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COLLECTIVE ANALYSIS BY EXPERTS FROM AROUND THE WORLD

NUCLEAR ACCELERATION IN GLOBAL POLITICS

No branch of the global economy has been the subject of such heated debates as nuclear power. Nevertheless, the sector is continuing to develop despite the lack of consensus in international public opinion.

The planet's growing population, the globalization of the international economy and the rise in the number of countries striving for industrial development are forcing us to recalculate the remaining reserves of fossil fuel with ever greater frequency. Above all, this concerns fuel for internal combustion engines, for which demand is greatest. Although estimates vary, analysts agree on one thing: oil-based civilization has only decades left.

In developed countries, nuclear energy has already superseded oil and is continuing to replace gas in the electricity generating industry. Newly industrialized countries are joining the queue for the "peaceful atom". Technologies for obtaining the "motor fuel of the future" at nuclear power stations – environmentally-friendly motor fuel from coal and hydrogen – create genuinely exciting prospects.

Yet the other side of the coin is also well known: any accident at a nuclear power plant is a radiation risk for the whole world; storing radioactive waste is a threat to future generations; the proliferation of nuclear technologies carries the risk of a new round of nuclear conflict.

The global discussion about the fate of the peaceful atom has had two peaks, 25 years apart, prompted by the nuclear disasters at Chernobyl in the Soviet Union and Fukushima in Japan. In this period of time the twenty-first century has replaced the twentieth. The current discussion is very different from the confrontation between supporters and opponents of developing the nuclear sector which occurred a quarter of a century ago.

Today, the discussion is taking place on a global scale. Thanks to the extensive development of the mass media and internet communication, millions of people are involved in it. In contrast to 1986, the developing world is now an active participant and it sets the world's "energy trend" to a large extent. There is mutual interaction between the "expert discussion" and wider public opinion, which both politicians and professionals in the nuclear sector must take into account.

Today, faith in a new technological breakthrough in energy has weakened. Back then, 25 years ago, it seemed that we were just about to find an alternative to existing nuclear technologies and an era of "new energy" was going to begin – safe and economically advantageous. These days there is an understanding that there is not going to be rapid technological progress in the sector. Moreover, if there is a breakthrough, it will probably be on the basis of the same nuclear power. Therefore, the post-Fukushima discussion is less concerned with the search for an "energy panacea" as weighing up the risks.

Finally, the picture of the world and the configuration of forces today are becoming more complicated. "Non-technological issues of nuclear technology" – humanitarian and geopolitical issues – are acquiring special significance. The "peaceful atom" is becoming a challenge to the political system of the modern world, creating the need for a highly responsible and farsighted political elite. There is a clear contradiction between the global nature of the environmental consequences of nuclear accidents and the local nature of political control by national governments, within whose sovereign zones of responsibility the nuclear power plants are located. This contradiction is going to grow due to the inevitable "spread" of nuclear technologies around the globe. It will push the elite to look for new solutions that ensure safety and determine the future political construction of the world.

By conducting our global expert survey roughly a year after the events at the Fukushima I nuclear power plant, we captured a highly interesting moment when the shock of the disaster had already lost its sharpness, yet the discussion had acquired a fundamental character: some countries had already

announced the end of their nuclear programmes (Germany), while others were making every effort to create their own nuclear power sector (Iran).

Nuclear energy is one factor behind the acceleration in the global political process. Issues of the sector are considered in an even broader context than the strategy for global energy as a whole. The nuclear discussion is an “active zone” where mankind’s attitude to a new kind of global political and industrial risk is determined; a vision of the future is developed; and international and national political institutions are appraised.

Ensuring nuclear safety both in Russia and around the world requires broad participation and the optimization of action by state authorities, the business community, independent experts and non-governmental organizations. This report is intended to initiate a constructive discussion and a search for solutions to one of the most important problems of the modern world.

INTERNATIONAL RESEARCH PASSPORT

The “Post-Crisis World” Foundation carried out the present research project between November 2011 and April 2012, as the winner of an open tender conducted by the all-Russian public organization “The League for the Health of the Nation” in accordance with an order of the Russian president. The theme of the grant was “The peaceful atom: a new quality of analysis and a new approach to protecting the environment or abandoning use”.

The project toolkit was a global analysis, including the organization and implementation of a set of research initiatives.

1. International expert survey

A survey of 306 experts from 44 countries of the world was conducted between December 2011 and March 2012. Participants in the survey included specialists from the nuclear energy sector, nuclear physicists, environmentalists, doctors, economists and financial analysts, journalists who write about economics and politics, academics from the humanities and social sciences, politicians and officials.

The experts were asked to answer a series of questions verbally or in writing, following a standardized survey sheet. The questions related to their vision of the present and future of nuclear power. This allowed us to conduct both qualitative and quantitative analysis of the data received.¹

The nature of the research objectives dictated the need to analyse and contrast the views of experts according to their profession and geographical location. In the first case, the experts were divided into three groups.

Table 1. Structure of the pool of experts

TYPE OF ACTIVITY	Nuclear technical experts (academics, analysts, nuclear energy sector workers)	Physiocrats (medics, environmentalists)	Independent experts	TOTAL
COUNTRIES				
DEVELOPED COUNTRIES (USA, Canada, Western European countries, Japan, Australia, Israel)	28	13	37	78
RUSSIA	22	31	95	148
DEVELOPING COUNTRIES (post-Soviet states, Baltic countries, Eastern Europe, Latin America, Asia, Middle East)	16	22	42	80
TOTAL	66	66	174	306

¹ The quantitative analysis was conducted on the basis of codes with a minimal level of closure (a maximum of three response options). Given the homogeneity of the sample in terms of the respondents’ level of competence in the survey subject matter, the data gathered from the quantitative analysis can be considered valid and reliable (the margin of error is no more than 7 per cent for the population as a whole). We do not claim to have a sample that represents the whole world. We have a sample that represents the expert community; we identify trends in the attitudes within that community that are caused by various objective factors.

-
- “Nuclear technical experts” – nuclear physicists, specialists, corporate managers and other functionaries in the area of nuclear power, i.e. people with a direct link to work in the sector.
 - “Physiocrats” - environmentalists, medics, biologists and others – people who come into conflict with the nuclear energy sector as a consequence of their professional activity.
 - “Independent experts” – officials, academics, journalists, political scientists, economists and others – people who essentially act as a mouthpiece of public opinion and a kind of mirror of civil society.

The experts were also divided into three groups according to their geographical location: specialists from Russia; developed countries; and developing countries.

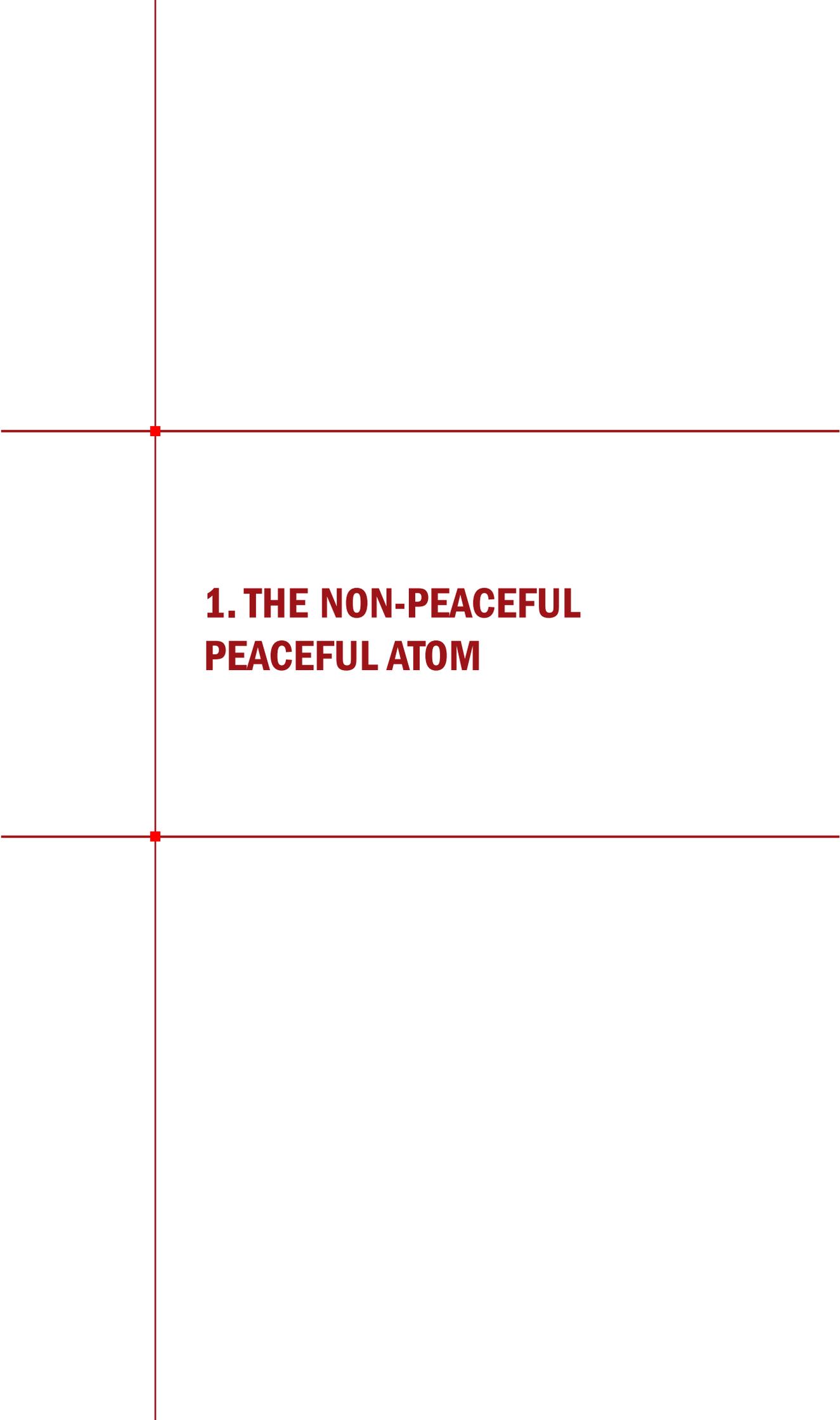
2. Sociological survey of the Russian population

In order to compare the views of the experts against the views of the Russian population on key topics of this report, a sociological survey about issues of the “peaceful atom” was conducted in the period 14–18 December 2011. The questions were included in a questionnaire of the all-Russian population survey FOMnibus, conducted by the Public Opinion Foundation. The sample represents the urban and rural population of Russia aged 18 and above. Geographically the survey covered 44 constituent parts of the Russian Federation and over 100 settlements. There were 1,500 respondents. The method was a standardized population survey. The technique was an interview at the respondent’s place of residence (face-to-face). Statistical error does not exceed 3.6 per cent.

3. Desk review of open sources

While the survey was being prepared, a desk review of open sources was conducted (national and international nuclear legislation, international conventions and agreements, scientific works), as was monitoring of the Russian federal media during the period March 2011 to March 2012 inclusive.

The final version of the report was prepared under the guidance of E. A. Shipova, director of the Foundation for Facilitating Research and Social Forecasting of the Post-Crisis World. The team of authors comprised A. M. Veselova, S. A. Pobyvayev, M. A. Polikarpov and V. P. Sednev.



1. THE NON-PEACEFUL PEACEFUL ATOM

ALL THE WORLD'S FEARS

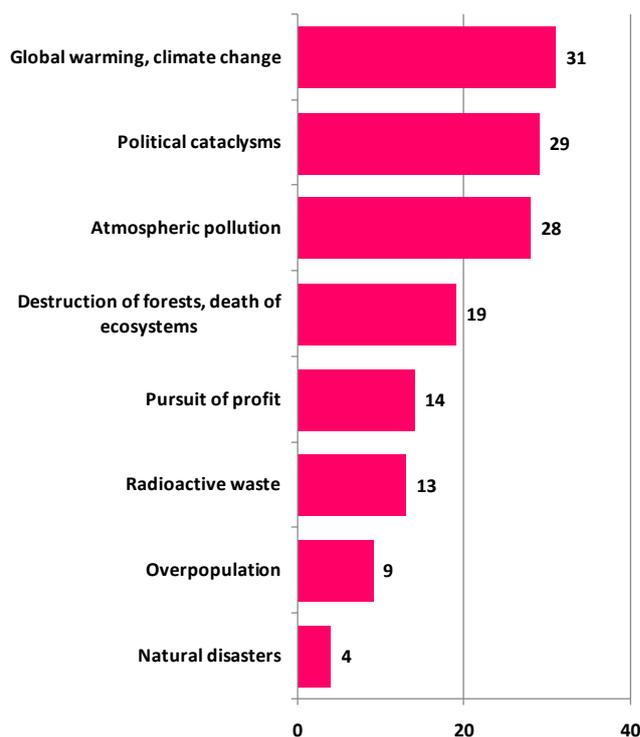
The human race will not perish in a nuclear disaster, but will suffocate in its own waste

Niels Bohr, Danish theoretical physicist and public figure, a founder of modern physics, recipient of the Nobel Prize for Physics in 1922

Risks which are fundamentally unpredictable are a factor of modern society which governments must face more and more often, and not only in the area of nuclear energy. We are experiencing a general “crisis of forecasting”. The current global crisis, its scale and duration, were insufficiently “foreseen” by economic science and professional financiers. The series of Arab Spring revolutions which started in Tunisia in 2011 were not predicted by either politicians or academics. Social and economic disasters have turned out to be as hard to see coming as natural ones.

In order to understand the configuration of global threats and nuclear energy’s place among them, the experts were asked: **“Which processes and phenomena do you consider the most dangerous for the environment and humanity today?”**¹

Diagram 1. Threats to the planet and mankind
All experts



As Diagram 1 illustrates, the expert community does not fear the “end of the world” which pseudo-scientific literature links primarily to collision with a giant asteroid, a powerful volcanic eruption, a huge fault under Antarctica, or in other words, various kinds of natural disaster (Diagram 1).

The top three places in the ranking of global-scale threats are taken by “global warming and climate change”; “political cataclysms” and “pollution of the atmosphere”. Each of these threats was mentioned by around a third of the experts.

The idea of “global warming”, which has been actively instilled in the public consciousness in recent decades, undoubtedly had a strong influence on the experts’ thinking. Moreover, it is assumed that the threat of climate change as a result of global warming is due to human behaviour.

«**Nam Sung Ahn**, professor at the Solbridge International School of Business, South Korea: *«Global warming due to climate change is the most dangerous to our environment and the lives of people. The impact of a nuclear accident is less than that from climate change».*²

Yekaterina Gonchar, secretary of Interregional Public Organization of Environmentalists (IPOE), Russia: *«At this stage, global climate change occurring under the influence of mankind constitutes the biggest threat. This includes harmful types of production which heavily pollute the environment*

¹ The question was open-ended, in order not to limit the experts in their selection of answers.

² The full titles of survey participants and names of organizations can be found in Appendix 1.

- nuclear energy above all. In general, people's consumerist attitude to nature is dangerous, with the resulting destruction of biodiversity and the exhaustion of the planet's resources».

The political conflicts which constitute a threat are primarily wars and terrorist attacks involving use of nuclear weapons, and to a lesser extent, the reconfiguration of the world through "coloured revolutions", the latest wave of which have been named the "Arab Spring".



Len Ackland, co-director of the Centre for Environmental Journalism at the University of Colorado, USA: *«The danger of nuclear war, even on a regional basis, is still the foremost danger. Unabated climate change is a longer term danger».*

Yelena Ivankina, research associate at the Pacific Ocean Institute of Geography, Far East division of the Russian Academy of Sciences, Russia: *«Global, regional or local armed conflicts (wars) are always accompanied by negative processes concerning all kinds of structures of the planet, from 'banal' bodily injuries, the destruction of soil and vegetation and pollution in the zone of direct action itself, to demographic changes, a shift in geopolitical emphases and a change in the quality of life of the civilian population, and so on».*

Man-made threats to the environment were mentioned by over half of the survey participants altogether. That included "pollution of the atmosphere", particularly chemical pollution, such as the rise in the concentration of carbon dioxide in the atmosphere; and "destruction of forests and the death of ecosystems", such as the pollution of the oceans and reduction of bio-diversity, the rise in general waste and "radioactive waste".



Valeriy Kashparov, director of the Ukrainian Scientific Research Institute of Agricultural Radiology, National University of Life and Environmental Sciences of Ukraine, Ukraine: *«Man-made pollution of the environment, where radioactive pollution - even after the accidents at Chernobyl and Fukushima-1 - is not the most dangerous. If one looks at Ukraine, the highest rates of illness among the population are found in the most industrial regions, not the regions which suffered as a result of the Chernobyl nuclear disaster».*

One in ten participants in our survey mentioned threats linked to the overpopulation of the planet. The essence of the threat of overpopulation is linked, above all, to mankind's inability to control this process.



Aleksey Shlenskiy, business analyst at Consona ERP, USA: *«The growing and uncontrolled increase in the population, linked to rising per capita use of available energy by mankind as a whole».*

Lukas Kronawitter, architect and specialist on issues of city environment and planning, Germany: *«Population growth exceeding supporting economic development».*

Overall, it seems obvious that the expert community considers the main harm to mankind and the surrounding world to emanate from mankind itself.



Viktor Mironenko, Cand. Sc. (History), head of the Centre for Ukrainian Studies at the Institute of Europe, Russian Academy of Sciences, Russia: *«In my view there is only one phenomenon which is most dangerous for the planet's environment, and that is mankind... And the biggest threat is the human psyche, psychology. On the one hand, people want to live better and that is a powerful driver of progress. On the other hand, if you consider the standards which the world's economies have enjoyed for the past 50 to 100 years, those standards are highly unlikely to be able to survive such an industrial burden and such exploitation of the environment».*

Yelena Stepanova, chair of the Dubăsari public organization "Medics for the environment", Transdnistria region of Moldova: *«People's aggression, the uncontrollable pursuit of consumption, the low*

level of awareness - after us the deluge, and it won't be slow in coming...»

Experts frequently name the main threat as *Avaritia* (“greed”, one of the seven deadly sins in Catholicism). This means the pursuit of profit, the psychology of consumption, which dominates in contemporary society.

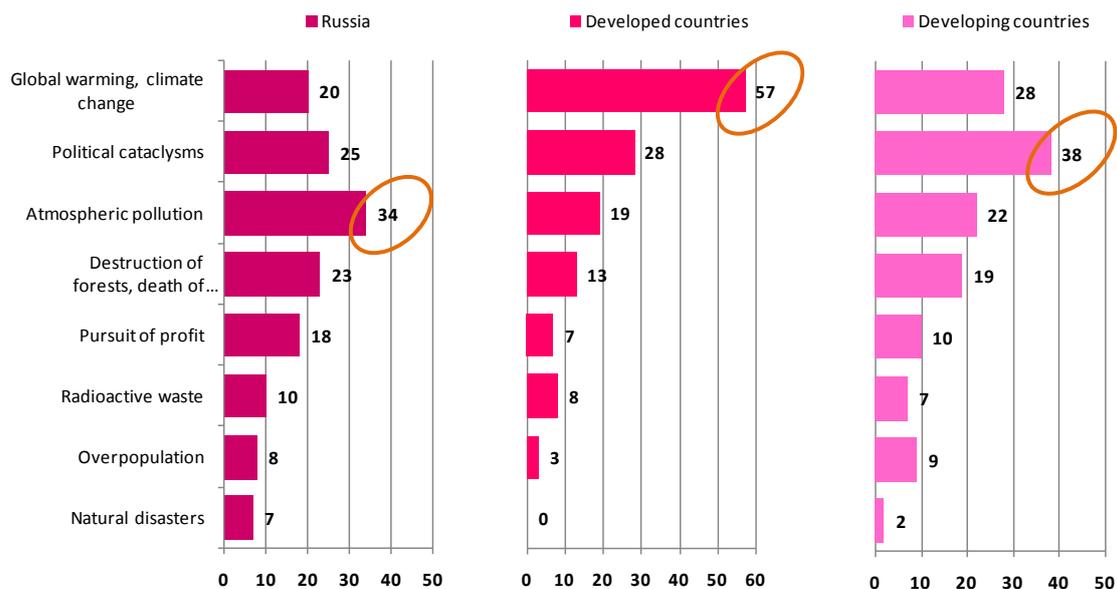
«**Alla Burtseva**, columnist at “Moskovskiy Torgi” magazine, Russia: «*The capitalist system, when both the economic aim and the aim of all human activity is, more often than not, to get profit, which is certainly not always calculated in terms of growth in real national and global wealth. The retention and reinforcement of transnational corporations will inevitably destroy the environment of the whole planet.*»

«**Idris Idrisov**, senior academic at the Institute of Geology, Dagestan Academic Centre, Russian Academy of Sciences: «*The most dangerous process is the rampant advance of the ideology of consumption and the forecast sharp rise in the scale of consumed resources and waste generated.*»

In our view, variation according to country of origin in the experts’ assessment of the main threats to the planet and mankind is particularly interesting. Diagram 2 presents three completely different pictures of possible “apocalypse”.

The theory of global warming, destructive for life on earth due to the man-made greenhouse effect, has been repeatedly subjected to serious scientific criticism in recent years.

Diagram 2. Threats to the planet and mankind
Experts from different groups of countries



«**James Terry Rogers**, professor emeritus at the University of Carleton, Canada: «*Unwarranted concerns about human-caused global warming may result in the waste of billions of dollars on wind and solar energies which cannot provide the base-load electricity needed in all countries. It would be much more sensible to work towards means of adapting to climate change, which is mainly governed by solar effects and which probably will result in global cooling in the near future.*»

However, it is precisely this threat which is the most pressing in the eyes of experts from developed countries. It seems that the lengthy presence of this topic in the news has facilitated creation of a firm attitude in the consciousness of Western society.

Meanwhile, among experts from developing countries first place is taken by the threat of “political cataclysms”. This is quite understandable: the threat of various coups, revolutions, civil wars and geopolitical conflicts - which was already rather high in the developing world - has recently become extremely topical in light of well-known events. It is notable that Russia, despite the activation of

political life in winter 2011-12, still remains an “island of stability”.

On the other hand, “pollution of the atmosphere” concerns Russian experts most of all. This topic entered the agenda for Russians relatively recently; much later than in the industrially developed nations. So far, neither the state nor civil society has developed a consistent tough policy on this matter, since environmental culture is only beginning to emerge. This is apparently why the expert community is concerned by a predatory attitude towards Russian nature, along with a “consumerist” attitude towards the environment in the pursuit of profit (“greed”).

Summing up our analysis of the experts’ views on current threats to mankind and the planet, one should note that nuclear energy, as such, is considered extremely rarely or in context - as:

- one factor of man-made risks;

« **Mikhail Teltsov**, head of laboratory at the Scientific Research Institute of Nuclear Physics, Moscow State University, Russia: *«Global development of nuclear energy without improvement to safety systems».*

- the origin of radioactive waste;

« **Joachim Sontag**, owner of “Sontag Consult”, Germany: *«...there is no long term solution for the nuclear waste. We leave that problem to our children».*

- a step on the path towards nuclear arms.

« **Vladimir Chuprov**, head of the energy programme of Greenpeace Russia, Russia: *«Nuclear proliferation under the guise of ‘peaceful’ nuclear programmes».*

« **Stepan Beril**, rector of T. G. Shevchenko Transdnistria State University, Transdnistria: *«The proliferation of nuclear energy technologies, uncontrolled by the international community, and the possibility of using them for military ends in conditions of a high level of terrorist threats».*

At the same time, however, nuclear energy appears in the answers of some experts as a way to prevent the most serious consequences of global warming, which many fear. Radioactive emissions into air and water resulting from the normal operation of nuclear power stations are not great; they cannot be a major factor in the pollution of the atmosphere. For example, damage to the environment from thermal power plants, the main competitor to the “peaceful atom”, exceeds the damage from nuclear power plants.

« **Bruno Combi**, president of “Environmentalists for Nuclear Energy”, France: *«[Nuclear energy] provides abundant and cheap electricity to populations with minimal risks and almost zero impact on the environment: just one gram of uranium provides as much energy as one ton of oil gas or coal (factor 1 million). The waste is not only produced in very small proportions, it is solid (easier to confine than CO2 combustion gases from burning carbon fuels) and it is not rejected in the environment, it is confined until it spontaneously decays, therefore there is zero impact (or near zero) on ecosystems».*

But on the other side of the scales of public consciousness there are images of Chernobyl and Fukushima and thoughts of the long-term consequences of man-made nuclear disasters - and the latter may weigh heaviest.

