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Russia:
Strategy
of Transition
to Hydrogen Energy

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Strategy of the innovative breakthrough is grounded in the book in the key direction of the scientific-technological overturn of the 21st century – a global energy-ecological revolution based on the development and large scale innovative assimilation of hydrogen energy – it expounds on the contents of the transition to hydrogen energy, experience of making the programs in the hydrogen area and fuel elements in the USA, European Union, experience of the Norilsk Nickel Mining and Metallurgical Company, Russian Academy of Sciences, National Innovative Company «New Energy Projects» for selection and implementation of research and innovative projects. An increased focus is also laid on educational projects, information support of the programs, the book also substantiates the structure of the national hydrogen program comprising research, innovative and organizational-management outlines, and discloses the contents of mechanism for the implementation of the program based on the innovative partnership of the state, science and education, business and civil society, and sets forth the regional and international aspects of the program.

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FOREWORD

Attention to the use of hydrogen as an alternative fuel exists not one decade. The leading industrial countries and major industrial companies have actively joint these activities that is determined by both a technological advance in this area and economic circumstances related to a high price for fossil energy resources, political aspects in the formation of the market of energy products. Environmental pollution by combustion products and forecasting changes in the climate as a result of the glasshouse effect determine not least the prospects of the development of environmentally clean energy.

Concern caused by the energy-ecological crisis is growing worldwide. The world energy based on traditional non-renewable sources – coal, oil and gas, first, is too expensive, and second, it becomes increasingly dangerous for humanity. It produces an adverse effect on nature, all living creatures causing changes in climate, mutations and diseases.

Surmounting the crisis is through the development of new technologies. Time of clean energy source is coming and hydrogen fuel may gain the lead. Russian and foreign specialists have already been working over its mastering from the 70s of the century elapsed. Admittedly, our country has lost its leadership for the time being, but it is recovering fast.

The national scientific-innovative program «Hydrogen Energy» for a period up to 2050 proposed in the book opens in actual fact a new format of the future before us. How do the Russian scientists see it? It should be a sustainable socio-economic development in harmony with nature that ensures a worthy life for each human.

It is obviously not an easy way to go and it is a long way. Development of new energy will begin not at once and everywhere. Innovation before they will be reduced to practice will be tested severely: hydrogen is not that safe and one should know how to use it. Then new energy will come to the pioneering regions and industries. In other words, where there is a special need in it and the conditions matured for that. Cars driving by fuel elements that will not pollute air will appear in cities. Self-sufficient hydrogen plants will be introduced at farms, hospitals, schools and in municipal housing and public utilities, and specially required in remote regions.

All it can be seen behind the sections of the book written by Russian scientists, originators of the program. I believe it will find a ready response not only in scientific and business communities of our country, but among the youth, engineering and academic. The youth is more receptive to new ideas; it has already now started to be involved in the ranks of active participants of the hydrogen program – impetuously and with fantasy.

The program deserves attention of all levels of power – from federal to municipal. And certainly it requires more active participation from business. Following the example of economically developed countries, major budgetary and private investments are necessary. The laws are also to be enacted that would ensure a favorable climate for future innovations.

S.M. Mironov
Chairman of the Federation Council
of the Federal Assembly of the Russian Federation

INTRODUCTION

In recent several years under conditions of the evolving global energy-ecological crisis it becomes more and more obvious that the key direction of the scientific-technological overturn of the first half of the 21st century is the energy ecological revolution. Its core is a transition from fossil fuel to alternative energy sources, including hydrogen energy based on a nearly inexhaustible source of clean energy. Hydrogen energy will ensure higher and sustainable rates of economic development and will lessen a threat of irreversible changes in climate.

The world energy crisis at the beginning of the 1970s became an impetus to evolve researches in hydrogen energy. However, long-term hydrogen programs becomes the basis of energy policy pursued in the vanguard countries from 2003 only following the summit in Johannesburg (2002) where energy problems was the focus of attention and also due to a leaping growth of world prices for fuel and enactment of the Kyoto Protocol.

In Russia, researches in hydrogen energy were conducted on the world level up to the 1990s, then in the course of neoliberal market reforms the governmental support of these farsighted efforts was nearly terminated. Only from the end of 2003 after the agreement between the Russian Academy of Sciences and the Mining and Metallurgical Company Norilsk Nickel and approval of the Integrated Program of exploration, scientific-research and development efforts in hydrogen energy and fuel elements, these researches were renewed and are underway extensively. However, the governmental support of researches in hydrogen energy is minimal and a lagging of Russia in engineering behind the vanguard countries has not been surmounted in this area.

