied System Analysis, Institute for Economic Strategies, P. Sorokin – N. Kondratieff International Institute etc., including in the treatises of B.N. Kuzyk and Yu.V. Yakovets 'Russia-2050: Strategy of Innovative Breakthrough', 'Integral Macro Forecast of Innovative-Technological Dynamics of Russian Economy for a Period up to 2030', 'Russia: Strategy of Transition to Hydrogen Energy', on the Internet site 'Energy-Ecological Revolution' (www.energy.newparadigm.ru).

Making a long-term energy-ecological forecast linked with the forecasts of dynamics of world economy, global and local civilizations will become a basis for working out within the UN framework a global energy-ecological strategy as the core of sustainable development, speed up the implementation of a global energy-ecological revolution and make its fruit accessible to all civilizations.

1.2. Objectives for such forecast are to identify tendencies and assessment of outlooks for development and change in the structure of the global energy sector, impact of its dynamics on the planetary eco-system, analysis of scenarios of energy-ecological development of global and local civilizations and development of world energy market, validation of recommendations for making and implementation framework for a long-term global energy-ecological strategy.

1.3. This global energy ecological forecast will be made based on the methodology of integral macro forecasting synthesizing and expounding in system a theory of foresight and doctrine of cycles, crises and innovations of N. Kondratieff, civilizational approach of P. Sorokin and balance macro forecasting of W. Leontieff and is based on the consolidated estimates and evaluations of the energy-ecological block of a geo-civilizational macro model in combination with other method and tools of macro forecasting, including the output of the Internet survey and evaluations of experts.

1.4. Forecast horizon: such global energy-ecological forecast covers a retrospect of the 2nd half of the 20th c. and prospect for a period up to 2050 with identification of some general tendencies for a longer period in the past and the future and detailed analysis of the tendencies from 1990.

2. Contents of the Forecast

2.1. Theory, Methodology and Experience of Global Energy-Ecological Forecasting.

2.1.1. Global energy-ecological forecasting, its structure, place in the world economy, regularities and tendencies of cyclical-genetic dynamics of the sector, change of energy-ecological methods of production.

2.1.2. Methodology of integral macro forecasting of global energy-ecological dynamics. Cycles, crises and innovations in the development of the energy-ecological sector. Civilizational approach to forecasting. The energy-ecological block of a geo-civilizational macro model, other macro models and methods of energy forecasting.

2.1.3. Experience of long-term global energy and ecological forecasting. Forecasts of the International Energy Agency, UNEP, International Institute of Applied System Analysis, Institute for Economic Strategies and the Pitirim Sorokin — N. Kondratieff International Institute, other research organizations, statistics of the World Bank, UNEP and other international organizations.

2.2. Outlooks for Global Energy Development

2.2.1. Global energy cycles and crises, their structure and tendencies in retrospect and prospect. Global energy balance in a geo-civilizational aspect. Depletion of reserves and appreciation of fossil fuel. Alternative sources: nuclear and hydrogen energy, renewable sources of energy. Comparative technical-economic and ecological evaluation of various sources and outlooks for energy supply, energy efficiency and energy security of civilizations.

2.2.2. Scenarios of dynamics of energy-saving energy, change in the structure of global energy balance by sources and civilizations for a period up to 2050 and for a perspective up to 2100. The evaluation of effect after the implementation of scenarios, ensuring global and civilizational energy security and sustainable development. The Eurasian civilization in the global space.

2.2.3. Consolidated estimations of dynamics and structure of the energy sector in the context of a transition to the sixth technological order, outlooks for development of population and world economy based on the energy-ecological block of a geo-civilizational macro model.

2.3. Global Ecological Future

2.3.1. Tendencies and outlooks of the support with natural resources and pollution of the environment in global and civilizational aspects. The ways of the evolvement of a noospheric civilization. Major methods of the post-industrial energy ecological method of production.