« **Andrey Subbotskiy**, engineer in the Industrial Group “Tavrida Elektrik”, Ukraine: *«The main disadvantage of nuclear power stations is that the consequences of an accident are very severe. This is primarily manifested in an environmental collapse - the massive pollution of an extensive territory, which subsequently becomes an uninhabited and dangerous zone for long decades. Furthermore, the consequences of an accident will influence residents even in relatively remote regions and countries, in the form of a rise in the frequency of cancers. These are precisely the consequences which are the most negative, since they lead to high death tolls, both among emergency workers and ordinary citizens».*

THE CONSEQUENCES OF DISASTERS AT NUCLEAR POWER PLANTS

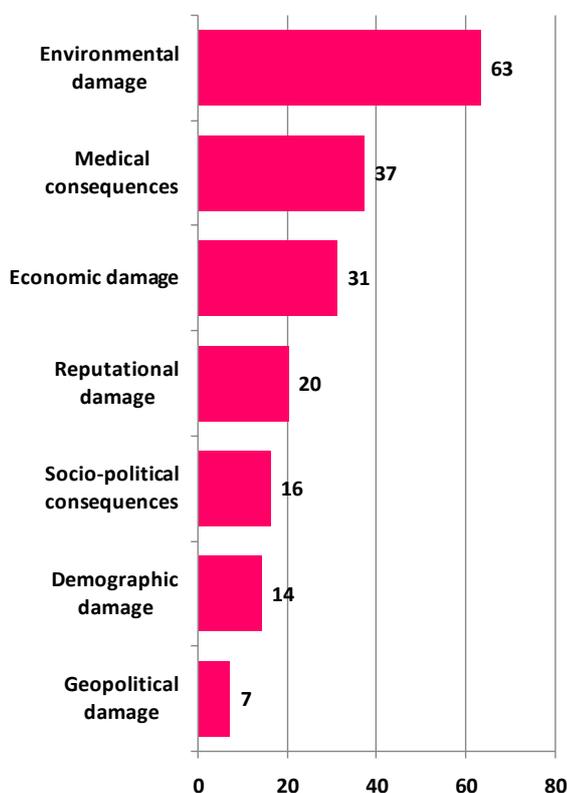
...nuclear accidents respect no borders. They pose a direct threat to human health and the environment. They cause economic disruptions affecting everything from agricultural production to trade and global services

Ban Ki Moon, UN Secretary-General, The New York Times, 25 April 2011

The *International Nuclear Event Scale (INES)* was developed by the IAEA to facilitate consistency when assessing emergencies linked to accidental radioactive emissions into the environment from nuclear power plants. Later, this scale came to be applied to all facilities connected to civilian nuclear industry.

To date, two accidents (Chernobyl in 1986 and Fukushima 1 in 2011) have been placed at the highest, seventh level of the INES (a large emission, severe consequences for the population's health and the environment). One (the accident at the Mayak Production Association in 1957) is rated at the sixth level (a considerable emission, requiring full-scale implementation of planned restoration measures) and one other (at Three Mile Island in the USA in 1979) is rated at the fifth level.

Diagram 3. Consequences of disasters at nuclear power plants
All experts



The consequences of disasters at nuclear power plants are long-term and varied. We attempted to discover how experts today rate these consequences by asking the survey participants: **“Which consequences of disasters at nuclear power plants do you consider the most negative?”**

Over two thirds of experts pointed to “environmental damage” (Diagram 3)³: radioactive pollution of land, water and the atmosphere.

Dino Giangregorio, technical director at Alta Visio S.R.L., Italy: *«Environmental damage, because we know when it starts but we never know how it stops, in Japan after 60 years there was continuous damage and we never know when it stops».*

Despite the fact that a quarter of a century has passed since the accident at Chernobyl, many districts of Bryansk Region (Russia), Kiev Region (Ukraine), Gomel Region and Mogilev Region (Belarus) have a high level of pollution which exceeds the level dangerous to life. According to existing forecasts, the exclusion zones will only disappear from Russia in 2049, and the zones of priority resettlement only by the year 2100. In Belarus, where the level of pollution is generally higher, these dates lie even further in the future.⁴

³ Closed question, multiple choice.

⁴ <http://www.souzveche.ru/news/detail.php?ID=9970>.

«**Andrey Kondratyev**, director of “Ekotsentr”, Russia: *«Environmental damage is a direct consequence of a disaster at a nuclear power station; moreover, it is large-scale and long-term, affecting all elements of the environment».*

Around half the participants in the survey spoke about the harm caused directly to people by disasters: this includes one third who believe that the most negative consequences of a disaster at a nuclear power plant are linked to “medical consequences” (a rise in the frequency of illnesses among emergency workers and residents of the territory which has been subjected to radioactive contamination).

«**Oleg Buklemishev**, chief analyst at MK Analitika, Russia: *«Plus psychological wounds, which are considerably more painful than the real impact of the disaster, as the experience of Chernobyl shows. The same scenario is playing out at Fukushima».*

Other experts focus attention on “demographic damage” (the direct loss of human life).

«**Dr Jan Willem Storm van Leeuwen**, senior academic at Ceedata Consultancy, The Netherlands: *«Demographic damage to millions of people will destabilise the social and economic systems of large regions».*

Rhodora Ledesma, deputy chair of the Department of Nuclear Medicine at the Mediatrix Medical Centre, the Philippines: *«I consider loss of lives and other medical consequences arising from exposure to radioactivity from nuclear accidents to be the most damaging. These generate fear towards nuclear energy in general, jeopardizing the reputation of both the nuclear sector and the field of advanced technologies derived from nuclear energy».*

“Economic damage”, which naturally flows from other kinds of damage, was mentioned by 30 per cent of survey respondents.

«**Sergey Orekhov**, deputy head of laboratory at the Institute of Nuclear Reactors, National Research Centre «Kurchatovskiy Institute”, Russia: *«Economic damage is characteristic for any accident, and as a result, a fall in the quality of life».*

Joonhong Ahn, professor at the University of California, Berkeley, USA: *«Despite the accident’s scale, Fukushima did not cause any civilian casualty directly, or by environmental contamination. However, societal loss by the accident is huge because of evacuation and environmental cleanup».*

For accidents at the seventh level (Chernobyl and Fukushima), the economic damage is estimated to be hundreds of billions of dollars. The Japan Center for Economics put the cost of the incident at the Fukushima power plant at 250 billion dollars, including the payment of compensation to 180,000 people who were evacuated from the contaminated zone. Belarus estimates the cumulative losses from the Chernobyl disaster to be 235 billion dollars. And today, 5-7 per cent of Ukraine’s state expenditure goes towards financing Chernobyl rehabilitation programmes. For comparison, there are estimates that say abandoning use of nuclear energy will cost Germany 1,700 billion euros in the period up to 2030.⁵

One in five experts believes the “reputational damage” from a disaster at a nuclear power plant to be important.

«**Ilya Kramnik**, commentator at “Voice of Russia” radio station, Russia: *«Major accidents at nuclear power stations are relatively rare, but they cause huge reputational damage, which hinders further development of nuclear energy. At the same time, a slowdown in development of the sector brings with it a threat to its safety. The main guarantee of safety in the sector is the uninterrupted accumulation of knowledge and skills in this area, which is only possible when there is large-scale and constant research».*

⁵ “Nezavisimaya Gazeta”, 24.01.2012, O. Nikiforov, “German revolution”.

At the same time, many experts believe that the sector's reputation is undermined less by the accidents themselves and more by "importunate non-objective statements in the media."

Strange as it may seem, "geopolitical damage" - implying the recognition of a state's inability to ensure the safety of its nuclear facilities - occupies the last place in the hierarchy of consequences of disasters at nuclear power plants.

« **Boris Oskolkov**, Candidate of Technical Sciences, head of department at the International Radio-Ecological Laboratory, Chernobyl Centre, Ukraine: *«The geopolitical damage from both Chernobyl and Fukushima was very large. However, whereas for the USSR it was highlighted by the international community, for Japan it is being substantially softened, since the weak organization and conduct of rescue work at the nuclear power plant are explained by extreme forces of nature - the tsunami. Of course, the root cause of the accident at Fukushima was the tsunami, but anyone can see the government's inability to take the necessary measures to prevent the accidental consequences of the natural phenomena at the nuclear facility».*

A less substantial share of the survey participants noted "socio-political consequences", meaning, above all, a fall in the quality of life for the population and its loss of trust in the authorities, as well as the development of nuclear-phobia.

« **Dmitriy Belousov**, Cand. Sc. (Economics), head of area at the Centre for Macroeconomic Analysis and Short-Term Forecasting, Russia: *«Despite all the danger of radioactive contamination of territories, especially by long-lasting isotopes, a bigger threat comes from the irrational phobias which can lead to a lengthy deterioration of the economy (as well as rapid negative consequences for the health of the population, judging from the experience of Chernobyl)».*

Paolo Raimondi, economist and commentator for economic and financial publications, Italy: *«Besides damage to the environment and the radiation's effects on the population, any disaster at a nuclear power station induces fear among people and decreases confidence in science and research. While the environmentalist movements are very active in raising fear with a doomsday scenario, very little is done to bring competent scientific explanations to the majority of the people. This problem is not only related to the nuclear question but to science and technology in general».*

However, such fears and phobias are extremely hard to expel. The results of our research illustrate this, if one looks at the differences in assessments of the significance of various consequences of nuclear power station disasters among various professional groups of experts (Diagram 4).

As we can see, specialists who have a direct or indirect link to the nuclear sector mention, above all, economic damage (which is no less important in their eyes than environmental consequences) and reputational damage. In other words, the interests of the sector, the state and prestige are in the foreground.

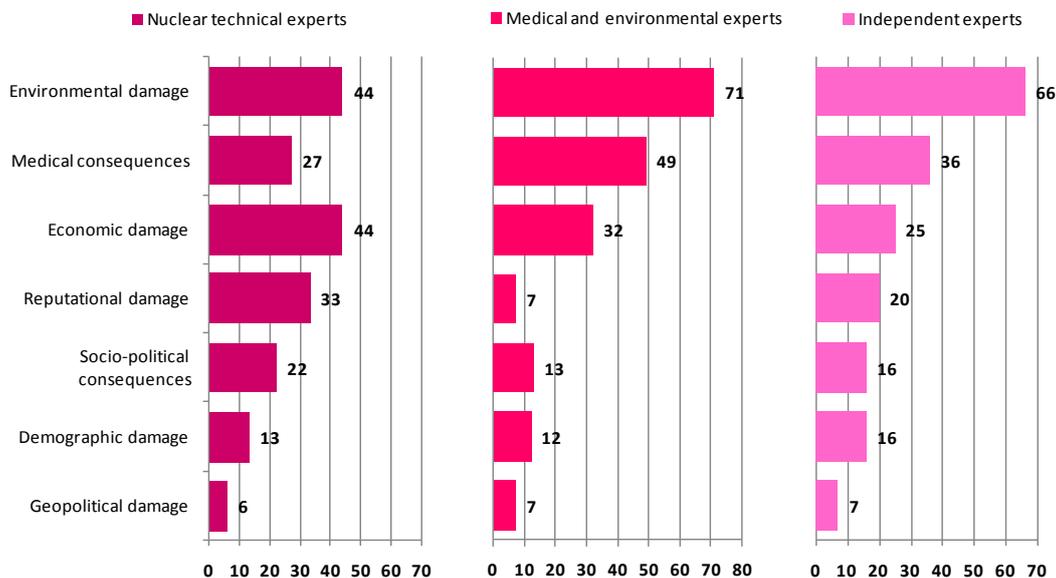
« **Aleksandr Uvarov**, president of "Atominfo-Centre", editor-in-chief of the Atominfo portal, Russia: *«The accepted approach in the sector of preventing deaths from radiation sickness during an accident means that the main direct damage from an accident is economic (and, of course, reputational). The approach is not a dogma and can be reviewed; then the consequences would change. But it is not realistic to expect a review in the next 5-10 years».*

Furthermore, however it may sound, specialists in the sector believe that every disaster at a nuclear power plant prompts improvement to the safety systems at nuclear facilities, thereby reducing the likelihood of a new disaster.

« **Andrey Konoplyanik**, director for development of energy markets, project head at the "Institute of Energy and Finance" foundation, professor at the Faculty of International Oil and Gas Business at the Russian State University of Oil and Gas named after Gubkin, Russia: *«Every accident boosts reliability at nuclear power stations, as next-generation nuclear power sta-*

tions learn the lessons of previous generations (the mistakes that have occurred are accounted for in their design standards)».

Diagram 4. Consequences of disasters at nuclear power plant
Experts from various professional groups



Quite predictably, medics and environmentalists speak, above all, about the environmental damage and medical consequences of disasters. In other words, nature and man are in the foreground.

At the same time, it is clear that professionals in the nuclear sector are completely losing the media war to the medics and environmentalists, and consequently, the battle for minds to physiocrats. Independent experts, who represent civil society in our survey, almost entirely agree with the latter.

« Aleksandr Mineyev, European correspondent of “Novaya Gazeta”, Russia: *«The environmental damage and medical consequences are frightening, if only because they are unpredictable and long-term».*

The medical consequences of disasters are seen as disputed, and are still a matter of heated discussion. Many conclusions drawn from certain pieces of scientific and medical research are challenged by other, no less reputable researchers. Thus, for example, a report on how health was influenced by factors linked to the Chernobyl accident (Health Effects of the Chernobyl accident and special healthcare programmes, 2006)⁶, notes, *inter alia*, that in 1990-1998 over 4000 instances of thyroid cancer were registered among those who were under 18 at the moment of the accident. Given the low likelihood of contracting it at such an age, some of these instances are considered a direct consequence of radiation.

Some research shows a rise in the frequency of cancer (besides leukaemia and thyroid cancer) among both emergency workers and residents of contaminated regions. A number of studies note that emergency workers and residents of polluted regions are subject to a heightened risk of various illnesses, such as cataracts, cardiovascular disease and lower immunity.

On the other hand, according to a report by the Chernobyl forum,⁷ statistical research that has been published about a very high level of congenital abnormalities and high infant mortality in contaminated regions does not contain convincing evidence to support its case. While the Chernobyl forum experts reached the conclusion that the link between cataracts and radiation following the accident had been established quite reliably, they believed that in regard to other illnesses more research was needed, with a careful assessment of the influence of rival factors.

⁶ http://www.who.int/ionizing_radiation/chernobyl/who_chernobyl_report_2006.pdf.

⁷ http://www.who.int/ionizing_radiation/chernobyl/who_chernobyl_report_2006.pdf.

There is even another side of the coin to environmental damage. For example, freedom from human pressure following the Chernobyl nuclear accident gave significant areas a unique chance to recover destroyed ecosystems. In 1988, the Poleskiy state radiation-environmental reserve (with an area of over 215,000 ha.) was created on the territory of the three districts of Gomel Region which suffered most from the accident, in the Belarusian part of the exclusion zone. There are 1251 types of plant registered in the reserve (over two thirds of Belarusian flora); 18 of them are in the international Red Book and the Red Book of the Republic of Belarus. Fauna includes 54 types of mammal, 25 types of fish and 280 types of bird. Over 40 kinds of animal are rare or endangered.⁸

Nonetheless, nuclear-phobia in public consciousness is most evident where the environmental consequences of accidents at nuclear power stations are concerned.

It is possible that the media, which spread an alarming image of “scare stories” instead of dull scientific calculations, play a significant role in feeding phobias and fears in the mass consciousness.



Sergey Boyarkin, director of programmes at Rosatom, Russia: *«It is the most ‘mythologized’ technology: views about its dangerousness which exist in the public consciousness, and the real damage to people’s health and the environment which has resulted from all accidents differ by an order of three or four».*

However, another explanation, lying in people’s ability to make an entirely rational choice in the face of real danger, is equally possible.



Yevgeniy Shvarts, Doctor Sc. (Geography), director for environmental protection policy at WWF Russia, Russia: *«One can play with statistics of human illnesses for a long time and speculate about it. But one can find rather clear and simple indicators. If I ask you: as a mother, would you want your children to live in that zone, and how would it affect the value of your home, then the answer, I think, is rather obvious».*

VOX POPULI: DEGREE OF DANGER

Like many others, I am full of nuclear phobias and fears. But I am in love with the future, and the future can live in peace with the atom. Otherwise it - the future - does not exist. At the moment we are just learning to have a dialogue with nuclear energy. But sometimes I think that the technology of managing the splitting of the nucleus has, over many years, become better than the technology of mutual understanding between people, between men and women

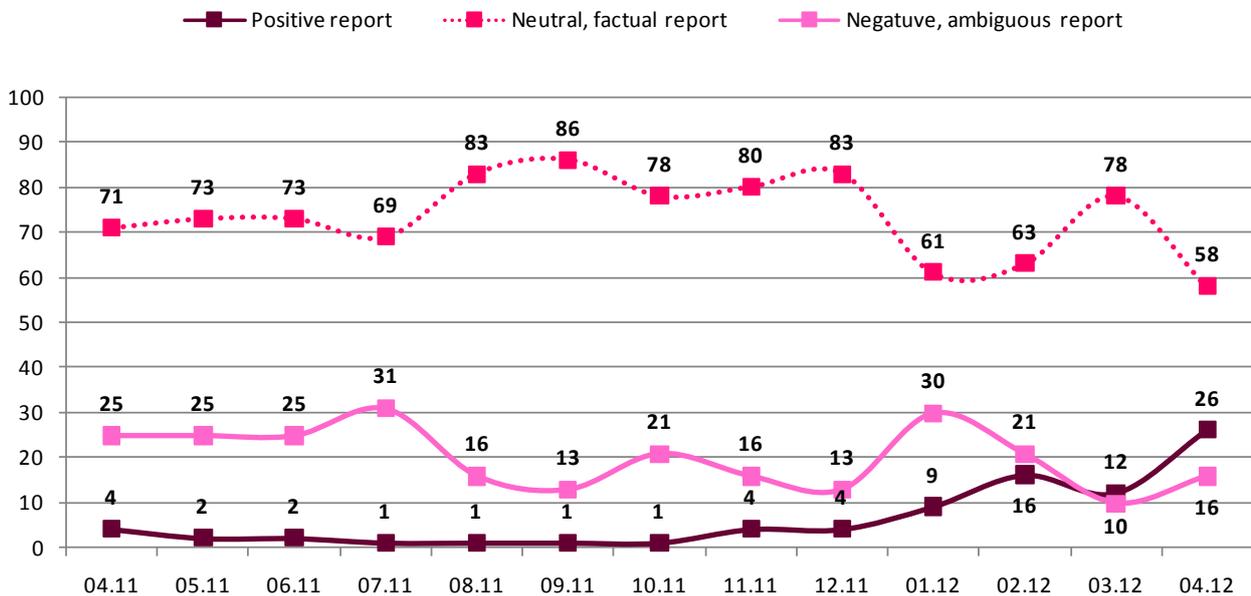
Maksim Kurochkin, screenwriter of the film “Nuclear Ivan”,
“Argumenty Nedeli”, Moscow, 21 February 2012.

After the accident at Fukushima there was a broad international discussion, during which the future of nuclear energy was once again thrown into doubt. For a long time it was a lead story across the media, which published the views (often directly contradictory) of many specialists, politicians and public figures.

⁸ <http://www.interfax.by/node/1018470>.

It should be noted that analysis of news in Russia in the period from March 2011 to March 2012 shows that the proportion of reports negative about nuclear energy was significantly greater than the proportion of positive reports, and only in the final months did the positive reports exceed the negative reports (Diagram 5).

Diagram 5. Dynamics of the tone of reporting between March 2011 and March 2012



In order to understand how residents of Russia “digest” the popular positions of newsmakers and the wave of negativity from the press, TV screens and the internet, and what remains as the bottom line in the minds of millions of Russians, we conducted our own sociological research.

Sociological surveys conducted in the months immediately following the accident in Japan showed that nuclear power stations had come to be considered almost the greatest danger to people and the environment.

A number of studies conducted by various research companies at roughly the same time - spring 2011⁹ - demonstrate that respondents began to note the danger of nuclear energy twice as often as in 2006 (it was mentioned by up to 60 per cent of respondents)¹⁰. Back then the nuclear energy threat was surpassed in the public consciousness by all other harmful man-made effects on the environment.

The research which we conducted 8-9 months later shows a different picture (Diagram 6)¹¹.

On the question: “**Which processes and phenomena do you consider the most dangerous today for the planet’s environment and mankind?**” the consequences of man-made influence on the environment prompt the most concern among Russians: a rise in the level of harmful emissions into the atmosphere, destruction of forests and ecosystems, man-made disasters, including accidents at nuclear power stations.

Thus, nuclear-phobia has significantly fallen in the Russian public consciousness over the past nine months.

The issue of fearing nuclear energy due to the possibility of another accident is rather controversial - to what extent is it reasonable and to what extent is it irrational?

Sociological surveys conducted in spring 2011 show that the vast majority of Russians fear new accidents at nuclear power stations. At the same time, we observed a curious particularity: the proportion of people who feared a repeat of Chernobyl was 76-80 per cent,¹² while the proportion of people who

⁹ FOM, April 2011; “Levada-Centre”, March 2011; VTsIOM, March 2011

¹⁰ VTsIOM. Closed question, one response.

¹¹ Closed question. Multiple choice.

¹² FOM, “Levada-Centre”, in both cases a closed question, one response.

feared a repeat of Fukushima was a third lower, at 55 per cent.¹³ In other words, residents of Russia are more afraid of a repeat of “our”, “domestic” mistakes 25 years on than “their” mistakes of today.

In our research, conducted nine months later, we tried to avoid the “domestic” component and to isolate the level of fear regarding the possibility of an accident at any nuclear power station. To the question, **“Do you consider the likelihood of another accident in Russia like those which occurred at the nuclear power stations in Chernobyl and Fukushima to be low, medium or high?”** respondents more often than not gave the answer “medium” - 36 per cent (Diagram 7).¹⁴ Some 21 per cent of respondents said the likelihood of another accident was low, and 25 per cent said it was high.

Diagram 6. Threats to the planet and mankind

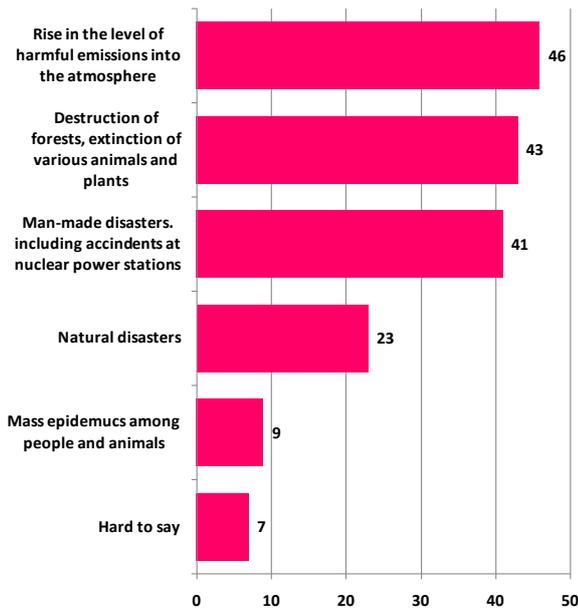
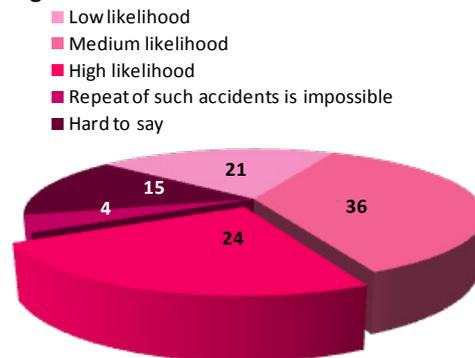


Diagram 7. Likelihood of a new accident in Russia



Thus, the “degree of danger” in relation to nuclear energy in the public consciousness is gradually falling. This seems to be a rather natural process. However, it is surprising that one third of the residents of Russia surveyed feel no fear regarding the possibility of another accident, just one year after the Japanese disaster.

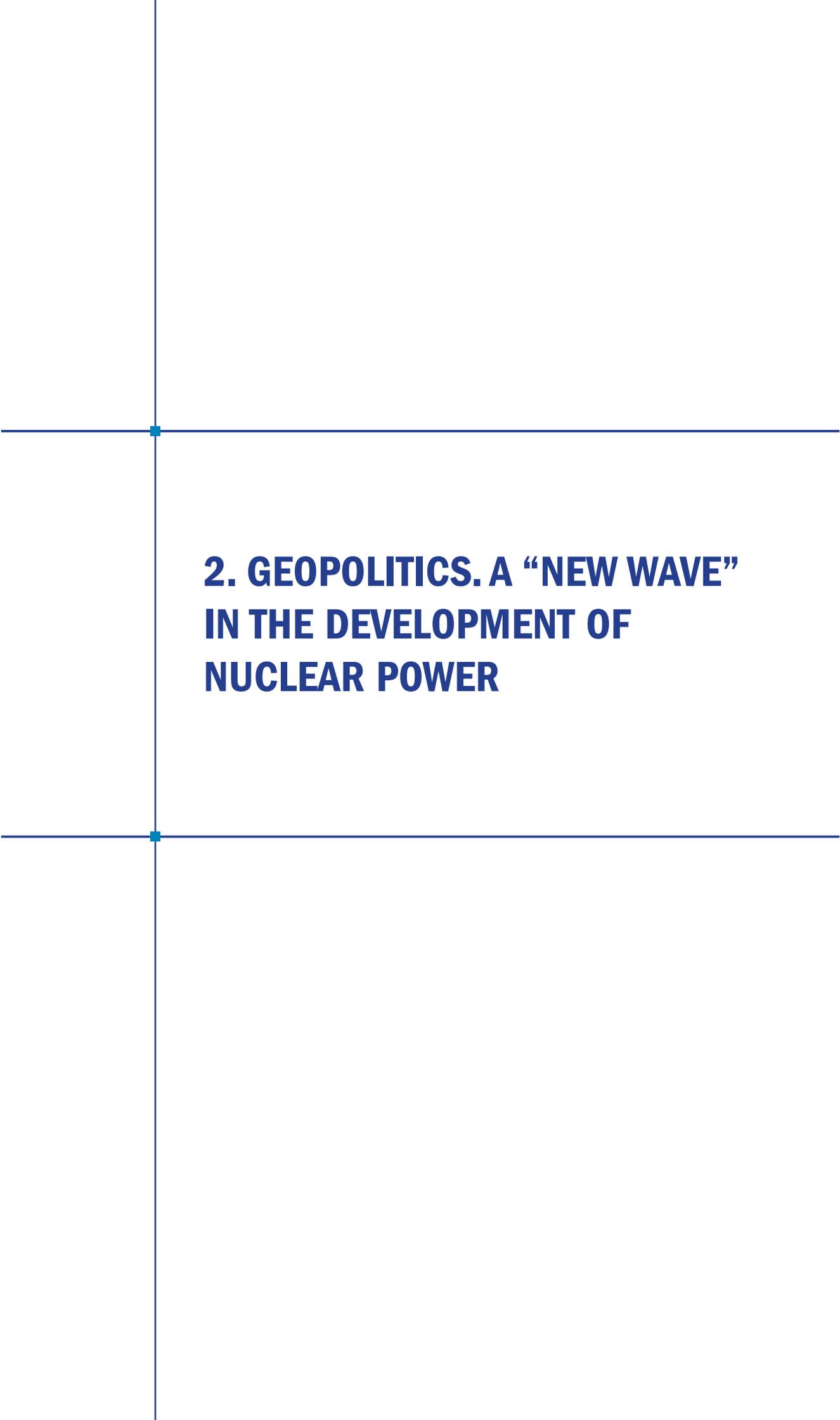


The ambivalence of attitudes towards nuclear energy is due to the fact that, as a sector which is organized in a very complicated way, it incorporates all kinds of risks. It is hardly surprising that the “peaceful atom” turns out to be at the crossroads of all civilizational threats.