In order to overcome such lagging and increase the role of the state in the implementation of a recent scientific-technological overturn, the Institute for Economic Strategies, P. Sorokin – N. Kondratieff International Institute, the chair of theory and practices of governmental regulation of market economy of the Russian Academy of Public Service (R.A.G.S.) under the RF President made a scientific report and a concept for making out the National Scientific-Innovative Program «Hydrogen Energy» for a period up to 2050. This report was published and discussed at the Cross-Disciplinary Discussion at the R.A.G.S. on March 30, 2005.

The report originators rested on the theory and methodology of innovative development expounded on in the monograph by B.N. Kuzyk and Yu.V. Yakovets «Russia – 2050: Strategy of Innovative Breakthrough», experience in the development of long-range programs in hydrogen energy in the European Union, USA, Japan and other countries, and also on the Soviet experience in the implementation of the G.O.E.L.R.O. plan, nuclear missile and space programs.

Since the publication of this scientific report at least three events occurred for two years elapsed in the world that made us to prepare this monograph and present it at the International Hanover Messe (April 2007) and the 20th World Energy Congress (Rome, November 2007).

First, at the G-8 summit in Saint Petersburg, July 2006 the global energy security was discussed and the Saint Petersburg Plan of Action Global Energy Security. Two items in such plan (21st and 26th) are directly related 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[1] 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 (let's add Russia on their export); 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. Such forecast is outlined primarily in the Integral Forecast of Innovative-Technological and Structural Dynamics of Russian Economy for a Period up to 2030 appeared at the end of 2006. The facts and comments of the relevant section of this forecast have been employed in this book.

Second, 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 elements, took part in several international exhibitions, established contacts with a number of foreign companies operating in this area. At the meeting of the Science and Technology Board of the Company on December 12, 2006 the report of Mr. V.A. Pivnyuk, First Deputy General Director, N.I.C. N.E.P. was heard «A Strategy of Scientific-Technological and Production-Technological Development» of the National Innovative Company «New Energy Projects» and promotion of hydrogen technologies and fuel elements to the Russian market. The final ver-

[1] *Kuzyk B.N., Yakovets Yu.V.* The Integral Macro Forecast of Innovative-Technological and Structural Dynamics of Russian Economy for a Period up to 2003. – M: INES, 2006.

sion of this report makes Chapter 3 of this book as well as the program for 2007–2012 and the milestones of the project «Hydrogen Energy and Fuel Elements». Furthermore, Appendix 1 includes for the first time the updated project of the National Scientific-Innovative Program «Hydrogen Energy» for a period up to 2050.

This indicates that Russia begins to surmount a lagging formed before in the development of alternative energy and has a chance to become the leader in certain direction with the lapse of time.

Third, 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 conference on these problems are held on a regular basis, youth hydrogen club was established, they publish the journal «Hydrogen General Education». The issues pertaining to the development of hydrogen energy are widely shown on internet-sites. Such approach meets the requirements worded by G-8 in Saint Petersburg (July 2006) when discussing the issue «Education for Innovative Societies in the 21st Century»: «Education is at the heart of human progress. Economic and social prosperity in the 21st century depends on the ability of nations to educate all members of their societies to be prepared to thrive in a rapidly changing world. An innovative society prepares its people to embrace change. We will promote the global innovation society by developing and integrating all three elements of the "knowledge triangle" (education, research and innovation), by investing fully in people, skills and research, and by supporting modernization of education systems to become more relevant to the needs of a global knowledge-based economy».

This document of the summit notes that it is necessary to cooperate on the international level through establishing innovative alliances to form a critical mass of scientific and engineering knowledge and labor resources that are required for the development of information societies. As a matter of fact such innovative alliance in hydrogen energy is underway in Russia. It comprises N.I.C. N.E.P., Nornikel, R.A.S., R.A.G.S, S.C.I.I., M.I.R.E.A., Moscow State University, a number of R.A.S. institutions and other departments, and also representatives of some foreign universities and companies. In its performance the alliance pursues the principle of innovative partnership of the state, business, science and education.