2.3.2. Scenarios of ecological development for a period up to 2050 and a further outlook in the context of demographic, technological and economic factors in the world and by local civilizations of the fifth generation. The role of the Eurasian civilization in the implementation of the scenarios of global energy-ecological dynamics.

2.3.3. Consolidated estimations of energy-ecological dynamics for a long-term perspective based on the geo-civilizational macro model in the world and by local civilizations.

2.4. About Global Energy Ecological Strategy

2.4.1. Recommendations for a global energy-ecological strategy and framework for its implementation based on partnership of civilizations under the UN aegis and energy-ecological partnership within the Shanghai Cooperation Organization (SCO).

2.4.2. Recommendations for the strategy of global sustainable development and energy ecological security and framework of the implementation of the strategy based on partnership of civilizations for discussions at the UN General Assembly and the World Summit Rio-20, and also for a long-term energy-ecological strategy of Russia, Kazakhstan and other CIS countries, Germany, China and Shanghai Cooperation Organization.

3. Milestones, Organization and Financing of Researches

3.1. Milestones of activities

Making a global energy-ecological forecast is performed within 2007—2008 and includes the following stages.

3.1.1. Concept formulation and key points of making such forecast, discussion at the joint meeting of the Department for Research of Cycles and Forecasting and SKII in Moscow (June 2007);

3.1.2. Making the report ‘Russian in Global Energy Ecological Revolution’ and discussion at the cross-disciplinary discussion and at the 20th World Energy Congress in Rome (November 2007) and energy forum in Peking (December 2007).

3.1.3. Elaboration of the energy ecological block of a geo-civilizational macro model, making consolidated estimations, preparing a consolidated report on the forecast (June 2008).

3.1.4. Translation, publication and placement on the Internet of the summary report on the forecast, discussion at the meeting of the Round Table in New York (October 2008), submission to the UN, UNEP, governments of Russia, Kazakhstan and other countries concerned, discussions at the UN General Assembly (October 2008).

3.2. Activities arrangement.

Research is conducted by the international creative team from representatives of the Institute for Economic Strategies, Association of 'Forecasts and Cycles', P. Sorokin – N. Kondratieff International Institute, Russian Academy of Public Service under the RF President, International Institute of Applied System Analysis, Center for Sustainable Development being established in Moscow under the UNESCO aegis and other Russian, Kazakhstan and international organizations.

3.3. Financing of activities is performed by Russia, Kazakhstan and Germany, and also the Shanghai Cooperation Organization, other international and national organizations and sponsors through the Institute for Economic Strategies and the P. Sorokin – N. Kondratieff International Institute, and also through the Russian Humanitarian Scientific Fund through the Association 'Forecasts and Cycles' (non-profit partnership with a minimum level of taxation).

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The report of the Director of the Institute for Economic Strategies, Managing Director of the National Innovative Company 'New Energy Projects', Corresponding Member of the R.A.S. B.N. Kuzyk and President of the Pitirim Sorokin – Nikolai Kondratieff International Institute, Professor of the Russian Academy of the Civil Service under the RF President, Academician of the R.A.N.S. Yu.V. Yakovets uncovers the regularities of cyclical dynamics with respect of the global energy sector, evolving energy rent and ecological anti-rent. They research into the manifestations of the global energy-ecological crisis of the turn of the 21st century as well as the fundamentals of the coming noospheric energy-ecological mode of production and ways of its establishment based on the partnership among civilizations. The energy-ecological matrix for assessing tendencies and outlooks of the energy sector in a civilizational aspect has been first applied. The role of Russia is demonstrated in the energy-ecological revolution of the 21st century with the validation of proposals for strategy of the Russian energy sector.

The supplements include the final document of the G-8 summit, outline national scientific-innovative program 'Hydrogen Energy' for a period up to 2050, and the program for making the section of the UN's global forecast 'Energy-Ecological Future of Civilizations'.