However, the survey of experts shows that nuclear energy is far from top in the list global threats to the planet, and the consequences of nuclear disasters are frightening but not fatal. Meanwhile, the population of Russia, despite the abundance of alarming reports in the news, are less and less concerned about a new accident at Russian nuclear power plants as the Fukushima tragedy becomes more distant.

¹³ VTsIOM. Closed question, one response.

¹⁴ Closed question. One response.



2. GEOPOLITICS. A “NEW WAVE” IN THE DEVELOPMENT OF NUCLEAR POWER

“THE DOUBLE-EDGED SWORD OF NUCLEAR POWER”¹

The atom is just a tool in people’s hands. It can warm, singe or destroy - that’s for man to decide

Aleksandr Gromenko, general director of “RCh Media” publishing house, editor-in-chief of “Rossiyskiy Chernobyl”, Russia

Neither Chernobyl nor Fukushima led to nuclear power being abandoned. Why is mankind’s demand for the “peaceful atom” so persistent, despite the considerable technological risks?

The accident at the Fukushima-1 nuclear power plant once again reminded people about the other side of the coin. In March 2012, Japan summed up the results of the first year following the nuclear disaster. The release of radiation turned out to be 2.5 times higher than had been estimated, amounting to 20 per cent of the radiation released from Chernobyl. Some 78,000 people faced compulsory evacuation from the disaster zone; another 16 million chose to distance themselves from the nuclear power plant. According to the data of an IAEA commission, it will take 30 to 40 years to fully overcome the consequences of the disaster.²

The disaster at “Fukushima” forced a number of countries to reconsider their nuclear programmes, yet by January 2012 eight new nuclear reactors had already been launched around the world (bringing the total number to 437), according to IAEA information. There are 63 reactors under construction and another 163 at various stages of planning. The *Wall Street Journal* writes that Russia (10 reactors) and China (26 reactors) are leading in terms of nuclear construction. Saudi Arabia (16 reactors) and Vietnam (10) lead when it comes to the planned construction of nuclear reactors.³

In mid-2011, i.e. after Fukushima, South Korea approved a plan aimed at obtaining 59 per cent of all power generation from 40 nuclear reactors by 2030 (it has 21 nuclear reactors today, which provide 31 per cent of the electricity consumed in the country).⁴

In the near future the Japanese government intends to put forward three alternative concepts for the development of nuclear energy in Japan for nationwide discussion. The first, which envisages the closure of all Japanese nuclear power plants, will inevitably resonate among a significant part of the population, which was gripped by “nuclear panic” following last year’s tragedy at Fukushima. However, the cabinet of Yoshihiko Noda will insist on two other concepts. The main one envisages retaining the 54 nuclear power plants that already exist in the country, while the third envisages the construction of new power plants and raising the level of nuclear-generated power to 40 per cent of Japan’s total energy consumption, from 29 per cent at the moment of the Fukushima disaster.

The Russian state corporation Rosatom has almost doubled its volume of orders for constructing power stations abroad.

It seems that demand for nuclear energy is only going to rise. What is the attitude of the global intellectual community to nuclear energy today, a year after the Fukushima tragedy? We invited our experts to characterise nuclear energy today using a metaphor.⁵ We have tried to group the answers we received - the original, apt and memorable judgements of our experts - into several categories, which we have labelled “a good thing”, “a matter of necessity”, “an obsolete path”, “a risky business” and “a source of problems and trouble” (Diagram 8).

¹ http://article.wn.com/view/2011/03/17/VOX_POPULI_The_doubleedged_sword_of_nuclear_power/

² “Russkiy Reporter”, 29.03.2012, P. Burmistrov “Fukushima one year on”

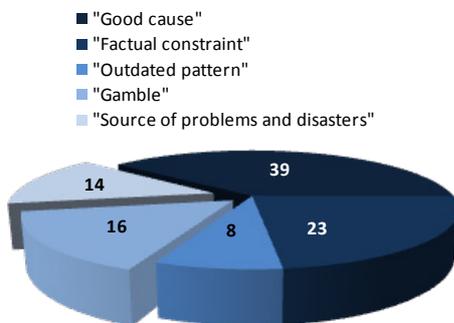
³ <http://www.akkunpp.com/2012-godu-v-mire-puscheno-uzhe-dva-novykh-bloka-baza-pris/update>

⁴ “Rossiyskaya Gazeta”, 16.03.2012 “The pendulum has swung and is coming back”

⁵ Open-ended question. One response.

As we can see, the proportion of unconditional supporters of using nuclear power (“a good thing”) is almost 40 per cent.

Diagram 8. Characteristics of nuclear power
All experts



Yevgeniy Masherov, Candidate of Technical Sciences, senior academic at the Scientific Research Institute of Neurosurgery, Russian Academy of Medical Sciences, Russia: *«The saviour of the world from two catastrophes - military and nutritional».*

Valeriy Murashov, deputy director for development and international activities at “Ukratomenergostroy”, Ukraine: *«An engine of progress in the country».*

Helmuth Boeck, consultant, Vienna University of Technology, Austria: *«Safe, economical and proliferation resistant, the same as GEN IV».*

Aladar Stolmar, former employee at Westinghouse, EROTERV, ERBE, Hungary: *«A mature and smart way to use natural resources for the benefit of mankind».*

Those who believe nuclear power to be “a matter of necessity” at the moment can also be classed as supporters of retaining the atom. They constituted around a quarter of the survey respondents.

Ilya Kramnik, commentator at “Voice of Russia” radio station, Russia: *«A way of ceasing to burn banknotes (recalling Mendeleev)».*



Dr Richard Blanchard, Director of Postgraduate Studies, University of Loughborough, UK: *«A mother in law. You may not like her, but she is part of the energy family».*

Arutyun Khachatryan, editor of the weekly “Noyan Tapan holding”, Armenia: *«It’s an evil without which life is impossible (also true of thermal power plants)».*

Dr Chidambaran Rajagopala, chief scientific adviser to the Indian government, India: *«Nuclear energy is an important, in fact, inevitable option in the context of global energy security and the climate change threat».*

Feodor Lisitsyn, Cand. Sc. (Biology), senior academic at the Scientific Research Institute of Virology, Russian Academy of Medical Sciences, Russia: *«It’s like explosives - it can be dangerous in incompetent hands; it can serve as a weapon and instrument of blackmail, but it is necessary».*

As for the camp of out-and-out opponents, in total they constitute a little over a third of all the survey participants. Some of them consider use of the atom for peaceful purposes to be “a risky business”.

Anatoliy Koshkin, professor at the Institute of Eastern Countries, Russia: *«A time-bomb - there is no such thing as safe nuclear power plants».*



Vladimir Petrushin, head of department at the Kaliningrad regional branch of United Russia: *«A boiling cauldron in hell, generating warmth for paradise».*

Professor José Goldemberg, professor at the Institute of Electronics and Energy, Universidade de São Paulo, Brazil: *«A Faustian bargain: it solves some problems and generates others».*

Mikhail Begak, deputy director at the Scientific Research Centre for Environmental Safety, Russian Academy of Sciences, Russia: *«A nuclear power plant in a country is like a trained tiger in a house - the*

owner is at high risk of being eaten».

Others see nuclear energy as “a source of problems and trouble”, to a large extent.



Yekaterina Gonchar, secretary of IPAE, Belarus: *«Nuclear energy is an ulcer on the body of the planet which gets worse with each year that passes»*

Dr Jan Willem Storm van Leeuwen, senior academic at Ceedata Consultancy, The Netherlands: *«Nuclear energy is energy on credit. The final bill has yet to be presented: the backend may cost as much as construction plus operational lifetime put together. Nuclear energy is a dead-end road. Nuclear energy is a financial black hole».*

Some experts stress that using the atom is “an obsolete path”.



Dirk Bannink, editor of WISE Nuclear Monitor, The Netherlands: *«The most expensive and dangerous way of boiling water. A dinosaur technology».*

Igor Slesarev, Doctor Sc. (Physics and Mathematics), professor at the Moscow Engineering and Physics Institute and the International Centre for Theoretical Physics in Trieste, Russia: *«An obsolete steam engine, incapable of meeting modern challenges».*

Dividing the experts’ views by professional group shows a predictable difference in their preferences. Most of the “nuclear technical experts” are positive about nuclear energy, while “physiocrats” provide more of the negative assessments. Nonetheless, in each group around a third of experts recognize the necessity of nuclear power generation.

The variation between the answers of experts from different countries is also entirely predictable. Half of the representatives of developing countries are unconditional supporters of using the atom, while almost half of their counterparts from developed countries belong to the camp of sceptics on this issue. The position of the Russian experts is interesting, however: with respect to modern nuclear energy they talk about a “matter of necessity” much more often than others.

The metaphors allow us to assess the subjective and emotional attitude of the experts to the issue we are investigating, but views of modern nuclear power as “a good thing”, “a bad thing” or “a matter of necessity” become secondary when the expediency of its use is concerned.

INTO THE FUTURE UNDER A NUCLEAR SAIL?

The discovery of the possibilities of nuclear energy is an irreversible process: having learnt to use a microwave, no-one is going to cook lunch on a fire, except perhaps when on holiday, to be exotic

Yelena Mishon, professor at Voronezh State University,
Russia

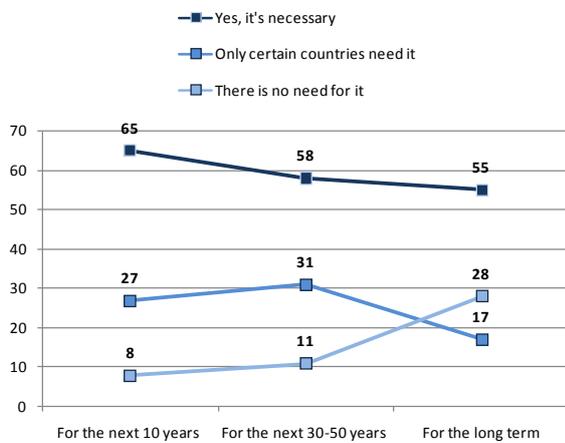
In order to “take a picture” of existing opinions about the expediency of retaining nuclear power, not just today but in the more distant future, we asked the experts: “In your view, does the world need nuclear energy, and if so, for how long?” We invited them to consider three time periods - the next 10 years, the next 30-50 years and the long term (the next century, for instance).

Here, we observe a very clear trend: even in the long term, the proportion of experts convinced that

nuclear energy is a necessity dominates strongly (Diagram 9).⁶

Over two thirds of the experts believe that the whole world needs nuclear power in the coming decade; even among the “physiocrats” this view is taken by over half of those surveyed.

Diagram 9. The need for nuclear power
All experts



Viktor Nikolayev, executive editor at “S-Peterburgskiy Vedomosti”, Russia: *«In the next 10 years even developed countries will not be able to abandon nuclear power, for technical reasons alone. For developing countries, abandoning nuclear power would be an economic disaster in the next 30-50 years too. But overall, mankind’s development trajectory should be aimed at using environmentally clean and renewable resources».*

Roughly another 30 per cent of the expert community believe that “only certain countries” need nuclear power. Most experts in this group think that countries with undeveloped economies will be substantially more dependent on nuclear power in

both the short and medium term.



Konstantin Bogdanov, commentator at RIA Novosti, Russia: *«For many countries that want to make an industrial leap forward, there is no sign of an alternative to nuclear technologies emerging in the energy sector in the next fifty years».*

Lukas Kronawitter, architect and specialist on issues of city environment and planning, Germany: *«It [nuclear power] can be used as a transitional energy source in coal-dependant countries until economic models and technology can support a larger share of renewable energy».*

It is notable that the experts’ forecasts for the next 30-50 years regarding use of the atom do not differ significantly - one can only talk about an impending trend.

Many of the participants in our survey believe that a condition for retaining nuclear power for more than half a century is steady growth in energy consumption on a global scale. At the same time, high levels of energy consumption that are characteristic of Western countries are tending to spread as industrial technologies are exported to countries with cheap labour forces - above all, the countries of South-East Asia.



Joonhong Ahn, professor at the University of California, Berkeley, USA: *«On a global scale we cannot do without the nuclear option, given the growth rates of population and economic activities, particularly in emerging countries, and the environmental burden of using any fossil fuels. This will continue to be true as long as this increasing tendency continues».*

A number of experts believe that the issue of compensating for the deficit of hydrocarbon fuel and decoupling from monopoly suppliers of pipeline gas and oil will remain topical for developed countries too. At the same time, the expected shift to more “expensive” hydrocarbons (heavy oils and so on) and the emergence on the market of fourth-generation reactors which are cheaper to use will only strengthen the position of nuclear power.

⁶ Closed-ended question. One answer for each time period.



Andrey Subbotkiy, engineer in the Industrial Group “Tavrida Elektrik”, Ukraine: *«In the coming decade, nuclear power will remain a priority area in the generation of electricity, especially for countries:*

1) which do not have much fossil fuel;

2) where there is no developed river system that could guarantee a year-round supply of water or a special topography;

3) which are concerned about being environmentally clean and safe;

4) which have scientific-technical potential.

In my opinion, nuclear energy is needed by developed countries that have a strong scientific potential allowing them to extract energy from the atom with maximum profit and safety. The active interest which more and more countries previously peripheral to the international economy (even those still on the periphery, such as North Korea) are showing in nuclear energy proves convincingly that the traditional means of getting energy are struggling to satisfy the increased requirements of post-industrial society. Alternative energy is still at an embryonic stage due to its high cost and dependence on irregular energy sources (wind and sun)».

Only in the long-term forecasts does the number of people who believe there will be no need for nuclear power rise noticeably, exceeding a quarter of all respondents. It is logical that the majority of them belong to the “physiocrats” - in the “green camp”, the proportion of opponents to nuclear power in the distant future is 46 per cent.

To a large extent, the experts link the factors that will reduce the need to use nuclear energy for economic needs to hope that new ways of generating energy will be discovered. Above all, this concerns renewable types of energy.



Carlos Alberto dos Reis Ferraz, project manager at the School for Studying the Use of Biomass, Brazil: *«We need to strive for peaceful, living energy - renewable sources (such as biomass). Power from the wind, water, heat and the sun complement each other. This is stability and democracy. Oil, gas, coal and nuclear are synonyms for instability and anti-democracy».*

Nevertheless, the number of people who support widespread use of nuclear power exceeds 50 per cent of those surveyed, even in the long term. On the one hand, this is linked to the need to satisfy mankind’s growing demand for energy.



Joerg Lalk, senior lecturer at the University of Pretoria, South Africa: *«Even in the longer term there are only two baseload technologies available, coal and nuclear; and in some cases gas. Of these, nuclear is the only truly ‘clean’ technology. Renewables such as wind and solar will continue to suffer from the lack of storage technologies and due to their inherent randomness will not form any part of baseload requirements».*

Dr Pen Si, lecturer at the Engineering College of Beijing University, China: *«Nuclear energy is indeed a key solution to the energy crisis in the world».*

Boris Oskolkov, Candidate of Technical Sciences, head of department, IRL of ChC Ukraine: *«The wider society’s economic basis of existence, the more resilient and successful its development will be. Nuclear power, understood broadly as using energy from an atom’s nucleus, has basically already become part of the foundation of mankind’s existence. It would be virtually impossible to abandon it. The history of society’s development shows that progress in science and industry cannot be stopped; it may only speed up or slow down. The processes of nuclear power’s development will vary too. In the very distant future, the specific ways in which the power of the nucleus is used will certainly change fundamentally. They may be entirely dissimilar to those which exist in our age».*

On the other hand, many experts place big hopes on the development of the sector itself, which would resolve the problem of safe use of nuclear power and make possible a switch to nuclear fusion.

«**Aleksandr Frolov**, expert at the Centre for Macroeconomic Analysis and Short-Term Forecasting, Russia: *«In the next 10 years there is no need for widespread proliferation of nuclear power in developing countries (apart from those which already have such technologies). Above all, this is linked to issues of safety and the expected appearance of new technological solutions in the next 10 years (the commercialisation of fast-neutron reactors, reactors which are naturally safe). In the more distant future, there is an objective need to develop civilian nuclear power which is linked to the following factors:*

- *an increase in safety of use;*
- *an increase in the resource base (in the case of implementing fast-neutron reactor projects);*
- *a diversification in the uses of nuclear technologies (providing energy to autonomous facilities, means of transport, nuclear medicine, safety technologies and so on);*
- *the future development of energy based on new principles (controlled nuclear fusion)».*

Dmitriy Belousov, Cand. Sc. (Economics), discipline head, CMASTF, Russia: *«As fundamental science and technologies develop, in the long term it is possible that we will be able to get energy from wind, sun and geothermal sources on a larger scale. However, nuclear energy will still constitute a significant share (perhaps the most developed countries will be able to fully switch to fundamentally new sources), although in a somewhat different form (thermonuclear fusion)».*

It is significant that experts from developing countries are the most consistent supporters of nuclear power, even in the next century (besides professionals from the sector).

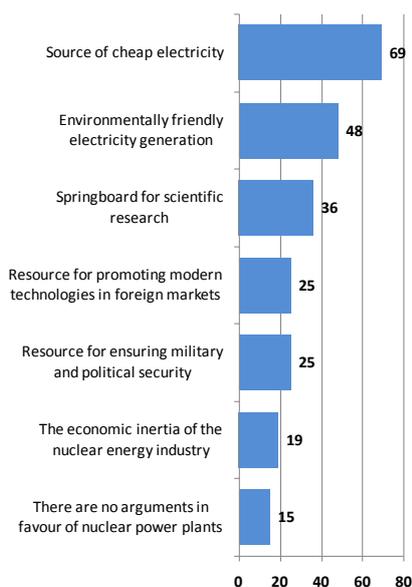
THE WHALES ON WHICH THE “PEACEFUL ATOM” STANDS

There is a direct link between the amount of energy people in a society use and the standard of living of such people and society. Next to air, water and food, shelter is an essential requirement for human existence. As the world’s population continues to grow and becomes more and more urbanized, the extensive use of energy is an essential requirement for the continuation and increasing standards of life

George Bereznai, professor, Dean of the School of Energy Systems and Nuclear Science at the University of Ontario Institute of Technology, Canada

In order to assess the weight of the various arguments in favour of continuing to use nuclear energy, the experts were invited to name what they considered to be the main arguments in favour of continuing

Diagram 10. Arguments in favour of using nuclear power plants
All experts



to use nuclear power plants (Diagram 10).⁷

The clear leader, chosen by almost 70 per cent of those surveyed, turned out to be the relatively low cost of electricity generated by nuclear power.



Sverre Hval, deputy head of department at the Institute for Energy Technology, Norway: *«It is not a very cheap source of energy, but cheap compared to other sources of energy».*

Andrey Kondratyev, director of “Ekotsentr”, Russia: *«The cost of generating electricity from nuclear power plants is the lowest and provided their safe operation is ensured, it is also the most environmentally friendly. Since the importance of energy to mankind is constantly rising, those countries which have modern nuclear energy technologies are in a good position in the global market».*

However, the recent technological breakthrough in the USA, the so-called “shale revolution”, has made it possible to get cheap gas in large volumes. In the future it may rival oil and coal as a fuel for thermal power plants and throw into doubt the viability of nuclear power plants. Of course, the technologies which currently exist to extract shale gas are not irreproachable from an environmental point of view, so France, for example, has already banned use of hydraulic fracking.⁸

With regard to nuclear power generation, almost half the experts stress that it is environmentally friendly.



James Acton, senior associate at the Carnegie Endowment for International Peace, UK: *«There’s only one argument for nuclear power. But it’s a really good one».*

Mariya Belova, senior analyst at the Energy Centre, Skolkovo Business School, Russia: *«From the point of view of CO2 emissions, this way of generating energy is even more environmentally friendly than a number of renewable energy sources».*

Ilya Yudanov, senior academic at the Catalysis Institute, Siberian Division of the Russian Academy of Sciences, Russia: *«Burning fossil fuels inevitably changes the composition of the atmosphere and affects the climate. Only nuclear power represents a real industrial alternative to fossil fuels».*

Over a third of the experts noted the importance of nuclear power plants as a springboard for scientific research.



Aleksandr Yanichev, nuclear reactor shift leader, Scientific Research Institute of Nuclear Physics at Tomsk Polytechnic University, Russia: *«Nuclear power plants are the core of the nuclear power cycle. We must continue to use nuclear power plants not only to generate electricity, but to develop the whole chain of the nuclear power cycle».*

John Stewart, Director of Policy and Research at the Canadian Nuclear Association, Canada: *«Nuclear power, on the other hand, got the world over 400 reactors, generating huge amounts of electricity for decades. The related scientific activity got us a sustainable ongoing industry in many countries, effective ways to diagnose and treat cancer and great advances in materials science».*

Viktor Zamyatin, independent expert, Ukraine: *«It would look like monstrous stupidity to abandon use of nuclear scientific and technical research in the light of the hysteria surrounding the disasters at Chernobyl and Fukushima».*

⁷ Closed question. Multiple responses.

⁸ RBK daily, 08.02.2012, “Free markets work better than monopolies with exclusive export rights”, interview with BP Chief Economist Christof Ruhl.

Around a quarter of the survey participants see nuclear power as a resource for promoting modern technologies in foreign markets and ensuring a country's military and political security.

«**Aleksey Fomenko**, first deputy general director of the Dnieper Metallurgical Plant, Ukraine: *«If any country has a nuclear power plant, it shows that the country is highly developed and so on. Highly developed countries always reach agreement and create the alliance that is needed for stable peace in the world».*

Marina Makovskaya, vice-president of the Harvard Club of Russia, Russia: *«Today, the peaceful atom is primarily a resource for ensuring a country's military and political security. In this regard, it is also a springboard for scientific research and a relatively underused opportunity to participate in international scientific-production cooperation».*

Much research in the nuclear sector relates to dual-use technologies - i.e. those which serve both military purposes and have potential civilian applications. A clear example of this is the activity of the technology park in Sarov (Nizhniy Novgorod Region).⁹

Less than 20 per cent of the experts mentioned the economic inertia of the nuclear industry (the nuclear lobby) as a factor.

«**Vladimir Knyagin**, director of the "North-West" Centre for Strategic Developments, Russia: *«For countries which already have nuclear energy, it is virtually impossible to abandon use of nuclear power plants. Scientific and production infrastructure has been built up around them, and the financial cost of closing plants would be huge. Certain arguments in favour of using nuclear power plants (source of cheap electricity) are not entirely correct, since they do not take into account the full life cycle of nuclear power (for example, the cost of cleanup following an accident, the final disposal of used nuclear fuel and radioactive waste). Even without taking into account these expenses, the cost of electricity generated by nuclear power plants is rising, just as the cost of building the plants is rising».*

Finally, 15 per cent of experts see no positive arguments in favour of using nuclear power stations.

«**Carlos Alberto dos Reis Ferraz**, project manager at the School for Studying the Use of Biomass, Brazil: *«There are no real arguments in favour of continuing to use nuclear power. The disasters at nuclear power stations speak for themselves. Use of nuclear power plants is not compatible with life of earth».*

Dr Jan Willem Storm van Leeuwen, senior academic at Ceedata Consultancy, The Netherlands: *«From the viewpoint of thermodynamics, resource availability and energy security there is not a single reason for continued use of nuclear power. On the contrary, nuclear power delays the transition to a really sustainable, clean and secure energy supply system».*

In our view, the differences of opinion between various groups of experts over support for continued use of nuclear power are particularly interesting.