The G-8 documents also include a call for more efficient use of information and communication technologies in education that play a decisive role in educational needs of high-technology economy. Therefore this book incorporates a chapter on human and information support of mastering and development of hydrogen energy. A video CD devoted to hydrogen energy is attached to the book.

The book will be published in Russian and English and displayed in the Internet **www.kuzyk.ru** thus making it available to the wide sections of scientists, specialists, teachers, students and schoolchildren who take an interest in hydrogen energy.

We hope that the book will contribute to the building up of the generation who will master hydrogen energy in practice, surmount a global energy-ecological crisis threatening to the future of humanity and create a global information knowledge-based society.

It should be highlighted new points represented in this book:

❖ the contents of the energy-ecological revolution of the first half of the 21st century have been disclosed and the need to implement the National Program permitting the concentration of the state and business in the key direction of a scientific-innovative breakthrough: building up the 6th economic order, has been grounded.

❖ long-range (up to 2050) horizon of the program allowing passing the consecutive milestones of scientific development and innovative mastering of the key direction of the scientific-technological overturn transforming the energy system and economy, in an optimal period;

❖ establishing an innovative partnership of the state, scientific community, education, business and civil society for the implementation of a scientific-technological breakthrough;

❖ orientation to international cooperation in the implementation of the program with the C.I.S. countries concerned, European Union, U.S.A., Japan, China and other countries, to the establishment of the international innovative alliance;

❖ generalization of accumulated experience and determination of the prospects for human and information support of a breakthrough to hydrogen energy in order to stimulate the involvement of the next generation in it.

We sincerely appreciate the scientists who were so responsive to our request and contributed to their respective sections of the book. These are A.S. Sigov, Corresponding Member of R.A.S., V.V. Shinkarenko, Doctor of Science, Engineering, A.A. Evdokimov, Doctor of Science, Chemistry, Yu.A. Kotlyar, Candidate of Science, Pedagogics, V.M. Lazarev, Doctor of Science, Engineering, P.B. Shelisch (Chapter 5); A.A. Dagaev, Candidate of Science, Engineering (Chapter 2); V.A. Pivnyuk (sections 3.1–3.4); A.N. Folomiev, Doctor of Science, Economics, Academician of R.A.N.S., K.I. Pletnev, Doctor of Science, Economics, Corresponding Member of R.A.N.S., O.V. Ivanov, Candidate of Science, Engineering; A.V. Todosiychuk, Doctor of Science, Economics, Academician of R.A.N.S., G.V. Bromberg, Candidate of Science, Economics (Chapter 4); V.I. Chalov, Doctor of Science, Corresponding Member of R.A.N.S., G.G. Lazarev, A.A. Tkachenko (sections 6.1– 6.3); V.N. Kushlin, Doctor of Science, Academician of R.A.N.S. and O.V. Simagina, Candidate of Science, Economics (section 6.4).

We have also incorporated the points appeared in the 2005 report of deceased L.V. Leskov, Doctor of Science, Physics and Mathematics, Academician of R.A.N.S, as sections 1.5. and 4.1.1. of the book.

AFTERWORD

The energy-ecological revolution is the prime direction of the scientific-technological overturn, epochal and base innovations of the first half of the 21st century with its major contents in transition from non-renewable, pollutive fossil fuel growing fast in its price to nearly inexhaustible and the system of fuel elements as autonomous generators of energy.

From the mid-70s the researches in hydrogen energy were launched; and from 2003 long-range programs were adopted in the vanguard countries and the European Union designed for the solution of production, transportation, safety and use of hydrogen fuel. It is forecasted that from the 1920s a wide innovative mastering of a new energy source will begin, thus changing the structure of economy in the vanguard countries, establish conditions for sustainable development and increase in ecological safety, and building up the hydrogen economy.

In the U.S.S.R. the researches and experiments in hydrogen energy were actively conducted on the world level. However, in the 1990s they were nearly phased down, and their governmental support was nearly terminated. Only from the end of 2003 on the initiative of the R.A.S. and Norilsk Nickel Mining and Metallurgical Company these researches were resumed. The tentative National Scientific-Innovative Program «Hydrogen Energy» up to a period to 2050 was worked out, the managing company was established for the Program –National Innovative Company «New Energy Projects».