If we analyse the differences of opinion between professional groups "on different sides of the barricade" (Diagram 11), it becomes clear that the physiocrats are losing the battle for minds to professionals in the sector. Society (whose views are represented in our survey by independent experts) is insufficiently informed about the environmental advantages of generating electricity using the "peaceful atom". However, an impression of the inexpensiveness of nuclear energy and its role in scientific research has become firmly embedded in the public consciousness.

Differences of opinion between experts from different countries about the advantages of using nuclear power stations (Diagram 12) also demonstrate familiar features. For experts from developed countries, the inexpensiveness and environment-friendliness of nuclear-generated power are almost

⁹ "Argumenty Nedeli", 08.02.2012, V. Aleksandrov "Where is the prospect of a Russian innovation breakthrough?"; "Rossiyskaya Gazeta", 29.02.2012, A. Yemelyanenko "Tested on bombs"

equal priorities and other arguments have much less weight. For their counterparts from Russia, the opportunity to develop scientific research and promote advanced technologies in foreign markets is no less important than environment-friendliness. In developing countries the potential of the nuclear sector is also important, but the inexpensiveness of nuclear-generated electricity is far more crucial than for other countries.

Diagram 11. Arguments in favour of using nuclear power stations
Experts from various professional groups

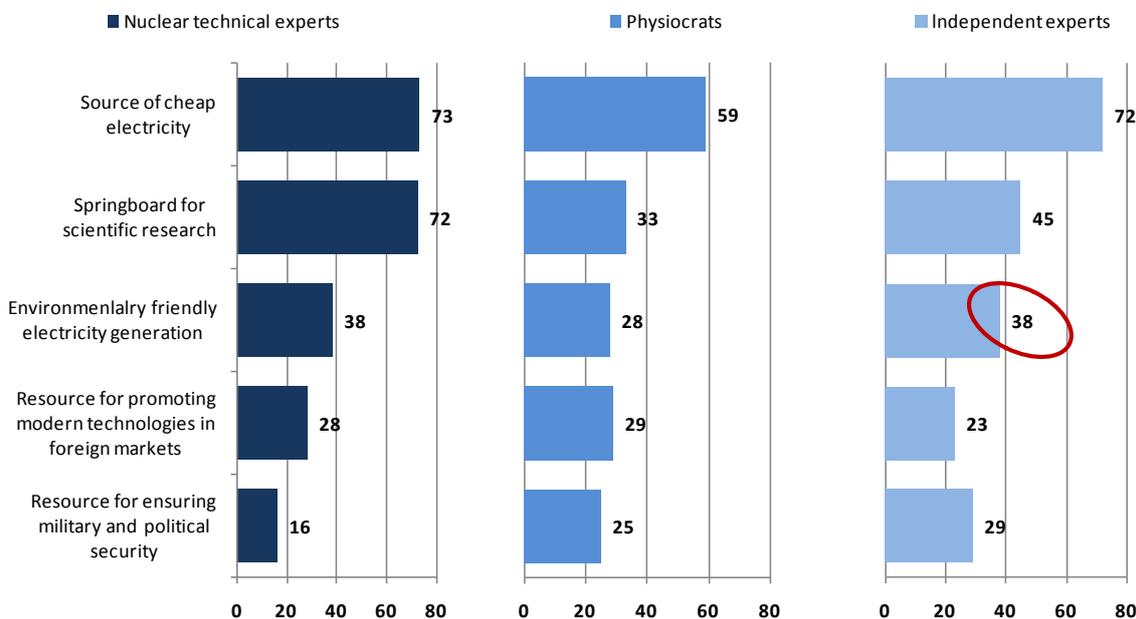
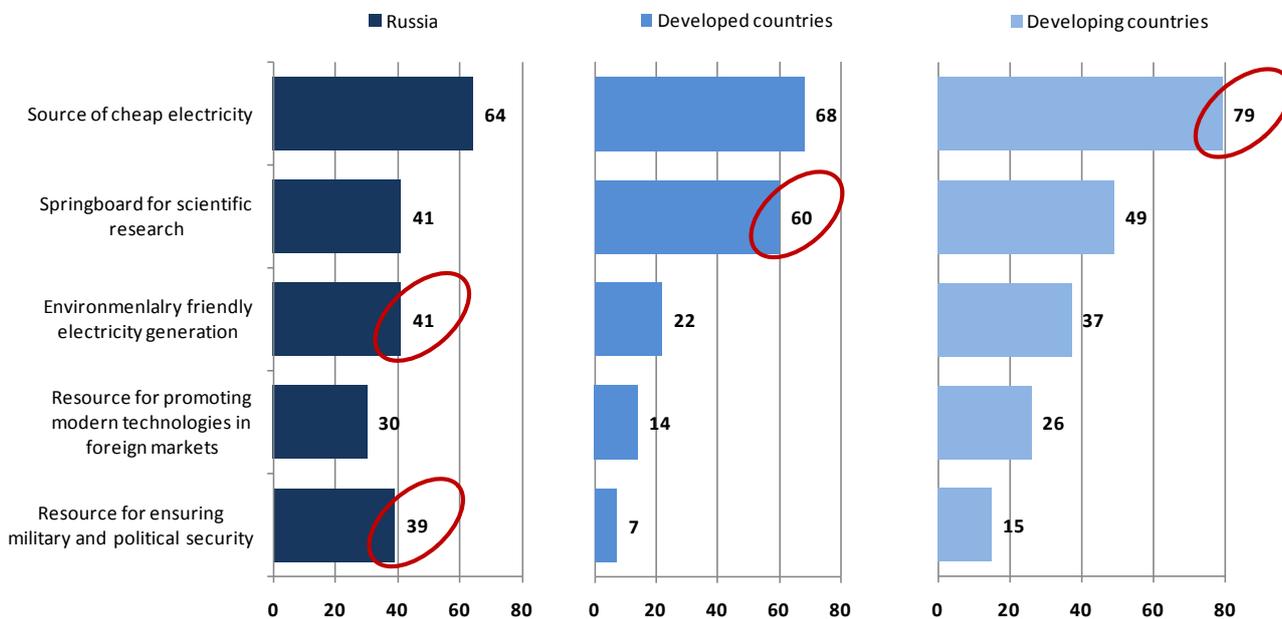


Diagram 12. Arguments in favour of using nuclear power stations
Experts from various groups of countries



« **Paolo Raimondi**, economist and commentator for economic and financial publications, Italy:
«The approach towards nuclear power of countries with different development levels is very symptomatic of the egoism dominating the Western world. Opposition to nuclear power is directly proportional to the high standard of living, which, by the way, is based on high energy consumption. After the developed countries experienced an extraordinary level of consumption for decades, they now want to impose energy production solutions that are convenient for them but not for the

two thirds of the world population still living in different degrees of poverty. Stopping nuclear energy production in the developed world would also produce extreme energy competition over gas and oil for the next decades with very dangerous geopolitical repercussions».

Mankind has made many important technological breakthroughs within the framework of an “arms race”. The “peaceful atom” is a clear example of this. Having one’s own nuclear energy is an issue of international political prestige and a ticket into the club of countries which, if not highly developed, have very serious development potential.

Therefore, one cannot consider nuclear energy merely as a sector that produces consumer goods or services like the textile industry, for instance. Besides energy, the nuclear power sector generates international prestige, advanced technologies, relative energy independence and potential access to the most destructive of all known kinds of weapon. This is one reason why nuclear power is attractive to countries with rapidly rising competitiveness. This circumstance cannot be discounted when discussing the great inertia of the nuclear sector and its resilience despite the risks associated with its use.

DEVELOPMENT OF THE NUCLEAR SECTOR: TRENDS AND GEOGRAPHY

In developed countries there are particularly high safety requirements. Post-industrial society is conservative with regard to ensuring its own comfort. That’s why the trend there will be directed towards the safety of existing systems. Industrially developing countries have no choice - nuclear power is an objective necessity for them. As for poor countries, they do not have the opportunity to develop, construct and safely operate nuclear power stations on their own under any scenario

Vadim Gasanov, consultant at VGTRK, Russia

Considering the international geopolitical tension that already exists in energy-producing regions, as well as the limited growth in known reserves of fuel, one might say that the world is actively searching for energy alternatives in order to avoid a global energy crisis and global conflict over the battle for energy resources. The expert community believes that this explains, in large part, the interest in nuclear energy.

« **Ilya Yudanov**, senior academic at the Catalysis Institute, Siberian Division of the Russian Academy of Sciences, Russia: *«The global economy is already in crisis; stopping nuclear power stations would lead to a catastrophe».*

Yet the “peaceful atom” is not that cheap. Nuclear facilities have to be maintained in the correct condition. In Ukraine, for example, up to 80 per cent of nuclear power plants will reach the end of their lifespan by 2020. It will be necessary to replace 12 nuclear reactors which were launched back in the days of the Soviet Union.¹⁰

In addition, some people say that the competitive price of nuclear-generated electricity is due to

¹⁰ “Nezavisimaya Gazeta”, 28.03.2012, T. Ivzhenko “Ukraine prepares reform in nuclear energy”

insufficient insurance cover of risks. In the USA, compulsory insurance of nuclear power plants is limited by law to the level of 375 million dollars, with maximum compensation of damages set at 12.6 billion dollars. In France, the required level of insurance is 91 million euros; government guarantees of compensation for damages are limited to 228 million euros. Comparable levels of insurance and government guarantees operate in the UK, Russia and the Czech Republic. In Switzerland, compulsory insurance is 190 million euros; in Germany it is 2.5 billion euros and all assets of the nuclear power plant operator are also liable.¹¹

In Switzerland, the Department of Civil Guard estimates that the cost of an accident at a nuclear power plant would be 2,600 billion euros. A 2009 study estimated the damage from an accident at the Indian Point nuclear power station, 24 miles from New York, to be 416 billion dollars, without taking into account that one of the world's major business centres and a huge metropolis would have to be evacuated. The German Economics Ministry estimates that the total damage from a full-scale disaster at a nuclear power plant would cost 7,600 billion euros.¹²

Despite all this, the development of nuclear power is continuing in the world, with some progress in nuclear engineering. First- and second-generation reactors (second-generation reactors were damaged in Fukushima) are being replaced by third-generation reactors, which include advanced boiling-water reactors, multiple-loop boiling-water reactors, heavy-water canal-tank reactors and a number of other constructions, including the KERENA boiling-water reactor which belongs to the third-plus generation.

 **Vladimir Krasnorutskiy**, Cand. Sc. (Physics and Mathematics), director of the Scientific-Technical Complex “Nuclear Fuel Cycle”, Kharkov Institute of Physics and Technology, Ukraine: *«The modern nuclear energy sector is at the stage of developing and implementing technical and physics solutions that will make it possible to achieve the required efficiency and practical safety».*

Within the framework of the international project *Generation IV*, part of the “Nuclear power systems of the fourth generation” programme, six promising nuclear technologies were developed which could make future nuclear power stations more economical, reliable and safe from the point of view of both their operation and the proliferation of nuclear weapons. New development of a fast-neutron reactor and a high-temperature gas-cooled reactor prompts particular interest. The latter's temperature regime allows it to ensure effective production of hydrogen, as well as the enrichment of heavy crude oil. The Institute of Fossil Fuels and the State Scientific Centre of the Russian Federation - Physics and Energy Institute in the city of Obninsk have achieved some success in creating a model nuclear energy technology system, which produces synthetic motor fuel from coal in an environmentally clean way. In other words, the development of nuclear energy has the prospect of becoming a new source of motor fuels, and most importantly - the environmentally clean motor fuel, hydrogen.¹³

In the USA there has been the promising development of an “eternal reactor”, which does not need to be stopped for refuelling. The fuel in this reactor is in the form of spheres which move around within the construction. As they burn up, the spheres replace each other one by one. In addition, the company *Westinghouse* in the USA has developed a “simple reactor” which has 60 per cent fewer moving parts and ducts than a traditional reactor. This makes it safer and facilitates servicing.¹⁴

 **Horst D. Simon**, deputy director of the Lawrence Berkeley National Laboratory, USA: *«A lot will depend on the development of SMR (small modular reactors) in the next five years. If they are developed and can be deployed inexpensively in developed countries, it will change the acceptance of nuclear power».*

Russian designers are not dozing either. In particular, a new fast-neutron reactor, BREST, has been developed. Its coolant is lead. There is also a fast-neutron reactor, RBETs, which has improved safety

¹¹ http://tristar.com.ua/1/art/tselesoobraznost_strahovaniia_atomnyh_elektrstantsii_25186.html.

¹² http://tristar.com.ua/1/art/tselesoobraznost_strahovaniia_atomnyh_elektrstantsii_25186.html.

¹³ <http://www.proatom.ru/modules.php?name=News&file=print&sid=990>.

¹⁴ <http://icdat.ru/rorea/aes42.htm>.

features.

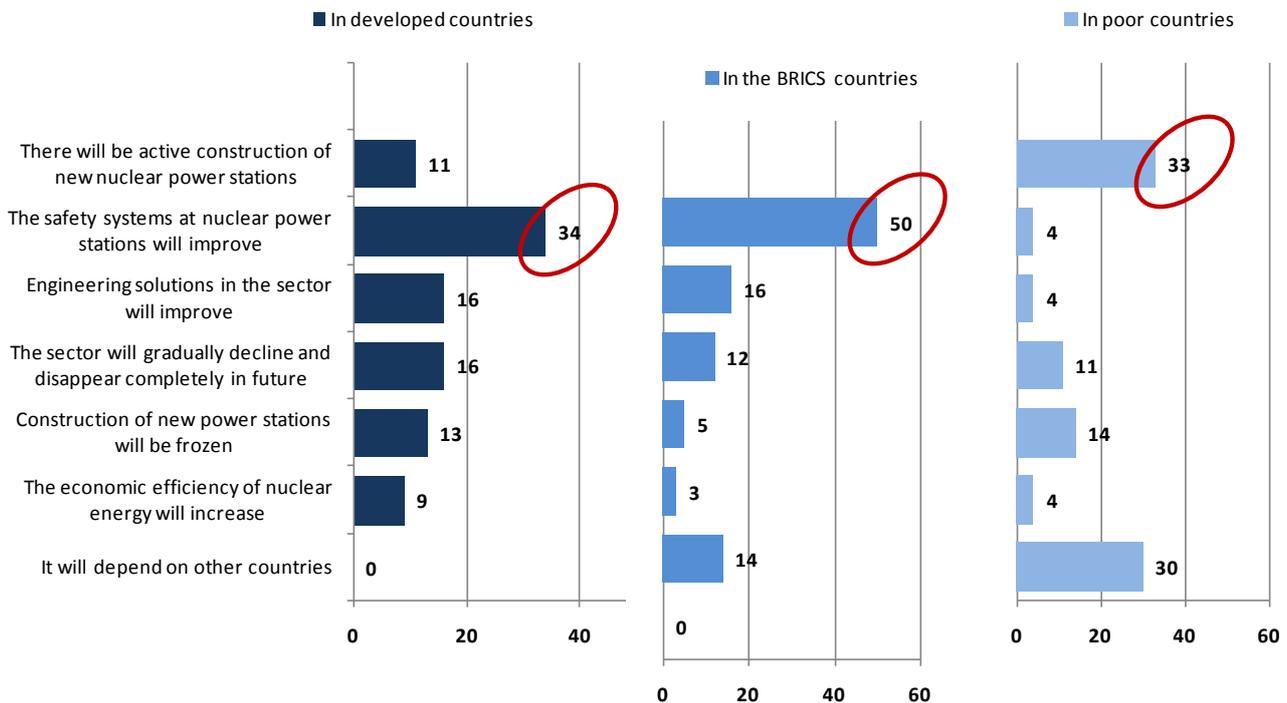
There is no need to list all the new developments in nuclear energy in this report, all the more so since there is only one operational fast-neutron reactor in the world - at the Beloyarskaya nuclear power station - despite the abundance of new engineering solutions and clever ideas. The world's other nuclear "breeder" states have been hindered by the operational complexities.

Currently it is primarily power plants of the second-plus, third and third-plus generations which are being built in the world. Prospects depend on many factors, including the state of the market for traditional fuels; progress in the area of saving energy; the development of renewable sources; progress towards creating an industrial fusion device and the success of engineering fuel elements, i.e. the speed of motor vehicles' transition to hydrogen fuel. One cannot say that obsolete reactors are currently being built in the world. For example, the decision was taken in Russia not to finish building the fifth reactor of the Kursk nuclear power plant for this reason. However, it seems that active use of existing scientific-technical reserves and next-generation systems will only happen if the nuclear energy sector receives an impulse of extensive development.

In our research, the view was expressed that *"a nuclear programme will be proposed, but its implementation will be ineffective. Only a few states, whether developed or developing industrially, will begin to develop new types of reactor"*.¹⁵

Currently, the BRICS countries - including Russia - are moving towards the creation of a political-economic union in order to strengthen their position in the international arena. Therefore, the BRICS countries, together with developed countries and poor countries, were a reference point in our research. In relation to these three groups of countries, the experts were invited to determine the main development trend of the nuclear sector in the medium term.

Diagram 13. Main medium-term development trend in the nuclear sector
All experts



The picture that emerged clearly demonstrates that the expert community expects absolutely different development strategies for the nuclear sector in the West, in newly industrialised countries and in poor countries (Diagram 13).

Most survey participants believe that in developed countries attention will be directed primarily towards modernizing existing reactors. First of all, plants' safety systems will improve (a third of experts believe this to be the case), as will engineering solutions in the sector (this was mentioned by one in five

¹⁵ The survey participant requested not to be named in the report.

respondents).

« **Aleksandr Yanichev**, nuclear reactor shift leader, Scientific Research Institute of Nuclear Physics at Tomsk Polytechnic University, Russia: *«In the nuclear energy sector and in the nuclear sector as a whole, developed countries set the development trend, while the rest of the world imitates them. After Fukushima, the leaders in the global nuclear energy sector should under no circumstances allow a major accident at facilities which use nuclear energy, so for them the priority task today is to improve safety systems».*

Dmitriy Belousov, Cand. Sc. (Economics), discipline head, CMASTF, Russia: *«Currently, the key part of the agenda is the further improvement of existing types of nuclear power station, particularly the safety systems (including ‘natural’ safety). In future, as a new technological platform emerges in the sector (fast-neutron reactors), one can expect ‘explosive’ proliferation of nuclear power, including to developing countries.»*

A number of participants in our survey believe that research in the area of nuclear power development will pursue wider goals than the modernization of existing reactors.

« **Aleksandr Frolov**, expert at the Centre for Macroeconomic Analysis and Short-Term Forecasting, Russia: *«Despite the importance of developing the safety systems of existing reactors, this trend will be secondary. In developed countries (and also in Russia) the majority of development of the nuclear sector will be concentrated in the following areas:*

- *extending the use of technologies from the nuclear sector to other areas (medicine, safety, special transport);*
- *improving the technical-economic specifications of reactors (including with a view to increase exports);*
- *development of new types of reactors».*

The experts expect relatively active construction of nuclear power plants only in South Korea and certain EU countries (the continuing nuclear programme of Finland and others). However, the total amount of construction will be relatively small, with a substantial amount of decommissioning. Around 30 per cent of those surveyed predict a decline in the sector in developed countries and a freeze in the construction of new plants.

« **Aleksey Protskiy**, general director of SOFEKS, Russia: *«In developed countries, construction of new plants will be frozen in expectation of a technological breakthrough, because there are already plenty of nuclear power plants in those countries».*

Meanwhile, the majority of experts expect active construction of new nuclear power plants in industrially developing countries (the BRICS economies). Only 8 per cent of the participants in our survey do not see major prospects for the sector in developing economies and believe a decline or freeze in nuclear power will happen here too, in expectation of new technological solutions.

« **Viktor Tsibulskiy**, Doctor of Technical Sciences, chief scientific officer at the National Research Centre “Kurchatovskiy Institute”, Russia: *«The need for energy, above all in China and India, will require large-scale construction of nuclear power plants. The main thing here is how to build capacity as quickly as possible. By 2040-2050, the large scale of the nuclear power sector in these countries will itself generate new conditions for the development of nuclear power».*

At the same time, the expert community believes that the modernization of the sector and issues of safety will receive much less attention than in the West.

On the one hand, the expected rapid development of the nuclear power sector is linked to the need for countries like India and China to diversify their energy supply, reduce the burden on the environment (especially in the heavily populated regions of southern and eastern China, or near the major industrial

centres of India) and lessen dependency on supplies of oil and gas from countries of the Middle East.

« **Vladimir Knyagin**, director of the “North-West” Centre for Strategic Developments, Russia: *«To all appearances it looks like nuclear energy is to be given the role of an outsider in the fuel and energy balance of developed countries. Only China, India, Russia and traditionally France are probably betting on nuclear power (although in France, if F. Hollande wins the presidential election, significant shifts are possible) along with developing countries which need large generating capacity. At the same time, the latter are more and more frequently opting for a “simple” solution, whereby all issues of the end of the fuel cycle remain outside their territories (nuclear fuel on leasing), i.e. there is no need to resolve the problem of storing used nuclear fuel and radioactive waste, or to purchase the necessary solutions from nuclear states».*

On the other hand, we believe this shows the expert community’s confidence that rapid industrial growth in countries like the BRICS will take place, to a large extent, thanks to the shift of low and medium-technology production from developed countries to developing ones. Above all, this concerns energy-intensive and polluting industry. It is clear that the energy sector will change to cater for energy consumers of this type. Given the need to make substantial capacity operational relatively rapidly, the source of energy can only be nuclear. As energy-intensive production leaves the developed world, there is also the possibility that a number of European countries might completely abandon nuclear power.

« **Ilya Grigorenko**, senior academic at the University of Pennsylvania, USA: *«In the near future some poor countries and many developing countries may become an ‘off-shore’ for nuclear power generation (a territory under complete control of a developed country)».*

There is a completely different picture among the group of poor countries. A third of the experts predict growth in nuclear energy here. Independently of each other, the experts note in their commentaries that the future of nuclear energy in poor countries will depend on other countries which have to provide investment. This also confirms the trend for energy-intensive production to shift to third countries. It is precisely this which can explain the willingness to invest capital in nuclear energy, as only this kind of industry can ensure effective demand. It seems this is why the issue of technological progress barely arises here.

« **Valeriy Belov**, senior adviser at Deloit, Russia: *«As for poor countries, I would like to say that the development of nuclear power, as such, is extremely limited in these countries. The construction of nuclear power stations can only take place if there are country-sponsors of such projects. A more likely development scenario is the use of alternative sources, for which the costs of construction and operation are now comparable with the costs of constructing and operating nuclear power plants and even certain types of traditional electricity generation».*

James Terry Rodgers, professor emeritus at the University of Carleton, Canada: *«Active construction of new nuclear power stations in poor countries will depend on financial support from developed countries and BRICS, perhaps through international organizations like the UN».*

Around a quarter of those surveyed believe that the nuclear sector in poor countries will either be shut down or frozen in future in expectation of new technological solutions appearing on the market.

« **Yevgeniy Masherov**, Candidate of Technical Sciences, senior academic at the Scientific Research Institute of Neurosurgery, Russian Academy of Medical Sciences, Russia: *«In poor countries there will be two competing trends - one for the construction of new nuclear power plants as a source of development and another for abandoning nuclear power on the pretext that they are dangerous, but with the real aim of profiting from the sale of ‘environmentally clean’ technologies to these countries».*

Rafael Macián-Juan, professor at Technical University Munich, Germany: *«In poor countries we will*

observe the gradual development of nuclear power, supported technically and economically by countries with established nuclear industries. From my point of view it is the moral responsibility of developed countries to help poorer ones start and safely implement nuclear programmes (training of personnel and regulators, safe building and operation methods, etc) if they need them».

Thus, the development paths and prospects of nuclear energy vary fundamentally depending on a country's economic (and political) status. For developed countries, there will primarily be progress in safety systems and new engineering solutions; for industrially developing countries there will undoubtedly be an expansion of capacity; for poor countries there will be expansion of capacity provided there is foreign investment.

VOX POPULI: ON OPPOSITE SIDES OF THE BARRICADE

Mankind has reached a point where it is frightening to go further. Nobody can guarantee that there won't be accidents, but it is also impossible to stop, otherwise it will be worse in the near future

Mikhail Umanets, director of Chernobyl nuclear power station (1987 -1992); former Ukrainian deputy minister for nuclear energy, Ukraine

The wide international discussion that broke out following the events in Japan once again threw the development of nuclear energy into doubt in the eyes of the general public. However, just a year on from the accident at Fukushima we see that the dominant expectation in the expert community is for further development of the nuclear sector in the world. In this regard, it is interesting to look at the changing views on the peaceful atom among Russians, who still have clear memories of the Chernobyl tragedy.

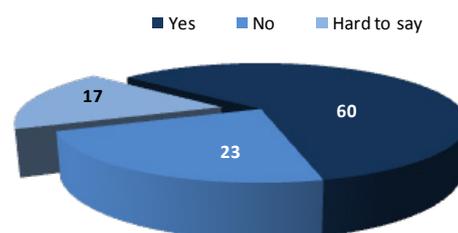
The results of this study demonstrate that most of our compatriots support the development of the nuclear sector in Russia.

Thus, when asked **“Does Russia need nuclear power stations, or not?”** two thirds of Russians give a positive answer (Diagram 14).¹⁶ This coincides with the experts' position. Less than a fifth of respondents gave a negative response to the question.

There is a similar ratio when people are asked about the future of nuclear power plants in Russia (Diagram 15).¹⁷ In total, two thirds of Russians talk about the sector's favourable prospects while only 15 per cent predict its decline and a quarter of respondents find it hard to answer the question. On this question, our compatriots are a little more cautious in their forecasts than the expert community, but the observed trend is undoubtedly the same.

The data we have collected generally coincide with the results of other surveys conducted in the course of the year that followed the accident at

Diagram 14. Does Russia need nuclear power plants?

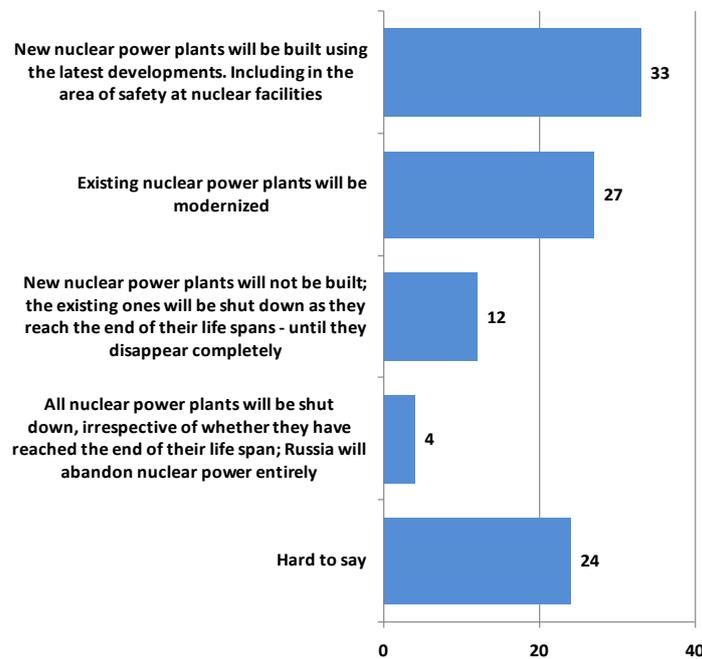


¹⁶ Closed-ended question. One response.

¹⁷ Closed-ended question. Multiple responses (two answers).

Fukushima.¹⁸ According to several studies, between 35 and 55 per cent of Russians continued to support the development of nuclear energy in spring 2011, even after the Japanese accident. One third of the Russian population was categorically opposed to nuclear power plants.

Diagram 15. What future do nuclear power plants have in Russia?



As we can see, Russians demonstrated a more optimistic attitude towards the sector's future just nine months after Fukushima (we conducted the population survey in December 2011). One can postulate that time was a major factor here - in this period, approximately 10 per cent of people regained their faith in nuclear power and got over their shock following the Japanese disaster.

At the same time, the supporters and opponents of the sector's present and its future have clear socio-demographic features (Table 1).

Thus, almost two thirds of the Russian population recognize the need for nuclear power and believe

SUPPORTERS	OPPONENTS
• More men	• More women
• More young people (20-30 years old) and people at the peak of their career (31-45 years old)	• More people over 60 years old
• More residents of cities with over one million inhabitants	• More village residents
• More leaders, specialists and employees	• More unemployed people
• More people with higher education	• More people with secondary-school education or below

in the renewal of the sector. Among them there may be more socially active, young and educated people.

¹⁸ Russia-wide survey by FOM, Russia-wide survey by "Levada Centre" and internet surveys of the Russian audience conducted by RuNet and the research centre portal Superjob.ru and others.

“NEW DEMAND” FOR NUCLEAR POWER: HORIZON 2030

Modern nuclear power is a complex nexus of economic and political interests

Aleksandr Apokin, leading expert at the Centre for Macroeconomic Analysis and Short-term Forecasting, Russia

In the next 20 years it is possible to forecast a “new wave” in the development of nuclear energy: existing reactors will be modernized, there will be active construction of new power plants and new technologies will be invented. At the same time, the driving force will be newly industrialised countries, with China, India and possibly Russia playing a leading role.

As the global economic crisis develops, we are today witnessing the emergence of a new “nuclear geography”. Newly industrialised countries (China, India, Brazil and others) are creating new demand for nuclear energy, which has a dual nature.

First, in light of objective growth in the need for power generation, economic demand is going to rise, since nuclear power is currently the only large-scale alternative to hydrocarbons, and so far no replacement for the atom is visible.

Besides economic demand, there is also geopolitical demand for nuclear energy. This will also grow as the world becomes multi-polar. A country that has nuclear power achieves a special status in the world, an additional instrument of global competition and additional guarantees of sovereignty.

Nuclear power arose as the “product” of geopolitical competition between the USSR and the USA. At the moment, a new geopolitical rivalry between many world centres is emerging. Just like in the mid-twentieth century, this will become the driver of growth in the nuclear power sector. Just like when nuclear energy was first developed, the main motivation today for getting access to nuclear technologies is political. It is hard for new countries which aspire to regional leadership to compete with the world’s leading powers in terms of military potential and modern weapons. It is much “cheaper” to ensure sovereignty by getting access to nuclear technologies through the development of nuclear energy.

Taking into account the crisis that occurred after World War II in the system of international security, one can assume that more and more developing countries are going to strive, like Iran, to obtain nuclear technologies to ensure their national sovereignty. Can the existing model of “containing” the proliferation of nuclear technologies withstand the new demand to possess nuclear power? More likely, nuclear safety is becoming “hostage” to geopolitical security. This means that in the next decades, every significant regional conflict may be accompanied by nuclear risks, since the likelihood of a nuclear facility (including stores of radioactive substances - fuel or used nuclear fuel) falling within a zone of political or military conflicts will rise.

Thus, states which aspire to the role of a regional superpower will confirm this status through the development of their own nuclear power, among other things. The development of nuclear technologies is becoming a necessary condition for “regional leadership”.

Here, one should note the unique scientific and engineering potential which may allow our country to be among the leaders of the global nuclear sector. In Russia there are scientific and technical foundations and promising developments which will be in particular demand during the coming decade, and which are capable of forming a new nuclear market.

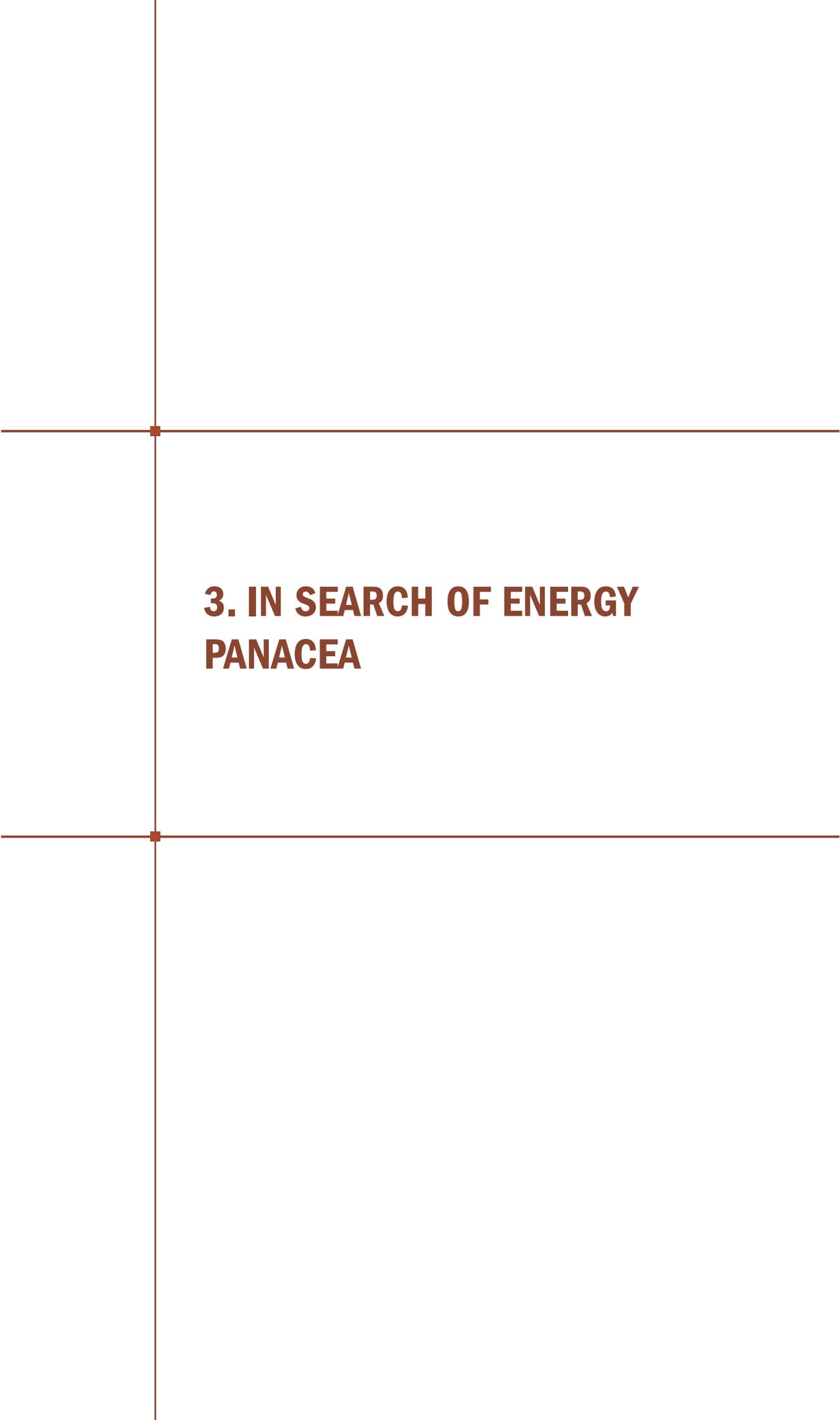
 **Sergey Shilov**, member of the coordinating council of St Petersburg State University, lecturer at St Petersburg State University, Russia: *«There is a unique situation at the moment: the technological solutions of industrially developing countries (the BRICS plus South Korea) look, if not more progressive compared to developed countries (the USA, Europe, Japan) then at least*

they have more points of growth. This is linked to the fact that developed countries froze their research and development and experimental design work in the area of nuclear power for a long time due to the 'Chernobyl syndrome'. This is not the case with the industrially developing countries, except for Russia, which takes an intermediate position: at the start of the 1990s R&D and experimental design work in Russia were shut down, but less due to the 'Chernobyl syndrome' and more due to the general economic collapse. However, thanks to the base built up during the Soviet period, it has been possible to overcome this trend».

The nature of the "new wave" in the development of global nuclear power depends greatly on the nature of Russia's participation. This will be either "quantitative growth" in the number of reactors, or a new technological breakthrough and moving up to a new level, taking into account the scientific-production bases of Russia, India and China (thorium energy, nuclear hydrogen energy and so on).

«**Andrey Gagarinskiy**, Doctor Sc. (Physics and Mathematics), advisor to the director of the Scientific Research Centre "Kurchatovskiy Institute", Russia: *«For Russia, the development of nuclear energy is the engine of the country's transition to innovative development».*

The demand for construction of new power plants has already been expressed by newly industrialised countries. The intrigue of the next 20 years is what nuclear supply will be.



3. IN SEARCH OF ENERGY PANACEA

THE WORLD WITHOUT THE “PEACEFUL ATOM”

The stone age did not end because the stones ran out, and the oil age will not end because the oil runs out

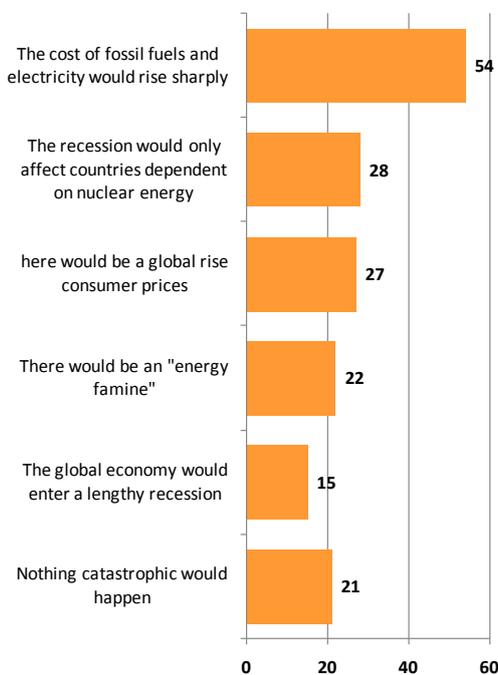
Sheikh Ahmed Zaki Yamaani, former minister of oil, Saudi Arabia

In recent centuries the global economy has experienced several energy revolutions. The industrial revolution, which began in the UK at the end of the 18th Century, became possible not least thanks to the widespread use of coal in heavy industry. The introduction of electricity began at the end of the 19th Century, revolutionising not only the economy but culture too. In the 20th Century first oil then gas came to rival coal. Then in the second half of the century the “peaceful atom” entered our lives. Nowadays alternative energy is making itself felt more and more. These technological revolutions transform our lives. Everything that used to seem ordinary and necessary gradually leaves the scene: when the coal era began, the use of horses as transport was seriously affected by the railways; in the era of oil, they lost the race irrevocably to motor vehicles.

Proceeding from existing trends, it is difficult to think of a turn of events whereby all countries would cease using nuclear power in one fell swoop. However, in order to understand the real situation better, we invited the experts to imagine a hypothetical situation by asking: “**What would happen to the global economy in the event of a general and simultaneous rejection of nuclear power stations?**”¹ (Diagram 16).

Over half the respondents have no doubt that abandoning nuclear energy would provoke a sharp rise in the price of fossil fuels and energy.

Diagram 16. Consequences of ceasing to use nuclear power plants
All experts



«**Dmitriy Belousov**, Cand. Sc. (Economics), Discipline Head CMASTF, Russia: «Today, nuclear power is a significant element in maintaining the world's energy balance. In a situation where demand for energy is continuing to rise (moreover, demand for electricity is rising faster than expected; the electrification of the economies of growing countries such as China, India and Russia is far from complete) this will lead to a global jump in the price of fuel and the corresponding inflationary consequences».²

The current growth in world oil prices is due not only to demand from the developing economies of Asia, but also the consequences of Fukushima: in January 2012 consumption of oil products at Japanese power stations was double what it had been in January 2011. The IEA estimates that the “oil burden” on developed economies is approaching the critical level of summer 2008, when oil reached 147 dollars per barrel. A rise in the price of energy sources is capable of

slowing the rate of economic growth considerably.

Nevertheless, only a few people supported the forecast of a lengthy global recession.

¹ Closed-ended question. Multiple responses.

² The full titles of survey participants and names of organizations can be found in Appendix 1.



Valeriy Belov, senior advisor, Deloit, Russia: «Given that nuclear power provides such a significant share of the energy balance in developed industrial economies (the world's leading economies), ceasing to use nuclear power would lead to a global economic crisis».

Rhodora Ledesma, deputy chair of the Department of Nuclear Medicine at the Mediatrix Medical Centre, the Philippines: «The simultaneous rejection of nuclear power sources would necessarily increase the cost of fossil fuels and electricity. Because of this, there would be a global rise in the production cost of commodities. There would be a tremendous domino effect starting with a rise in consumer prices, eventually resulting in a lengthy recession for the global economy».

Certain experts are particularly pessimistic.



Aleksey Nikolskiy, “Vedomosti” newspaper correspondent, Russia: «There would be technological and intellectual degradation of mankind, comparable to abandoning the aviation industry, for example».

A fifth of the survey participants take a diametrically opposing view. They say that nothing catastrophic would happen should nuclear power be abandoned.



Dmitriy Yefstafyev, independent expert, Russia: «The cost of electricity and ‘heavy’ types of fuel (at least gas) would rise, but gradually rather than suddenly, and not so catastrophically. If the abandonment of nuclear power stations were to coincide with a global economic crisis, the effect would be even less catastrophic. In the phase of decline, the economy would have enough time to adapt to the new conditions. Europe has chosen a relatively good time to stop using nuclear power plants».

Walt Patterson, Associate Fellow at Chatham House, visiting fellow at the University of Sussex, UK: «The global economy would benefit from removal of a crippling distraction. Future energy systems would be cleaner, more reliable, cheaper and safer».

One argument in this case is the impossibility of shutting down nuclear power plants suddenly; a gradual abandonment would not lead to catastrophic consequences because it is happening already in Germany and essentially in Japan too.



Tom Blees, president of the Science Council for Global Initiatives, USA: «Countries that depend on nuclear power would obviously be affected most, including the USA. France, Sweden, Belgium, the USA and many other nations would have severe energy shortages, virtually catastrophic to their economies. It simply won't happen. Even if something were to cause such a nation to reject nuclear power, the shutdown of its nuclear plants would happen only over a period of time that would allow other systems to come online. This is what we see happening in Germany today».

Some experts predict not so much economic consequences as the development of a new energy configuration in the world.



Frank Carré, head of the Nuclear Energy Division of the CEA, France: «There would be a sharp rise in the cost of electricity and CO₂ emissions. This would accelerate the transition to other energy technologies: renewable but also gas and coal-fired plants».

ON THE PATH TO A CONSENSUS OF SALVATION

Each type of energy has its own set of pluses and minuses – but there are no absolute leaders. A reduction in the variety of choice where energy sources are concerned could lead to unpleasant consequences for the global economy

Vladimir Khrustalev, expert on nuclear technologies at the State Naval University named after Admiral Nevelskiy (Pravda.ru, 18.03.2011)

The nuclear disaster in Japan, which occurred on the eve of the 25th anniversary of Chernobyl, provoked a powerful, “domino effect” wave of radiation-phobia in a number of countries. It became a weighty argument for those who support the total rejection of nuclear power, which they see as a global threat to life on the planet, and for those who trust in the development and widespread use of alternative energy sources.

A year after the accident at the Fukushima 1 power plant, calls for radical measures – total closure of nuclear plants – have faded, but discussions about alternatives to nuclear power are continuing. “An important result of the discussions that unfolded in the world was the conclusion drawn by a number of countries about the hastiness of their decision to stop using nuclear energy... Alternative energy has been around for a long time, but it has not been able to constitute any kind of serious competition to traditional sources of energy, including nuclear,” (Dmitriy Baranov, leading expert at “Finam Management”).

Demographic research by various institutes suggests that by 2050 the earth’s population will have grown to 9 billion. At the same time, specialists predict that mankind’s demand for energy may double or even triple by the middle of the century. This will be determined by a number of factors: increases in the world’s population, improvements in standards of living, economic growth and so on.

In order to discover the experts’ forecasts about the likely areas of an energy breakthrough, survey participants were asked: “**What do you think is most likely to become a real alternative to nuclear energy in the world: in the short, medium and long term?**”³

Diagram 17 illustrates the range of opinion among the experts about the development trends in the energy sector.

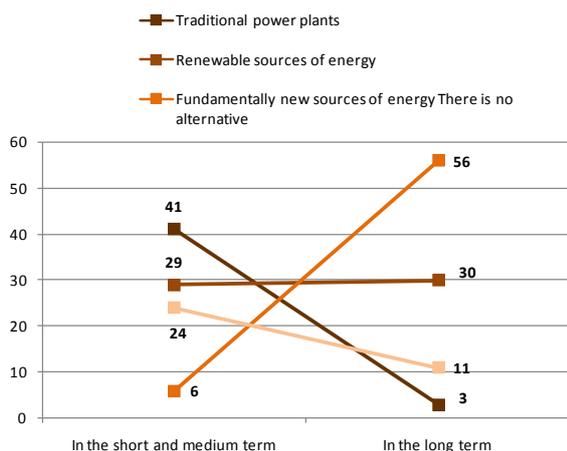
One in four survey participants is sure that there will be no real alternative to nuclear power in the coming years and decades.

«**Andrey Konoplyanik**, professor, Gubkin RSU of oil and gas, Russia: *«Each energy source has a competitive niche, which over time is squeezed or expands in a tough competitive battle with other claimants to the niche – with the emergence of new energy technologies that change the balance of supply and demand. The competitive niche of nuclear power plants is the base part of the load curve. Plus mini nuclear power plants for decentralised production of electricity and heat in distant regions for isolated major consumers. Therefore, nuclear power plants will always keep their competitive niche – in one form or another and one quantity or another, in one country or another – until a cheaper replacement for them is found. Within the framework of existing technologies I do not see such a replacement for nuclear power stations».*

Mastro Lorenzo, creator of a branch of electronic government, Switzerland: *«It looks almost impossible to get away from nuclear power because a lot of countries are dependent on it: between 30 per*

³ Closed-ended question. One response.

Diagram 17. Alternatives to nuclear power
All experts



cent and almost 70 per cent. Japan was 30 per cent dependent on nuclear power; Switzerland is 30 per cent dependent on it; France depends 70 per cent on nuclear power. Until we find other sources, I think it is really going to take a while. I think we still need it for the next 10 years but I also believe that we are on the way out».

When it comes to the long-term prospects for the development of nuclear energy, the proportion of “orthodox” nuclear power supporters falls to just one in ten.

Bruno Comby, president of “Environmentalists for Nuclear Energy”, France: «Is there any alternative? When oil and gas are exhausted, there won't be. Nuclear

energy involves risks and of course these risks should be properly managed (nuclear safety is important) but these risks are minimal and they can be safely managed. Nuclear energy is clean and respectful of the environment, at least cleaner than the alternatives. It is the best solution we have, much better than reverting to dirty coal (polluting energy of the 19th century) which is the only significant alternative in the long term (sun, wind and energy conservation should be encouraged and can contribute to a small extent, but will not suffice to fill the energy gap)».

Joerg Lalk senior lecturer at the University of Pretoria, South Africa: «At this stage it cannot be postulated that nuclear has any real alternative, even in the long term. However, should the critical shortcoming of a reliable mass storage technology for renewables be solved, this view may change and renewables may become a real alternative».

In the view of many experts (over 40 per cent), traditional electricity generation will continue to be the only real alternative to nuclear power in the coming decades.⁴

Andrey Subbotkiy, engineer in the Industrial Group “Tavrida Elektrik”, Ukraine: «Alas, in the short term I do believe we can only rely on traditional ways of generating energy. Alternative (renewable) energy hardly constitutes 1 per cent of the total quantity and is not developing very quickly (for various reasons)».

James Terry Rogers, professor emeritus at the University of Carleton, Canada: «In the short to medium term, traditional power stations will continue to be built based on economic and practical conditions (e.g. hydro where available, coal-fired stations with proper controls on SO₂ and NO_x emissions)».

George Bereznai, professor, dean of the School of Energy Systems and Nuclear Science at the University of Ontario Institute of Technology, Canada: «Unless a country/region is blessed with abundant hydro-electric capacity, nuclear provides the only means of greenhouse-free base-load electricity generation. Advanced urban societies cannot function without a reasonably priced reliable supply of electrical energy, and only hydro and nuclear can provide this without major adverse environmental effects».

Meanwhile, the experts see no prospects for the development of traditional types of power generation in the more distant future. The survey participants say this is due to the low performance of thermal and hydroelectric power plants; their inability to meet modern demands; the limited reserves of hydrocarbons and also the irreparable damage done to the environment, linked to the burning of natural materials or the flooding of land.

⁴ Traditional electricity generation includes thermal power plants and hydroelectric power plants.



Bruno Comby, president of “Environmentalists for Nuclear Energy”, France: *«Dangerous and dirty coal! (a giant leap 100 years backwards)».*

Dmitriy Potapenko, managing partner at Management Development Group INC, Russia: *«The harm done by hydroelectric power plants is no less – so much land is flooded».*

With regard to renewable sources of energy (apart from hydroelectric power, which we have categorised as traditional),⁵ the experts’ views are stable – around a third believe they are serious competitors to nuclear energy in both the short and long term. On the other hand, the fact that opinions about the possibility of using renewable energy do not vary by time period may also indicate that there are certain limits to the development of this sector.



Carlos Alberto Dos Reis Ferraz, project manager at the School for Studying the Use of Biomass, Brazil: *«Traditional and renewable sources are already used in developed countries; it is a matter of time as to when they will replace nuclear power stations. The sooner, the better».*

Frank Carré, head of the Nuclear Energy Division of the CEA, France: *«Renewable energy sources are called upon to play an increasing role in electricity/energy production, but in the absence of nuclear power, gas and coal will remain dominant in the coming decades (especially for transport and industrial applications)».*

Michael E. Kraft, professor emeritus at the University of Wisconsin, Green Bay, USA: *«So the only way to move in the medium to long term is to reply on renewable energy, combined with stringent requirements for energy efficiency and conservation».*

Yet the experts’ predictions regarding fundamentally new sources of energy do depend considerably on the timeframe.⁶ In the short and medium term, a minimal number of experts believe them to be a serious alternative to nuclear power plants. However, when talking about the distant future, over half the research participants are confident about the development of “new” energy.



Aleksandr Uvarov, president of “Atominfo-Centre”, editor-in-chief of the Atominfo portal, Russia: *«In the distant future, of course, new technologies may appear (for example, dematerialization), which would squeeze out most of the energy sources we use today».*

Konstantin Loganovskiy, Doctor Sc. (Medicine), head of department at the Institute for Clinical Radiology, National Centre for Radiation Medicine, Ukrainian Academy of Medical Sciences, Ukraine: *«The only real alternative to nuclear power might be nuclear fusion. The alternative at the moment is fossil fuels. Everything else is fiction and populism».*

At the same time, when talking about new sources of energy some experts emphasise the opportunities which arise from the development of the nuclear sector itself.