For wiping out the lag in mastering the primary direction in the present-day global scientific-technological overturn, one of the base directions of the six technological order it appears necessary to approve and implement a long-range (with a horizon up to 2050) national scientific-innovative program that should become a major tool in solving the issues pertaining to the evolving of hydrogen energy in Russia and deal with the following problems:

❖ large-scale production, storage, transportation, safety of hydrogen fuel and making its cheaper;

❖ creation, mastering and production of a wide range of hydrogen fuel elements – reliable and relatively cheap;

❖ use of hydrogen and fuel elements in various sectors and areas of economy (transport, industry, housing and utilities, portable radio electronic devices, etc.)

Success of the National Program lies in the building efficient legal framework and organizational economic mechanism for managing its implementation, including:

❖ federal laws and regulatory acts, norms and standards;

❖ system of long-range forecasting and strategic planning;

❖ innovative-technological evaluation and selection of scientific-technological and innovative-investment projects;

❖ multi-channel financing with the prevalence of budgetary investments at the launching stage and private investments at the assimilation stage of hydrogen energy;

❖ enhancement of the role of the managing company under the Program, establishment of the strategic innovative international alliance;

❖ integration of science and higher educational institutions, training, re-education and advance training of scientists, designers, engineers, managers, skilled workers, civil servants involved in the implementation of the Program;

❖ building up the innovative partnership of the state, business, science, education and civil society;

❖ active inclusion of regions in mastering hydrogen energy, establishing zones for its pioneering mastering;

❖ fostering international cooperation, active involvement in international hydrogen energy programs;

❖ information support and support with human resources of an innovative breakthrough in energy and ecology, establishing favorable climate.

The result of such transition to hydrogen energy will be not only an additional widely available energy source, a solution of both purely economic (on a certain level of development hydrogen will become the cheapest source of energy) and ecological (this type of energy does not nearly pollute the environment) issues.

The building up of the management system for the development program of hydrogen energy in the Russian Federation will allow promoting and efficiently coordinating the fundamental and applied researches in hydrogen energy and innovative breakthrough based thereon, establish organizational-economic conditions for transition of Russia to an innovative type in development of economy.

The outputs of the Program should be to ensure the establishment of innovative space Russia wide building the market of high-technology products, further promotion of researches based on a higher level of cooperation and coordination between the participants of the Program on all levels, enhancement of scientific and technological base of hydrogen generation, encouragement of competition, ensuring and strengthening the development of low-cost open hydrogen-based energy systems and accompanying technologies of the world class, stimulating governmental and private investments in hydrogen energy projects, and also induce foreign investments.

The National Program is of a primary significance for the enhancement of competitive ability of domestic products under conditions of Russia's WTO accession, for developing partnership relations with the vanguard countries in the implementation of an innovative breakthrough.

For a successful implementation of the Program it is necessary to establish institutional and methodical base of hydrogen energy, development of a scientific-innovative potential, inclusion in the international programs and projects in hydrogen energy researches, work out legal frameworks of the governmental regulation, mastering and development of hydrogen energy and establishment of infrastructure.

The implementation mechanism of the Program should provide for the specifics of work (types of business) at the starting and further stages of its implementation. If rather huge investments and guarantees are required at the first stage, then market mechanisms are triggered further on. Therefore the «Hydrogen Energy» Program should have the status of national and be supported with necessary resources and be implemented under the guidance of the highest agencies of state power of the country as a prime element of the system of strategic planning of national development.

A large source of project financing under the National Program is to channel an essential part of world oil and gas rent that is now accumulated in the currency reserves of the Central Bank, Stabilization Fund and super profits of oil and gas companies and are used to a lesser extent for innovative renovation of national economy. It will be necessary to establish an innovative-investment fund, insurance company, to grant tax and customs preferences for projects implementing the National Program, ensuring a strategic innovative breakthrough being crucial for competitiveness and efficiency of the Russian economy in the 21st century.

The implementation of the National Hydrogen Energy Program requires personnel training specialists in this area, awareness of the wide sections of population with the fundamentals of hydrogen economy, especially the youth. The M.I.R.E.A. proposals for the establishment of hydrogen general education deserves support as well as publication of special, educational and popular literature on this issue, establishment of the international youth hydrogen club. It will contribute to the involvement of an active part of the younger generation in the implementation of an innovative breakthrough changing the look of economy and being an important step on the path to noosphere.

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