Boris Oskolkov, Candidate of Technical Sciences, head of the department, IRL of ChC Chernobyl Centre, Ukraine: *«There is no real alternative to nuclear power at the moment. The cost of developing alternative energy sources is extremely high, and at a time of de facto recession in the global economy money has to be counted even more carefully. In the future, if the forces of regression do not triumph, then the development of nuclear power will surely make it possible to invent sufficiently technological, economical and safe ways of applying nuclear fusion. Perhaps new ways of using the energy from an atom’s nucleus which we cannot foresee at the moment will also be invented».*

Nikolay Meshkov, Doctor Sc. (Medicine), head of department at the Scientific Research Institute for

⁵ Renewable sources of energy are wind, solar, waves, geothermal and others.

⁶ Fundamentally new sources of energy include hydrogen, cosmic, nuclear fusion and others.

Human Ecology and Environmental Health named after A. N. Sysin, Russian Academy of Medical Sciences, Russia: *«Efforts should already be directed at finding new technological solutions in the area of nuclear energy and fundamentally new (fusion) sources of energy, with the simultaneous development of renewable sources».*

A number of survey participants place their hopes in technological improvements in the sector and the creation of next-generation nuclear power plants.

« **Aleksandr Apokin**, leading expert at the Centre for Macroeconomic Analysis and Short-term Forecasting, Russia: *«In the long term, next-generation nuclear power may become widespread. It uses a less radioactive isotope of uranium (U-238) so this kind of power would be safer for the environment in the case of an accident».*

Arkadiy Naumov, senior scientist at the Scientific Production Enterprise “Kvant”, Russia: *«I am talking about contemporary global nuclear energy, i.e. thermal-neutron reactors. In this survey I am not talking about fast-neutron nuclear power with a full fuel cycle as a possible and acceptable alternative to contemporary nuclear energy in the medium term».*

However, most of those who support switching to fundamentally new sources of energy talk primarily about another direction in the development of nuclear power – controlled nuclear fusion. Many experts believe that using the energy from fusion rather than fission is the only industrial-scale source of energy in the long term. In addition, if a nuclear fusion reactor is created one can hope for solutions to all the problems of nuclear power, including safety issues and the need to collect nuclear waste and find ways and means to store it securely.

« **Ilya Kramnik**, commentator at “Voice of Russia” radio station, Russia: *«In the long term, controlled nuclear fusion is the only hope».*

« **Vladimir Krasnorutskiy**, Cand. Sc. (Physics and Mathematics), director of the Scientific-Technical Complex “Nuclear Fuel Cycle”, Kharkov Institute of Physics and Technology, Ukraine: *«The most promising source of energy, nuclear fusion, requires complex technical applications and the creation of new materials».*

Paolo Raimondi, economist and commentator for economic and financial publications, Italy: *«Fusion energy has the potential to become a cheap and more secure source of energy. In the 1970s I was involved in promoting the creation of a foundation for fusion power and at that time I experienced a big attempt to sabotage it. De facto, fusion research has been delayed by 30-40 years due to political and financial decisions primarily to exploit very lucrative fossil resources and, to a lesser extent, old nuclear technologies as well. From this point of view, I believe that the international decision to invest in the Cadarache fusion research centre in France is very important. Fusion energy is also required to deal efficiently with future challenges, beginning with space exploration».*

In addition, a number of experts say that a technological breakthrough is needed above all in the areas of economical “storage”, transport and use of the energy generated.

« **Idris Idrisov**, senior academic at the Institute of Geology, Dagestan Academic Centre, Russian Academy of Sciences: *«There has long been the need for a technological revolution in global energy, whereby energy would be generated in one place and transported to other places. This began in the Soviet Union: super-powerful thermal power stations were built in Siberia and Kazakhstan, and super power transmission lines of 1.5 and even 2 million kW were laid from them to the European regions. Similar but even bigger projects should be implemented at the international level».*

Analysis of the experts’ comments about the real alternatives to the “peaceful atom”, grouped by professional affiliation, shows a rather predictable polarization of opinions:

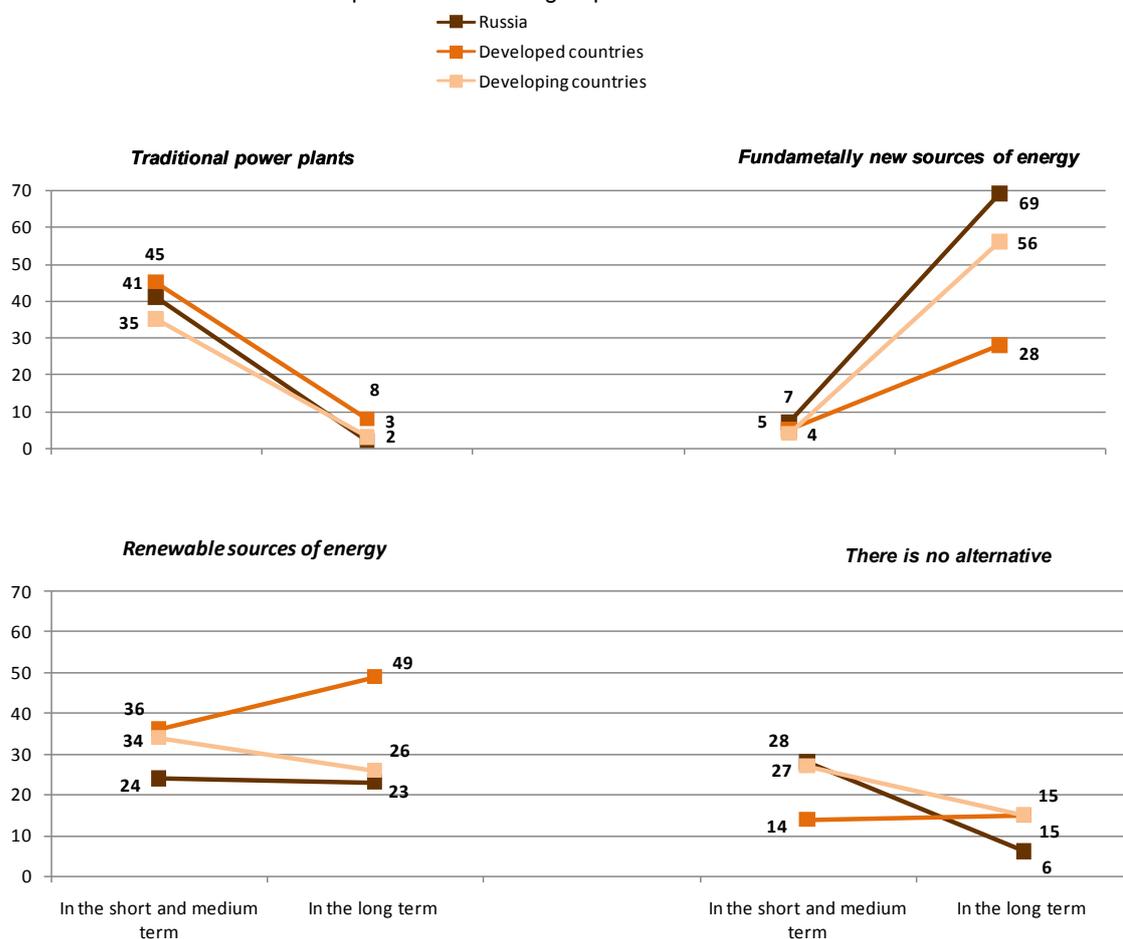
- among “nuclear technical experts” there are far more believers in the lack of an alternative to

nuclear energy, while more “physiocrats” support renewable energy;

- traditional forms of power generation remain the main alternative to nuclear energy in the view of “nuclear technical experts” and “independent experts”. The “physiocrats” believe that hydroelectric and thermal power plants will recede into the background in the near future.

A much more interesting picture emerges when one compares the opinions of experts from countries with different levels of development (Diagram 18).

Diagram 18. Alternatives to nuclear power
Experts from various groups of countries



In the view of the world held by representatives of developed countries, nuclear power, like traditional power generation, will be replaced primarily by renewable sources of energy. A far smaller proportion of survey participants hope for fundamentally new energy sources. Meanwhile, representatives of developing countries place their bets on a technological and scientific breakthrough in energy, above all. Experts from Russia take the most maximalist position: they are the most consistent believers in fundamentally new sources in the global energy sector of the future, and they are ready to completely cease use of nuclear power plants in the long term.

It should be noted that some survey participants believe a combination of energy sources, rather than a preference for individual types of energy, will be the most topical and popular option in future, whereby sources will complement each other taking into account the geopolitical and socio-economic conditions of each particular country.

« Aleksandr Yanichev, nuclear reactor shift leader, Scientific Research Institute of Nuclear Physics at Tomsk Polytechnic University, Russia: «It is important to keep a balance between traditional (including nuclear) and developing alternative methods of generating power».

James Terry Rogers, professor emeritus at the University of Carleton, Canada: «In the long

term, practical fusion energy systems may be developed. Wind and solar energy systems will never provide any significant energy for modern advanced economies».

Moreover, certain respondents predict the development of such systems in the fairly near future.⁷

«**Vladimir Markov**, leading expert at the Russian Commission for the Study of Natural Productive Forces (KEPS), Russia: «Real alternatives are riverside water-pressure hydroelectric systems in the Coriolis relief of the Volga and Don basin, technology park infrastructure of regional power plants and riverside water-pressure hydroelectric systems, and wind and solar generation».

Aleksandr Frolov, expert at the Centre for Macroeconomic Analysis and Short-Term Forecasting, Russia: «In the medium term, the development of a “smart-grid” system based on renewable energy sources linked to traditional sources is entirely likely».

In an attempt to find out how realistic this is, we turned to our survey participants.

GAMES OR REALITY?

“At the moment, ‘alternative power generation’ is a game for rich countries which is played for exclusively ideological reasons. Correspondingly, its widespread use depends on state subsidies and the population’s ability to pay an inflated price for electricity.”

Andrey Galushka, chief analyst at Credit Agricole investment bank, UK

The Fukushima tragedy made many countries decide to review their energy programmes. A trend towards the priority development of alternative energy based on renewable sources has clearly emerged in the world, as has a trend towards reducing the share of fossil fuels in the global energy balance and the energy balances of leading economic powers. Thus, Germany plans to spend around 200 billion euros on a megaproject to build wind turbines on an area six times the size of New York.

Besides unquestionable advantages such as inexhaustible supply, absence of harmful emissions and autonomy, the development of alternative technologies for generating energy also has a number of well-known limitations. Obstacles to the universal use of alternative energy may include the high cost of scientific research and development to introduce modern technologies, as well as many other factors. We asked our survey participants: “What conditions are needed for the development of alternative electricity generation in the coming decades and in the long term?”⁸

Over half of all respondents say that targeted state policy and state regulation are needed for the successful development of alternative energy in the coming years. This includes legislation suited to the goals of development; the attraction of investment; and market mechanisms to ensure the competitiveness of this part of the energy sector (Diagram 19). It is notable that state support remains important in long-term forecasts too, although the experts believe that its significance in the future will diminish a little.

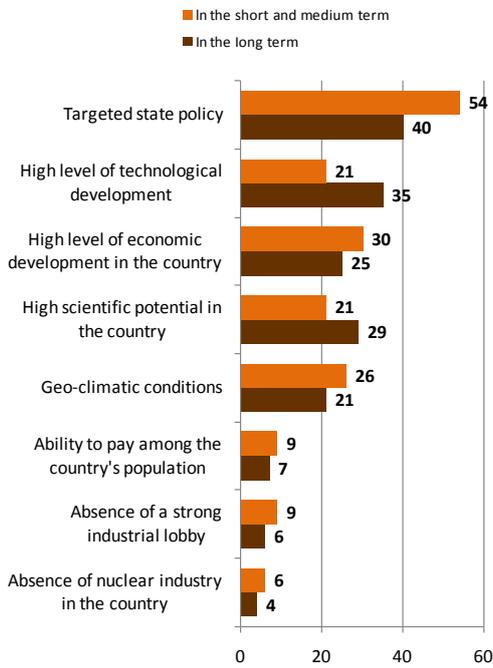
⁷ For example, the generation of hydro-nuclear power on a new technological platform – the construction of hydro-nuclear modules linking a nuclear reactor to a pumped storage plant at man-made construction sites (in quarries).

⁸ Closed-ended question. Multiple responses.



Walt Patterson, Associate Fellow at Chatham House, visiting fellow at the University of Sussex, UK: «*Political will and the appropriate framework for investment; governments as energy users should set the example by upgrading their own facilities and adding decentralized generation to them*».

Diagram 19. Conditions for the development of alternative energy
All experts



Aleksandr Yanichev, nuclear reactor shift leader, Scientific Research Institute of Nuclear Physics at Tomsk Polytechnic University, Russia: «*In order to create alternative energy a new state project is needed (like the nuclear project of the 1940s and 1950s), based on scientific potential*».

At the same time, a number of survey respondents believe that consolidation of efforts in the international area is needed for the successful development of alternative energy, not only state decisions within certain countries.



Mario Villa, executive manager at the research reactor TUWIEN/Atominstut, Austria: «*One country alone cannot switch to alternative electricity generation; the backup systems have to be placed all around the world and this cannot work without a global system, which cannot be installed in the near future*».

Viktor Mironenko, Cand. Sc. (History), head of the Centre for Ukrainian Studies at the Institute of Europe, Russian Academy of Sciences, Russia: «*More than once I have heard*

the view that hydrogen technologies are already ready and even already profitable. The reason why they are not used, is that switching to fundamentally new sources of energy, on a much bigger scale than nuclear power's share at the moment would inevitably trigger and demand a change in all the world's political mechanisms. It would be a new glodal "perestroika"».

Anatoliy Koshkin, professor at the Institute of Eastern Countries, Russia: «*Scientists and resources need to be united on a global scale to develop alternative sources of energy. In the development of new types of power, the abandonment of selfishness, competition and advantage-seeking by individual countries needs to be promoted*».

The experts consider a high level of economic development within a state and willingness to subsidise programmes of this type to be another very important condition in the short and medium term.



Mariya Belova, senior analyst at the Energy Centre, Skolkovo Business School, Russia: «*The experience of European countries shows that the presence of political will, strengthened by a high level of development in the country and the population's corresponding ability to pay, leads to active development of alternative energy (primarily solar and wind). However, the crisis of 2008-09 demonstrated that as soon as a state has more important tasks to worry about, alternative energy becomes an expensive pleasure; i.e. it no longer receives subsidies*».

Len Ackland, co-director of the Centre for Environmental Journalism at the University of Colorado, USA: «*The big push for renewable energy must initially come from wealthier countries, such as Germany (and hopefully Japan, in the wake of Fukushima). Technology transfer to poorer countries should then occur*».

Ellen Vancko, manager of the project "Nuclear energy and climate change", UCS, USA: «*Regardless of what new technologies will be relied upon, they will have to be paid for. Nuclear is becoming the most expensive way to generate electricity but moving to something else will require overcoming entrenched*

However, when it comes to the more distant future, the experts shift the emphasis to factors such as a high level of development in fundamental science and technology within a country.

«**Michael E. Kraft**, professor emeritus at the University of Wisconsin, Green Bay, USA: *«There are no simple answers or two or three conditions to be met. Clearly, nations must be sufficiently developed to be able to afford a transition to new energy sources, and this requires scientific and technological developments».*

Around a quarter of the survey participants note the significance of geo-climatic conditions as a factor in the development of alternative energy. It is clear that this factor will remain rather important with the passing of time, too.

«**Andrey Subbotkiy**, engineer in the Industrial Group “Tavrida Elektrik”, Ukraine: *«As for suitable geo-climatic conditions, they are certainly necessary. But if one talks about alternative energy as a whole, every country probably has one resource or another (solar energy in hot countries; wind and river power in northern countries, and so on)».*

Vadim Gasanov, consultant at VGTRK, Russia: *«Without favourable climatic conditions there is no chance at all for the development of alternative energy. Even with all the will in the world, Moscow will not get solar panels or wind turbines, and the conditions certainly aren't right for tidal or geothermal power generation».*

The other listed conditions are of little importance in the eyes of the experts, whether in the short and medium or long term.

It is interesting to note that only a handful of individuals mention the “inhibitory influence” of the nuclear industry on the development of alternative energy. On the contrary, the opinion was repeatedly voiced that the development of alternative energy is facilitated by a country having nuclear power.

«**Viktor Tsibulskiy**, Doctor of Technical Sciences, chief scientific officer at the National Research Centre “Kurchatovskiy Institute”, Russia: *«Renewable sources of energy may become an alternative in the long term, but for this we would have to become around three to five times wealthier compared to now. We can only reach that level of wealth with nuclear power».*

Claudio Tenreiro, professor at the University of Talca, Chile: *«Nuclear energy is a technology that can allow us to generate enough power while we discover a new set of grid-connected sources to satisfy our demand. This in turn is the key factor; it has to reach the minimum level that is needed for sustainable growth. There is no solution to the ever growing demand for energy, so it has to be minimized and allowed to reach a sort of ‘saturation’ value».*

Overall one can conclude that alternative energy is currently a matter for wealthy countries. Industrially developing countries will have to increase their energy capacities by balancing between fossil fuels and nuclear power. Thus, chief economist at BP Christof Ruhl believes that “globally, the events at Fukushima will only have a short-term negative effect. Yes, the gradual rejection of nuclear energy will begin in Japan itself and in Germany, for instance. However, in 20 years time its share in the global energy balance will still be at the current level. Rapid growth in nuclear power will occur thanks to three countries – Russia, China and India. Little will change here. Countries like Germany, Italy and to some extent Japan will cease to use the atom, but the fact is that these countries were in no way centres of nuclear power development even before Fukushima. At the same time, there are no signs that development of the sector is slowing in Russia, China or India”.⁹

In this regard, people’s attitudes towards this prospect in developing countries are an important issue. After all, it was under the pressure of public opinion that many countries in the developed world were forced to halt the introduction of new programmes to develop nuclear power, or at least announce a suspension of projects in the sector.

⁹ RBK daily, 08.02.2012, “Free markets work better than monopolies with exclusive export rights”.

VOX POPULI: PASSION OR COMMON SENSE – PARADOXES OF THE MIND

“We are truly free when we keep the ability to reason independently, when need does not force us to defend imposed and in some sense prescribed opinions.”

Marcus Tullius Cicero, ancient Roman politician and philosopher

Polls conducted in Russia shortly after the Fukushima disaster show that almost 60 per cent of people in Russia would be ready to support their country taking the German decision to completely abandon use of nuclear power.¹⁰ Analysing data correlation in this research, it becomes clear that the main reason for the popularity of this initiative is fear and radiation-phobia. Just 20 per cent of respondents refused to support the idea. They point to the economic advantage of using nuclear power stations, believing that Russia could not survive without nuclear power.

In our study we tried to get to grips with the age-old conflict between passion and common sense. When asked **“What do you think would be the consequences of Russia completely abandoning use of nuclear power stations?”** more than half of the Russian residents surveyed pointed to a rise in the price of electricity and other housing and utility bills (Diagram 20).¹¹ Only 4 per cent of those polled believe that ceasing to use nuclear power plants would have no negative consequences.

At the same time, when asked **“How much more are you willing to pay for electricity in the event of rates rising following the closure of all nuclear power plants in Russia?”** only 21 per cent of respondents expressed willingness to pay 10 per cent more for electricity in such a situation. Two thirds of respondents were completely unwilling to pay higher rates (Diagram 21).¹²

Thus, these studies show that when the discussion about nuclear energy switches from “general” to “how will it affect my wallet”, the rational element of Russian consciousness overpowers fear. The more

Diagram 20. Consequences of ceasing to use nuclear power plants

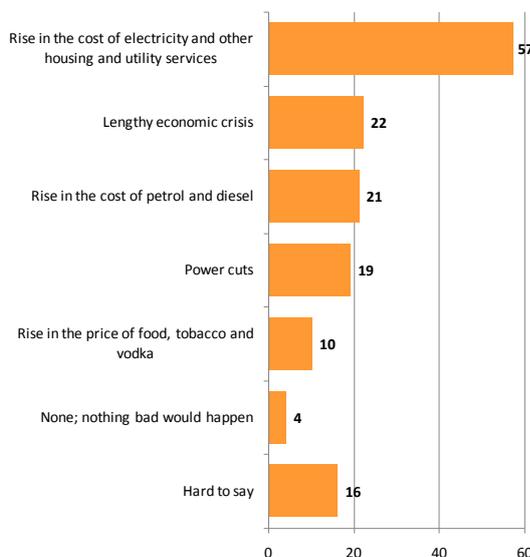
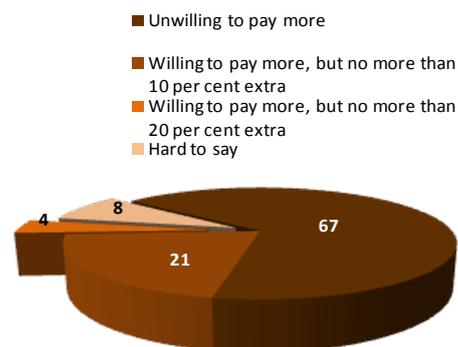


Diagram 21. Willingness to pay higher prices



¹⁰ VTsIOM, June 2011. Closed-ended question, one response.

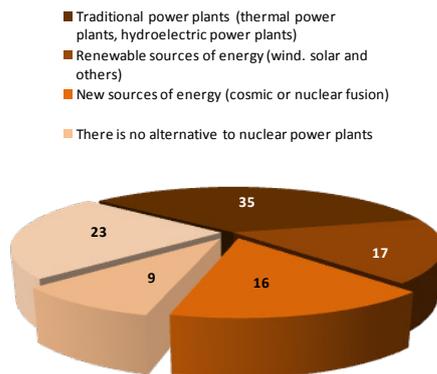
¹¹ Social survey. Closed-ended question. Multiple responses (two responses).

¹² Social survey. Closed-ended question. One response.

time that passes following the shock of the Japanese disaster, the more valid economic arguments seem in resolving the issue of whether Russia needs nuclear power or not. For at least a third of respondents, it is precisely the “economic component” which forces them to overcome their concerns and is the main argument in support of Russia needing nuclear power plants.

Nevertheless, a gap remains in the Russian public consciousness between fear of the “nuclear dragon” and the search for a cheap alternative. When asked “**If all the nuclear power stations in Russia were shut down, what would be most likely to replace them in future?**”, only 8 per cent of those polled believe that there is no alternative to nuclear power stations (Diagram 22).¹³ This fact is completely out of line with the data presented in the previous part of our report, according to which 60 per cent of survey participants believe that Russia needs nuclear power.¹⁴

Diagram 22. Alternatives to nuclear power plants



For many respondents, concerns about nuclear power plants imply that they should be replaced by traditional power generation (thermal power plants and hydroelectric power plants). The proportion of “conservatives” in the survey was 35 per cent.

Another third of the population is willing to fantasize about the future of energy in Russia and await global changes. Their expectations are divided equally between renewable and fundamentally new sources of power. At the same time, the research results show that the younger the respondents are, the more they believe in the effectiveness of new energy sources.

A paradoxical picture emerges: in the minds of over half the country’s population nuclear energy is not without alternatives and it is dangerous to both people and the environment. Yet Russia also needs it. The solution to this paradox lies in the time scale: “now” nuclear energy is necessary, while “some time in later in the bright future” an alternative will be found.

It seems we are dealing with a pendulum of public opinion which, after swinging sharply to the side a year ago, has now almost returned to its original position. Public support in our country for the “peaceful atom” has almost reached the pre-Fukushima level. In 2010, 73 per cent of Russians expressed support for the development of nuclear power; immediately after the accident this fell to just 22 per cent; in February 2012 it was back to 66 per cent of the Russian population.¹⁵

Furthermore, it can clearly be seen that Russians understand that Russian nuclear power remains one of few drivers of modern hi-tech branches of industry. Nuclear power is an area in which Russia has kept its unique scientific and engineering capacity as one of the leading players on the international market for power plant construction. This allows Russia to remain among the world leaders in the sector. The country has a unique technology park in Sarov. Meanwhile, the current era of studying the possibilities of nuclear fusion started with the Russian Tokomak (toroidal chamber with magnetic coils) back in 1969. Today, Russia is a participant in the international project ITER to construct an international nuclear fusion reactor. The initiative for creating this project also belongs to our country.¹⁶



Thus, there are various expectations as to where an energy BREAKTHROUGH might be made that would create an alternative to oil and gas. Many people hope for fundamentally new technological solutions that would make it possible to find an alternative to nuclear power, which is potentially dangerous. The search for such solutions requires a considerable amount of time and serious investment,

¹³ Social survey. Closed-ended question. One response.

¹⁴ See. “Vox-populi: on opposite sides of the barricade”.

¹⁵ Results of social surveys conducted by the Levada Centre.

¹⁶ In November 1985 Academician Yevgeniy Velikhov, on behalf of the Soviet Union, proposed the creation of a next-generation Tokomak with the participation of countries most advanced in the study of nuclear fusion.

which is impossible without political will and targeted state policy.

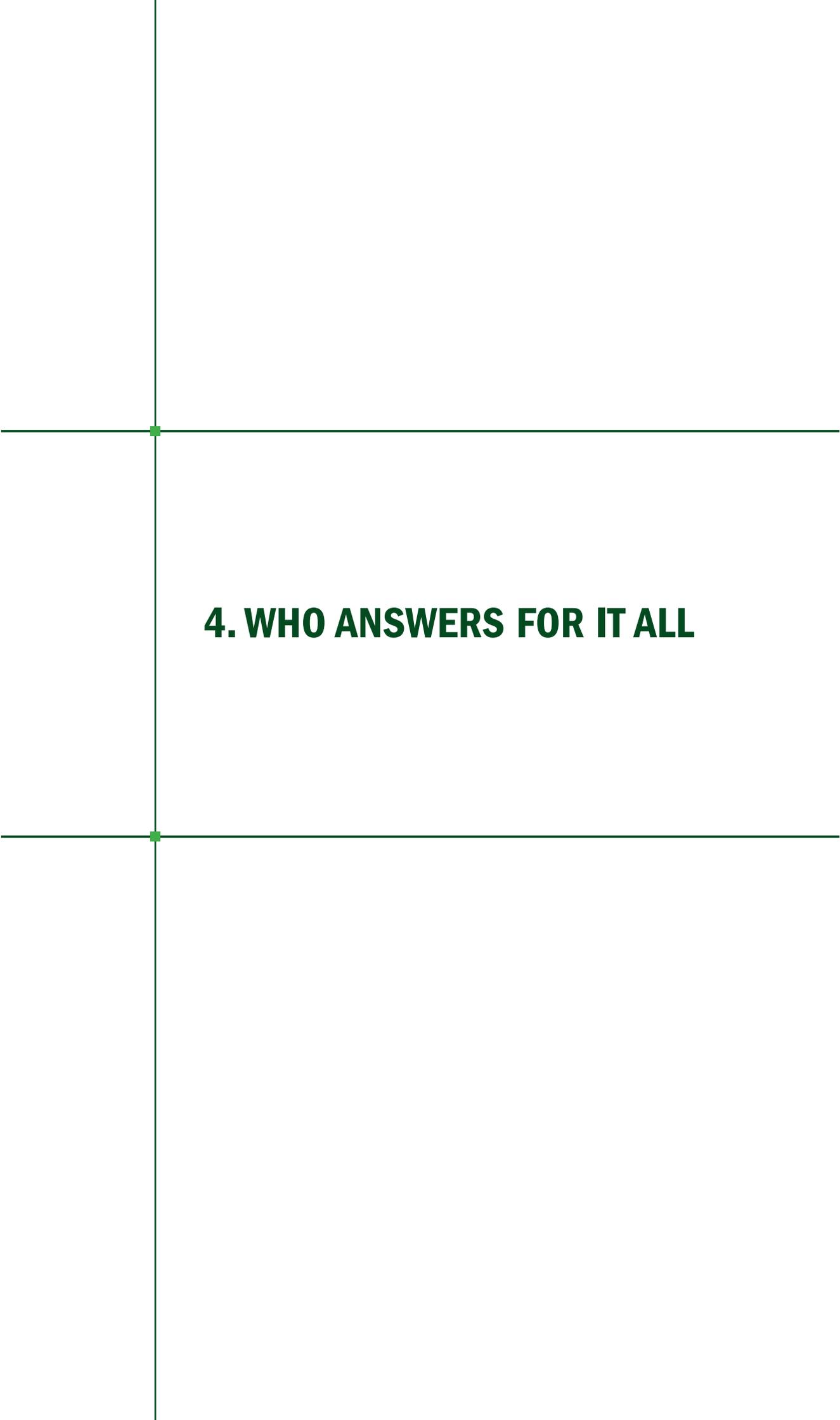
Nevertheless, a unique scientific and technological reserve has accumulated within the nuclear sector itself which is able to not only fundamentally change the approach to safety in nuclear power generation, but also revolutionize world energy in the medium term.

« **Andrey Konoplyanik**, director for development of energy markets, project head at the “Institute of Energy and Finance” foundation, professor at the Faculty of International Oil and Gas Business at the Russian State University of Oil and Gas named after Gubkin, Russia: *«Today, nuclear power is like a teenager, like children in a family emerging from their teens: the problems of growing up are gradually being left behind and it (nuclear power) is becoming a support for the family (the energy sector as a whole) to an ever greater extent, as well as an equal participant in ‘family councils’, at which the big decisions are taken and the burden is split between the family members».*

However, the observed trend for a gradual “shift” of nuclear power to the developing world gives rise to a serious problem: the greatest demand for nuclear power generation comes from newly industrialised countries, while the greatest scientific and technological reserves for development of the “peaceful atom” are accumulated in the old industrialised countries and Russia.

The very real danger arises that outdated “second-generation” technologies will be replicated in the developing world, not to mention poor countries, even though prototype fourth-generation reactors have already been created.

This leads to the same “old” questions arising with new urgency: how can we prevent new accidents at nuclear power plants; how and at what level should the safety of nuclear power be controlled; which conditions might facilitate the transfer of the latest nuclear technologies to the developing world?



4. WHO ANSWERS FOR IT ALL

UNDER THE SWORD OF DAMOCLES

In principle, problems are possible at any nuclear power station. A malfunction may be caused by errors in the design or servicing, by sabotage or natural disaster. But the weakest component in any nuclear power plant is the people

Robert Gale,¹ “Final Warning: The Legacy of Chernobyl” (Moscow, 1990)

If an outside observer wants to study statistics of the incidents and accidents that have happened at nuclear power stations in various countries of the world, he will not find it easy at all. Information about all the incidents is kept in secret databases at the IAEA and the OECD, as well as an independent database at the World Association of Nuclear Operators (WANO), but they are not accessible to the general public.

The IAEA deletes from its website information about incidents which happened over six months ago. The agency says this is because a long story about problems at nuclear power plants could show certain countries in an unflattering light. According to IAEA data, the number of accidents is falling – it has almost halved in a decade (from 200 to 100 incidents, approximately). However, even analysts within the agency itself are dubious about such optimistic figures, since national nuclear power regulators provide information to the agency on a voluntary basis. One can only guess how many incidents have been covered up, recalling the behaviour of the infamous Japanese company Tepco in 2007, for example, when it tried to conceal a radiation leak at the Kashiwazaki-Kariwa nuclear power plant. It would be naive at the very least to assume that other nuclear power plant operators behave differently.

Since 2001 there have been nuclear power plant incidents in Bulgaria, Hungary, Taiwan, the USA and Japan. The most recent incident occurred in Belgium on 13 April 2012, when a reactor stopped suddenly due to an emergency safety mechanism activating.

Any complicated technical system requiring highly qualified staff is prone to breakdowns. In some cases, internal defects in these systems coincide with mistakes by staff. This is precisely what happened at Chernobyl and Fukushima.

We asked our survey participants “**What do you see as the most likely cause of an accident at a nuclear power station?**”² (Diagram 23).

Two thirds of the experts identify the notorious “human factor” as the weakest link in the chain.

«**Dino Giangregorio**, technical director at Alta Visio S.R.L., Italy: *«The human factor, because nuclear plants are so complex and the nuclear explosion needs to be controlled. It is not so easy – there are so many different things to control for the safety of plants».*

«**Konstantin Bogdanov**, reviewer, RIA Novosti, Russia: *«To a significant extent the sector has developed an understanding of the risk factors and concepts for ensuring safety. However, the personnel of the operator inevitably have a lower level of professional training than the personnel of the designer. This is the main source of accidents at nuclear power plants themselves».*

Michael Kraft, Professor Emeritus, University of Wisconsin-Green Bay, USA: *«Regulations for safe*

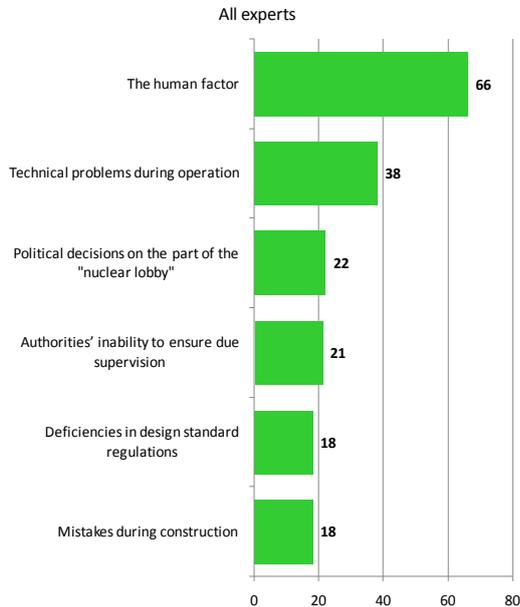
¹ Robert Gale is an American doctor who helped to treat the victims of Chernobyl. Dr Gale was invited to the USSR as the main consultant on treating radiation sickness, leukaemia and bone marrow transplants.

² Closed-ended question. Multiple responses.

operations are clearly imperative. Yet there is a limit to how much regulations can do. People, companies and governments invariably tend to become negligent over time».

To paraphrase Bismarck, who observed that the Franco-Prussian war was won by a German teacher, one can say that the roots of future “Chernobyls” can be traced to the schools of today. In this regard, a number of experts were extremely concerned about the quality of specialist training in Russia, especially in conditions of education system reform.

Diagram 23. Causes of disasters at nuclear power plants



«**Ivan Grachev**, chairman of the Energy Committee of the Russian State Duma, Russia: *«I can see that the education system is deteriorating. I can see that the system ccof responsibility is being eroded. In other words, there are several systemic things which I believe indicate that problems in that area will increase, if nothing changes».*

«**Vladimir Pleshonov**, executive director at “AZP Invest”, Russia: *«Serious problems in the training of specialists are also evident. Light-water reactors should be stopped now, before it's too late, while there are still competent personnel. An uncontrolled shutdown due to climate, social or political disaster could lead to another Fukushima».*

In total over two thirds of the experts mention various kinds of technical problems which could lead to an accident. Problems during a plant's operation attract the most complaints.

«**Andrey Kondratyev**, director, “OOO Ecocenter”, Russia: *«Technical problems during the operation of nuclear facilities may occur either due to the 'human factor' or various shortcomings (regulations, construction). It is technical problems which cause industrial accidents most often».*

The experts talk considerably less often about shortcomings in design standards and mistakes during power plant construction. However, almost nobody talks about “bad” technologies. Rather, it is a case of problems caused by economizing and the pursuit of excessive profit.

«**Alla Burtseva**, columnist at “Moskovskiye Torgi”-“Moscow Tendering” magazine: *«If the Fukushima I nuclear power plant had been built without trying to economize, and if it had not been run only to extract profit, there would simply have been no accident».*

«**Alex Shlenskiy**, business analyst at Consona ERP, USA: *«Corporations economize on safety systems at all stages and levels (design, planning, establishment in the locality, construction, the development of and consistent adherence to regulations, personnel training) due to their desire for excessive profits. It's the same systemic element which led to BP polluting the Gulf of Mexico — corruption of the top management, which in itself is an extremely serious problem not only in nuclear energy, but also in finance, for instance (it almost caused a global crisis far worse than a Chernobyl-type accident at a nuclear power plant could cause). The weakest link in modern man-machine systems is the man, not the machine. What's more, not every man, but top managers specifically, who are concerned more than anyone else about extracting excessive profit».*

Altogether 40 per cent of the experts point to the “political factor”. Half of them speak about the “nuclear lobby” as a determinant, while the other half see shortcomings in how the authorities ensure

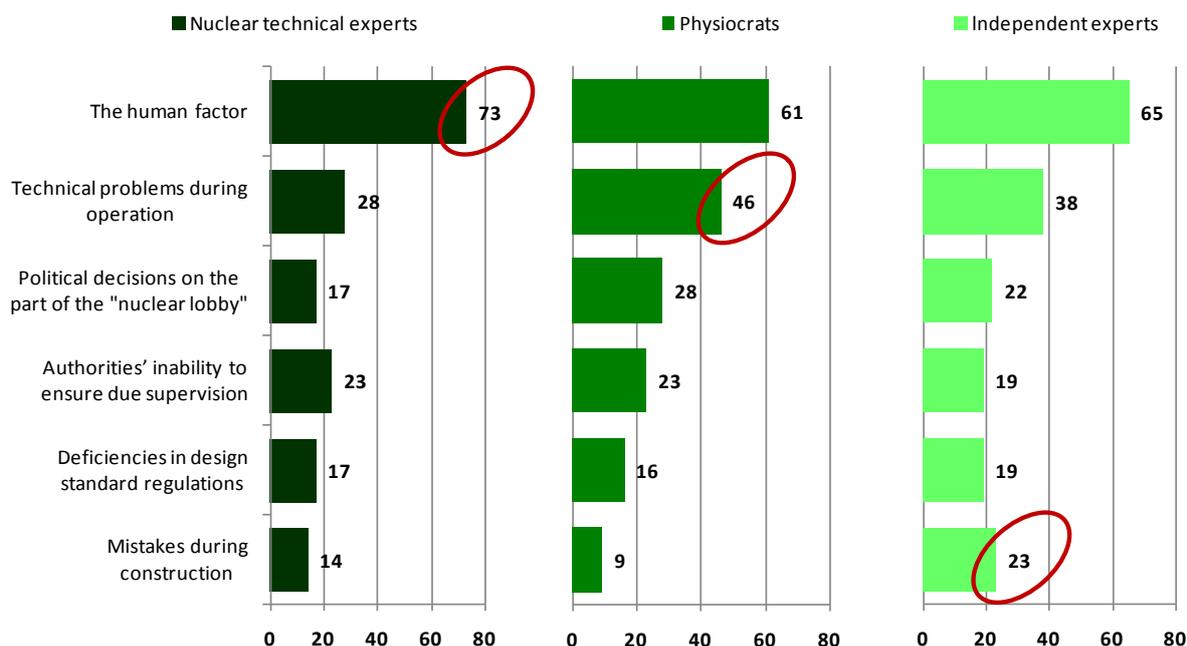
due oversight of the sector.



Vladimir Markov, leading expert at the Russian Commission for the Study of Natural Productive Forces (KEPS), Russia: «*The militant ‘obstinacy of the nuclear lobby’, which does not want to develop nuclear energy on a suitable technological platform*».

Vladimir Shuleykin, chief scientist at the Institute for Oil and Gas Issues of the Russian Academy of Sciences; participant in dealing with the Chernobyl nuclear accident, Russia: «*At any stage of a plant’s life cycle there is a need for independent analysis of the ‘regulations’, analysis of the construction and use of buildings, monitoring of operating technologies and the professional suitability of staff, as well as the personal responsibility of the powers that be*».

Diagram 24. Causes of disasters at nuclear power plants
Experts from various professional groups



It is interesting to note that the physiocrats and independent experts are significantly more concerned about technical problems (Diagram 24), while nuclear physicists and those working in nuclear energy do not trust power plant personnel.

Since major accidents at nuclear power plants have resulted from a combination of several unfortunate circumstances, one can only talk about each of the abovementioned factors as a kind of accident “trigger”. It is clear that the activity of such “detonators” needs to be stopped in order to prevent accidents.



Barry Brook, Professor, University of Adelaide, Australia: «*External forces beyond the bounds of planning which can act as triggers (earthquakes, tsunami and so on)*».

Yekaterina Gonchar, secretary, International Public Association of Environmentalists (IPAE), Belarus: «*Accidents at facilities linked to nuclear energy (not only nuclear power plants, but also all enterprises involved in the nuclear fuel cycle and the transport system) depend on the set of causes listed above. It’s often an unpredictable combination of several factors, so preventing accident situations is impossible*».

The question is how to prevent them having an effect. Problems linked to the human factor and technological solutions are made worse by the fact that nuclear energy has long escaped the confines of nuclear club countries. It is attracting more and more attention from newly industrialised and even

poor developing countries. Clearly, the main incentive for them is to get a large amount of cheap energy, where the key word is “cheap”. In turn, this means that in the best case scenario the reactors built will be second generation, and they will economize on everything, including safety systems and personnel training. All this may have the most tragic consequences, since operating a nuclear power plant goes beyond national liability. In the case of a full-scale accident, neighbouring countries inevitably suffer too.

«Alexander Mineyev, European correspondent, “Novaya Gazeta” newspaper, Russia: «Regulations and standards can be made accessible to all – old and new – possessors of nuclear energy. It is almost impossible to rule out mistakes in construction and the human factor».

All this renders more relevant the question of which measures should be taken to ensure safety at operational and soon-to-be operational nuclear power plants.

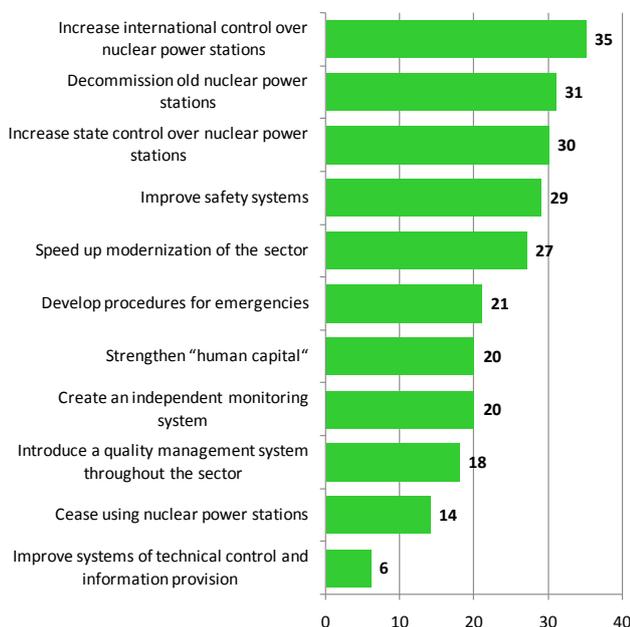
FUNDAMENTAL SOLUTIONS

We know that man’s natural tendency to reassure himself can lead to the erosion of the nuclear safety regime. In other words, if we do not improve safety constantly, the safety level falls

From an appeal to the IAEA by a group of scientists from 10 countries, “Never again!”

Every serious accident at a nuclear power plant has led to a review of safety requirements. Despite the fact that neither power plant personnel nor the general population suffered from the events at Three Mile Island, safety systems at nuclear power plants were improved and work began to construct nuclear power plants with passive safety. The much more serious accident at the Chernobyl nuclear power plant prompted an even more serious reaction. As a result, nuclear power plants within the former Soviet Union were modernized.

Diagram 25. Measures to increase safety at nuclear power stations
All experts



The IAEA department responsible for nuclear safety has drawn up a document containing general principles for safety and operational culture at nuclear power plants around the world. An association of nuclear industrialists who operate nuclear facilities has been founded – the World Association of Nuclear Operators (WANO). An international nuclear safety regime has been established and international cooperation in this area has expanded, including the creation of regional nuclear training networks around the world. A major accident was considered impossible among the expert community, especially one as huge as the Fukushima disaster. Nevertheless, it happened.

In connection with this we asked the participants in our survey the following question: «In the past 25 years there have been accidents at the nuclear power stations in Chernobyl and Fu-kushima. What measures should be taken, first and foremost, to

increase the safety of nuclear power stations?”³

As Diagram 25 demonstrates, all measures are good when it comes to safety at nuclear power stations and nothing can be “too much”. Nevertheless, if one groups all the proposed efforts for boosting nuclear power plant safety into three main categories – Monitoring, Technology and People – the following picture emerges.

In total, over two thirds of experts insist on increasing monitoring of the sector. Most of them speak primarily about such monitoring at the international level, which would make possible a more objective risk assessment at all stages of the cycle.

«**Alexander Mineyev**, European correspondent, “Novaya Gazeta” newspaper, Russia: *«States and sector elites, having made the industry as secretive as possible, are unable to ensure safety monitoring. We need transparency, international oversight and access for non-governmental organizations».*

«**Joachim Sontag**, owner of “Sontag Consult”, Germany: *«Supervising bodies need to be far better qualified and truly international. There are many governments, including the Russian one, which value their political image higher than long-term safety and reliable information and protection of the population».*

However, the role of the state in ensuring nuclear safety standards (like its responsibility) is also highly significant. In the view of a number of survey participants, the optimal solution is to have regulation at both the international and the national level.

«**Frank Carré**, scientific director at the Nuclear Energy Division of the CEA, France: *«Harmonizing safety and security goals, as well as quality management systems, is crucial, while the mission of licensing and control should remain the responsibility of a national safety authority».*

«**Ilya Kramnik**, commentator, RSBC “The Voice of Russia”, Russia: *«The strengthening of national and international monitoring should be combined: the former with regard to the direct development of the relevant branches of industry; the latter, with regard to observing safety standards».*

The proposal to ensure independent monitoring of the sector by non-governmental organizations has fewer supporters.

«**Aleksandr Uvarov**, president of “Atominfo-Centre”, editor-in-chief of the Atominfo portal, Russia: *«The real experience that we have of independent monitoring by non-governmental organizations has been unsuccessful because the monitors were insufficiently professionally qualified. Such organizations should have a powerful team of nuclear experts. But since there are not enough professionals for the nuclear sector itself, one cannot hope that numerous professional experts will appear in non-governmental organizations».*

As for the technological aspects, here the survey participants insist above all on the need to decommission old nuclear power stations which have reached the end of their lifespan.

«**Ilya Yudanov**, senior researcher, BIC SB RAS, Russia: *«People today use computers that are no more than two years old, they drive cars no more than five years old, fly on planes that are no more than 15 to 20 years old, and yet there are reactors in operation which were built over 30 years ago».*

«**Claudio Tenreiro**, professor at the University of Talca, Chile: *«All plants that have already reached the end of their lifespan should be decommissioned at once, no doubt about it. This should be done even at the cost of having just marginal profitability from nuclear power».*

It is clear that such an approach would entail improving safety systems at nuclear power plants and

3 Closed-ended question. Multiple responses.

more rapid modernization of the sector as a whole.

«**Rhodora Ledesma**, vice-chair of the Department of Nuclear Medicine at the Mediatrix Medical Centre, the Philippines: *«The disasters which occurred at Fukushima and Chernobyl, among others, have something to do with deficiencies in safety controls and standards. Therefore, measures to increase the safety of nuclear power plants should primarily focus on modernizing and improving safety systems, taking into consideration all the factors that contributed to the previous accidents».*

Igor Shamanin, professor, head of the Department of Nuclear Technologies at Tomsk Polytechnic University, Russia: *«In the next 20 years we need to lower the requirements for the economic efficiency of nuclear energy and increase financing for work to find new technological solutions in all areas of production of the nuclear fuel cycle as a whole».*

Finally, 14 per cent of experts say that ceasing to use nuclear energy is the only real measure than can guarantee safety: “no sector, no danger”.

«**Helen Caldicott**, president of the Helen Caldicott Foundation for a Nuclear Free Planet, Australia: *«All nuclear reactors should be shut down as they continually generate radioactive waste for which there is no solution to long term isolation from the ecosphere, and which will leak and contaminate food chains and human bodies for eternity, as well as all other species on earth».*

The demand to find and introduce new technological solutions that minimize the risk of accidents like Chernobyl and Fukushima is entirely to be expected. What is surprising is that only one fifth of survey participants believe in the need to boost financing of “human capital” in the sector, despite most experts identifying the “human factor” as the main cause of accidents. Approximately the same number of experts talk of the need to introduce modern management models into the sector.

«**Aleksey Fomenko**, first deputy general director of the Dnieper Metallurgical Plant, Ukraine: *«Experience, direct communication among all who operate nuclear power plants, an appropriate salary, continuous training, training exercises at special facilities, like cosmonauts and perhaps on an even larger scale. An understanding of the planetary responsibility won't leave any chance of an accident».*

Smbat Mazmanyán, deputy director of “Ararattsement”, Armenia: *«Increasing the financing of human capital, because a worker when he is working will not be thinking about their daily bread; a quality management system would guarantee safety; development of technical control systems would reduce the influence of the human factor».*

Another fifth of the respondents focussed attention on the need to improve the rules of procedure for emergency situations and develop effective procedures to overcome the consequences of nuclear power plant accidents, to facilitate, among other things, the rapid evacuation of people from the unsafe area.

«**Andrey Kondratyev**, director, “OOO Ecocenter”, Russia: *«Clear rules of procedure are needed for actions in the first hours following an accident, for personnel, the rescue services and the state authorities. They are often critical from the point of view of how the situation develops further».*

At the same time, few experts noted the importance of preventatively informing the public and explaining to the population the essence of nuclear energy, its real dangers and benefits.

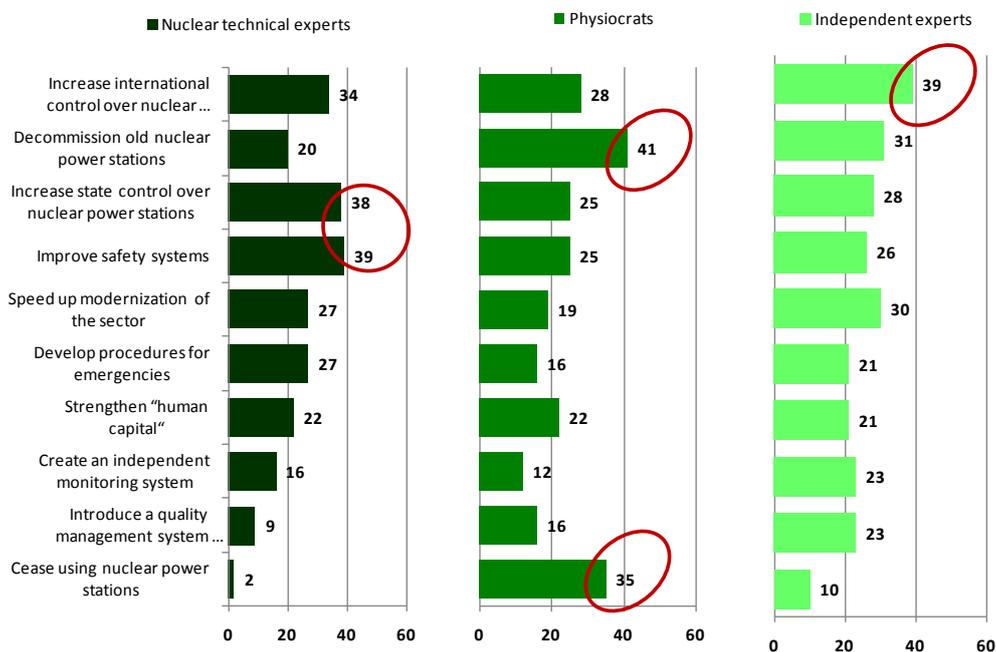


Viktor Zamyatin, independent expert, Ukraine: «Efforts should be aimed at entirely changing the attitude (both utilitarian and negativist) of the majority of the international community towards the sector».

Gennadiy Trukhanov, Cand. Sc. (Physics and Mathematics), lecturer, scientific manager at the autonomous non-commercial organization “Kleps Plyus”, Russia: «At a state level, seriously engage in raising the level of competence in natural sciences and radioecology among the population (school pupils – through the education system, including additional education; adults- using radio and TV programmes and the internet)».

More detailed analysis of the responses illustrates the polarization of the expert community by professional group (Diagram 26). One can see the radical attitude towards nuclear energy among the “physiocrats”: three quarters of them insist on ceasing to use nuclear power plants partially or totally.

Diagram 26. Measures to increase safety at nuclear power stations
Experts from various professional groups



Professionals in the sector are counting on an improvement of safety systems under state control, while “independent experts” (that is to say, civil society) are hoping above all for international monitoring of nuclear power plants.

If we study the experts’ responses, taking into account their country of origin (Diagram 27), one can also see geopolitical polarization of the expert community.

Experts from Russia approach the issue as pragmatically as possible – the sector should be totally modernized in the country. In particular, obsolete reactors should be decommissioned and there should be serious work with personnel. Experts from developing countries are most concerned about improving safety systems at nuclear power stations and in this respect they place great hopes in international monitoring of the sector.

Meanwhile, it seems experts from developing countries have little hope of progress in that area. For them, development of procedures for the immediate response to accidents at nuclear plants is most important, along with ceasing to use nuclear power altogether.

At the same time, in the area of technology, model reactors have been created in the developed world that are significantly better than current ones when it comes to reliability and safety.

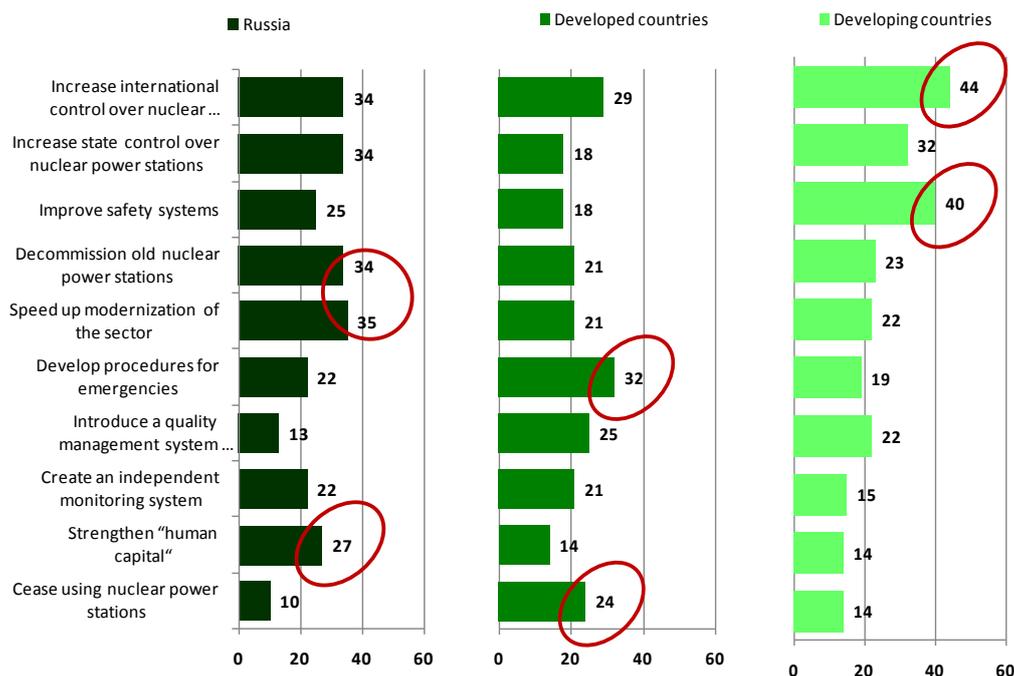


Tom Blees, president of the Science Council for Global Initiatives, USA: «*The Integral Fast Reactor developed by the USA should be deployed commercially as soon and as widely as possible. It promises to be safer than even the most advanced nuclear power plant designs being built now*».

Similar developments in creating “fourth generation” reactors have been achieved in both France and Russia. At the same time, the experience of the Fukushima tragedy showed that it was not possible to prevent a disaster even in a developed and technologically advanced country. Furthermore, the authorities and owners of the nuclear power plant turned out to be not entirely ready to deal with the consequences of an accident.

This once again returns us to the question of who monitors the state of affairs in nuclear energy.

Diagram 27. Measures to increase safety at nuclear power stations
Experts from various groups of countries



WHO ARE THE JUDGES?

We ensure only confidence in non-proliferation. As for safety – that is the responsibility of member-states. We help them, but that is the duty of member-states⁴

Yukiya Amano, director-general of the IAEA

Among the many international organizations which operated in the nuclear sector before the tragedy in Japan, the IAEA and WANO were considered the main ones. Following the accident in Fukushima, the position of the European Nuclear Safety Regulators Group (ENSREG), which conducts checks at European nuclear power plants, became stronger. In May 2011, EU states agreed criteria for conducting stress-tests at nuclear plants, which would include an assessment of the nuclear power plant’s resilience to emergency situations caused by natural disasters (earthquakes, hurricanes, floods, unusual heat and

⁴ http://www.bellona.ru/articles_ru/articles_2011/Fukushima-Amano

snowfall) as well as human impact (plane crashes and explosions affecting the district in which the power plant is located or its infrastructure), excluding terrorist attacks. Decisions about measures proceeding from the results of the inspections are to be taken at the national level.

The emergence of a regional organization in the international arena calling for compulsory stress-tests to be conducted not only at European nuclear power plants raises the question of reformatting the existing control system, and what its optimal configuration might be. Thus, in summer 2011 Germany proposed the creation of an umbrella organization for nuclear safety in the EU, which could unite various national and supranational structures working in the given area.

The question of the effectiveness of the existing system for monitoring the nuclear energy sector (cooperation, non-duplication of functions, sufficiency of rights, international authority) remains open. If everything in the system were fine, it probably would not have been possible for the Japanese government to cover up the scale of the disaster at the Fukushima nuclear power plant in the first weeks following the accident.

In connection with this, and continuing the topic of necessary measures which should be taken in the sector, we asked the experts: **“In your view, at what level are nuclear energy regulations and safety controls needed, first and foremost?”**⁵

Diagram 28. Main level of regulation in the nuclear energy sector
All experts

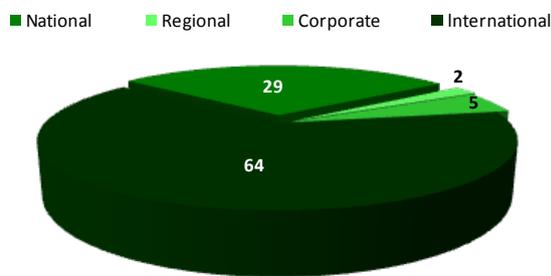


Diagram 28 shows that an overwhelming majority of those surveyed believe in the primacy of international regulation and control of the sector. Above all, they stress its global nature and the impossibility of keeping the consequences of disasters at nuclear facilities within the national borders of individual countries.

«**Aladar Stolmar**, retired, formerly Westinghouse, EROTERV, ERBE, Hungary: «The effects are international, so the controls and regulations have to be too».

«**Rafael Macián-Juan**, professor at Technical University Munich, Germany: «Nuclear power is a truly international endeavour. An accident in any part of the world may impact the global industry. Therefore, a move towards internationally accepted and enforced basic safety regulation should be a priority for the future development of nuclear power».

At the same time, a number of experts expressed doubt about the effectiveness of international monitoring which presupposes common and compulsory rules for all.

«**Sverre Hval**, deputy head of department at the Institute for Energy Technology, Norway: «It would be best to have the control at the international level but I think it would be too difficult because of different standards, different opinions, and different philosophies. We can already see this, with IAEA having problems because of differences around the world. I'm not sure everybody will agree on what is important. There might be different priorities in different countries».

Almost a third of the experts believe in the priority of national regulation, considering that no-one has levers of influence on the situation or interest in the safe operation of nuclear power plants to match those of the state.

«**Mustafa Bahrán**, chairman of the National Atomic Energy Commission, IAEA, Yemen: «Safety is a national responsibility».

«**Sergey Boyarkin**, programme director, ROSATOM, Russia: «Only the state has real levers to take measures toughly and rapidly in its sovereign territory. International monitoring is a

5 Closed-ended question. One response.

necessary addition, but the main control should be provided by the state».

Literally just a handful of experts talk about the advantages of other levels of regulation such as regional monitoring (within the framework of political and economic unions uniting a number of states) and corporate monitoring (within the framework of a company that builds or operates nuclear power stations).

«**George Bereznai**, professor, dean of the School of Energy Systems and Nuclear Science at the University of Ontario Institute of Technology, Canada: *«For large countries such as China, Canada, the USA and Russia the ‘state’ should mean the local province or region, not the federal government».*

Mariya Belova, senior analyst, Energy Centre of Moscow School of Management Skolkovo, Russia: *«A company which builds and operates nuclear power plants is risking its capital and image, so monitoring at that level will be the most effective».*

At the same time there are many ardent opponents of safety regulation and monitoring at the corporate level in the nuclear energy sector.

«**Vladimir Pleshanov**, executive director at “AZP Invest”, Russia: *«The corporate level of monitoring should not be allowed under any circumstances. The owners of nuclear power plants would hide technological problems and artificially extend service life for the sake of maximum profit; they would exploit the plants to excess. They would economize on safety systems wherever they could».*

In this regard, Russia is in a peculiar situation. Given the ambiguous status of Rosatom, there is a major internal task here: to fully clarify the state and corporate areas of responsibility.

«**Ivan Grachev**, chairman of the Energy Committee of the Russian State Duma, Russia: *«There is an international convention, signed by Russia, about physical protection (I mean the Amendments to the Convention on Physical Protection of Nuclear Material), the central idea of which is the full and indivisible responsibility of the state for the safety of its nuclear facilities. In Russia these functions used to be concentrated in the Ministry for Nuclear Energy. Then the ministry became Rosatom, which is no longer a state structure. This means that we have to quickly and forcefully replace the previous, more or less effective system of working with something else. In my view, it is not at all a give that the new scheme will immediately begin working according to new rules, while at the same time maintaining continuity in safety provision and monitoring. The new system needs to be formed like a living organism in a gradual step-by-step process, in order to raise it up to a level that satisfies all the requirements of the international organizations. This is not such a simple task».*

Support for integrated monitoring at all possible levels simultaneously, yet with clear division of responsibilities, was expressed quite often.

«**Nikita Nikiforov**, Candidate of Technical Sciences, expert in the Nuclear Energy and Industry Council of Veterans, Russia: *«The state should provide organizational regulation, while technical regulation should be corporate and agreed with a state safety regulation body. Organizational and technical regulation should be ‘transparent’ to the country’s civil society and the international community. The role of the IAEA should be depoliticized and independent from the geopolitical interests of certain countries».*

Thus, despite all the reservations, clear priority is given to the international level of regulation, which presupposes common and compulsory rules for all. The state level is in second place, leading by a very wide margin.

VOX POPULI: TRUSTING IN THE STATE

All regulations are only valid for ‘model’ accidents, but accidents happen which go beyond the models

Yevgeniy Shirokov, vice-president of the Belarusian branch of the International Environment Academy, Belarus

Regarding the causes of accidents and the main measures to prevent them, we believe the relationship between the views of the expert community and the wider general public to be very interesting.

Thus, when asked **“What do you believe is most likely to cause an accident at a nuclear power plant?”** no less than 50 per cent of Russians responded with “the human factor” (Diagram 29).⁶ Moreover, it seems that the higher the status and level of education of the survey participant, the more likely they are to mention this cause.

A third of respondents mentioned problems in the operation of nuclear power plants, while less than 20 per cent of those polled highlighted the use of nuclear power plants beyond the end of their lifespan and shortcomings in state supervision over their activity.

Thus, the main trend in public attitudes when it comes to understanding the reasons for accidents at nuclear power plants is almost entirely in line with the experts’ views on the issue.

However, when asked **“What measures should be taken, above all, to improve safety at nuclear power plants?”** the picture is completely different (Diagram 30).⁷

Russians identify the strengthening of state control over nuclear power plant activity as the most important measure – this is the view of almost half of those polled. Oversight by international and public organizations only resonates with one in ten Russians. Meanwhile, the idea of completely ceasing to use nuclear power plants receives virtually no public support.

Second place in the rating of measures proposed by Russians to improve safety at nuclear power plants is taken by the improvement of staff training in the sector. At the same time, people with a higher

Diagram 29.
Causes of disasters at nuclear power plants

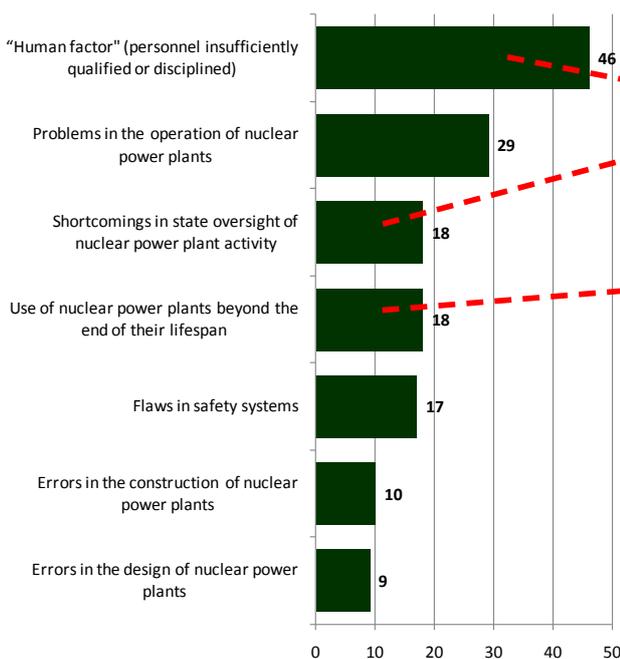
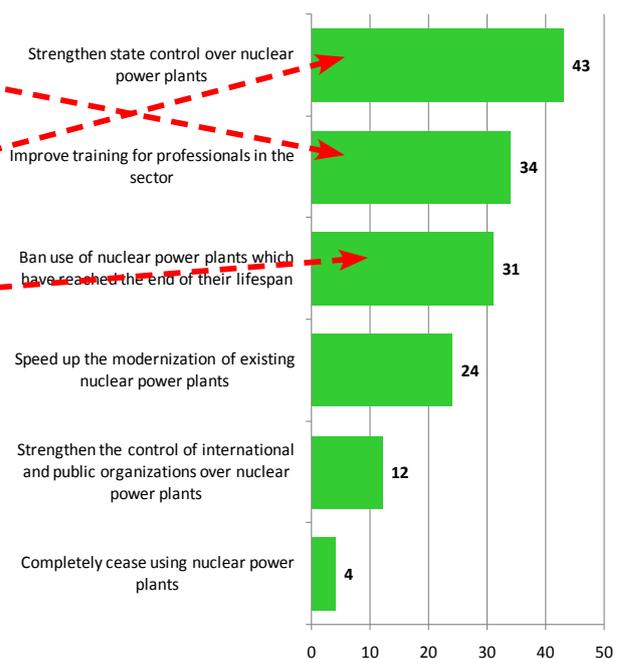


Diagram 30.
Measures to improve safety at nuclear power plants



6 Closed-ended question. Multiple responses (two answers).

7 Closed-ended question. Multiple responses (two answers).

education and young people place greater hopes on state control, while people in the managerial pool of survey respondents underline the primacy of purely personnel solutions (Table 2).

Table 2. Socio-demographic qualities of respondents who identified each measure to improve safety at nuclear power plants.

MEASURES	SUPPORTERS
Strengthening state control over nuclear power plant activity	<ul style="list-style-type: none"> • More people with higher education • More young people (linear relationship)
Improving training for professionals in the sector	<ul style="list-style-type: none"> • More people with an average or above average income (linear relationship) • More people with a high status (linear relationship)
Ban on power plants that have reached the end of their lifespan	<ul style="list-style-type: none"> • More older people (linear relationship)

This discrepancy between “people’s attitudes” in the Russian Federation and the position of the expert community can, of course, be explained by the fact that the population is poorly informed about nuclear energy, the underdevelopment of civil self-awareness or the fact that a high level of paternalism is still characteristic of Russians, so for them state oversight presupposes both the resolution of personnel issues and modernization of the sector, and so on. However, the problem can also be considered from a different angle. The Russian population gives carte blanche to the state for the further development of nuclear power, but their demands are high too: in the eyes of citizens, the entire responsibility for the future development of events in the sector lies inevitably with the authorities. No room is left for interpretations along the lines of “force majeure” or “unforeseen circumstances”.

It can be assumed that a similar picture of public attitudes is characteristic of many developing countries which have gone for industrial development (at least one can talk about the post-Soviet states in this context).

ON THE PATH TO NEW NUCLEAR COOPERATION

The international expert community talks of the need to monitor the nuclear energy sector at the international level. To a large extent, this can be explained by the fact that even developed countries are not always able to prevent accidents at nuclear power plants or fully deal with the consequences of a disaster. Meanwhile, for countries that consider nuclear energy to be an “entry pass” into the club of nuclear states, neglect of safety issues is even more possible.

Current international oversight conducted by the IAEA is largely targeted at the non-proliferation of military nuclear technologies. Yet even within that narrow framework, the IAEA is not quite coping with its task, since the number of countries conducting military research in the nuclear sector is increasing, while the existing international treaties which define the status and power of the IAEA contain multiple loopholes. For this reason the IAEA is often used as an instrument in geopolitical games.

«**Igor Slesarev**, Doctor Sc. (Physics and Mathematics), professor at the Moscow Engineering and Physics Institute and the International Centre for Theoretical Physics in Trieste, Russia: «Unfortunately, the role of the IAEA is insignificant because it is determined by lobbies. Scientists play a minimal role there».

In addition, a technical discrepancy can be observed today between the developed world, which intends to construct only clean and – at the initial stages – expensive power generation capacity, and developing countries, whose main objective is immediate and rapid economic growth. The latter demand a well-known degree of low cost from the nuclear energy sector, which entails the predominant construction of 2+ generation reactors at most. At the same time, it seems like this state of affairs suits their wealthy Western neighbours quite well.

«**Len Ackland**, University of Colorado Co-Director, Center for Environmental Journalism: *«International control over the nuclear fuel cycle, which is contested by nuclear weapons states in particular, would help prevent proliferation. But the danger of nuclear accidents persists».*

Today, developed countries and Western countries above all are leaning towards either partially abandoning old nuclear power generation in favour of alternative renewable energy sources (primarily the EU states), or towards new technological solutions, such as integrated nuclear power plants based on multiple low-power reactors or nuclear power plants based on blanket reactors with a sub-critical fuel mass, controlled by particle accelerators. Next-generation fast-neutron reactors have been or are being developed in many developed countries which could resolve the problem of radioactive waste. At the same time, there are around 500 reactors of previous generations operating in the world, and new ones are constantly being built.

Moreover, developed countries essentially enjoy a monopoly on new technological solutions and are striving to reinforce this status, not without using international institutions. For instance, a communiqué from the Nuclear Safety Summit, which took place in March 2012 in Seoul, said: *“We urge states to adopt measures that will reduce to a minimum use of highly enriched uranium, including switching reactors to low-enriched uranium fuel where this is technologically feasible and economically justified.”*⁸ The point of this rather obscure clause is to encourage developing countries to use ordinary light-water reactors, under the pretext of reducing the threat of terrorists stealing or seizing highly enriched uranium. However, the reactors which resolve the safety problem – fast-neutron reactors – require highly enriched uranium.

«**Igor Shamanin**, professor, head of the Department of Nuclear Technologies at Tomsk Polytechnic University, Russia: *«It is important to differentiate between the safety of nuclear power and the threats of nuclear weapon proliferation. The USA allows itself to interfere in the peaceful nuclear programmes of sovereign states or express its disapproval about the existence of such programmes under the flag of battling the threats of nuclear weapon proliferation».*

Thus, the most effective international control, recognized by experts, currently has serious political limitations as well as limitations due to varying levels of technology. This facilitates continued growth in the gap between the developed and developing worlds, while the single system of safety monitoring at nuclear facilities deteriorates.

«**August Schläpfer**, professor, Energy and Environmental management in Developing Countries, International Institute of Management, University of Flensburg: *«An international regulatory framework that guarantees transparency and accountability is required; however, the implementation of such regulations and safety controls is very difficult to enforce. Who should decide whether a country can be trusted to develop nuclear energy in the first place? What should be the conditions under which a country is allowed to join the nuclear club? These are very difficult questions, precisely because nuclear energy has so many risks associated with it».*

In these conditions, a new type of international nuclear cooperation between states that are developing nuclear power is evidently needed. The new format of cooperation should facilitate the transfer of technological achievements in the construction of nuclear power plants to the developing world. Clearly, such cooperation should incorporate fair reimbursement for the donor countries in exchange for the technology transfer. Solving these problems would also make it possible to build a new system of international nuclear safety monitoring, which would benefit everyone.

8 <http://eco.ria.ru/business/20120327/607136593.html>

CONCLUSION.

FOURTH NUCLEAR STRATEGY

Following the accident at the Fukushima I nuclear power plant in March 2011 a broad international discussion sharply intensified, during which the development of the nuclear industry was thrown into doubt once again. Yet just one year after Fukushima, an expectation of further development in global nuclear energy dominates among the international expert community and political elites.

The arguments “for” and “against” the “peaceful atom” have long been known. They have been forged by decades of confrontation between supporters and opponents of the sector, and they have been raised repeatedly during the current discussion. But now there is a new keynote in this chorus: the inevitability of the development of nuclear energy – at least for the foreseeable future. This is recognised by both its supporters and its opponents. This means that the “nuclear challenge” today is primarily a question of assessing and forecasting the growing risks. Moreover, these are risks of a non-technological nature above all.

1. “New demand” for nuclear power

In the coming 20 years we can expect a “new wave” in the development of nuclear power, for two main reasons.

The first reason is entirely obvious: the concentration of centres of economic growth in newly industrialized countries. The real rise in demand for electricity generation in the developing world will inevitably lead to new economic demand for nuclear power as the only real alternative to fossil fuels today.

The second reason is less obvious, but no less significant (and possibly more so). As the world becomes multi-polar, geopolitical demand for the “peaceful atom” is going to grow alongside economic demand. Just like at the dawn of nuclear power, the main incentive for acquiring access to nuclear technologies today is the political incentive.

On the one hand, having one’s own nuclear industry is an entry pass into the club of countries with high development potential. It is becoming a necessary condition for “regional leadership”. On the other hand, nuclear energy “produces” not only relative energy independence, but also potential access to nuclear technologies, i.e. the most destructive of all known types of weapon. Nuclear energy arose in the middle of the twentieth century as a “product” of geopolitical competition between the USSR and the USA. Half a century later, geopolitical competition between new global centres aspiring to regional leadership is again becoming the main driver of growth in the nuclear sector.

Thus, China, India and Russia are going to modernize their existing reactors, actively build new power plants and create new technologies in the nuclear sector. What is the rest of the world going to do?

2. Three strategies for the development of the nuclear sector

The expert community predicts different development strategies for the nuclear sector in the West, in newly industrialized states and in poor countries.

In the West, the main issue will be ensuring safety. This implies partially abandoning old nuclear power in favour of either alternative renewable energy sources (primarily the EU states), or new technological solutions (the construction of next-generation reactors) which not only minimize risks but also resolve the problem of radioactive waste. Yet this is an expensive pleasure, and alternative energy is a matter for wealthy countries at the moment.

Meanwhile, the developing world will have to increase its energy generating capacity, balancing between fossil fuels and nuclear energy. Therefore, priority number one in newly industrialized states will be boosting generating capacity that is independent of the oil market to provide an economic growth spurt. Such a state of affairs would entirely suit the Western world; essentially it is even being encouraged by the West. After all, the sought-for industrial progress will happen largely thanks to energy-intensive production (including polluting production) moving from developed to developing countries. Nuclear power will follow the new major consumers of energy in order to serve them, and this will create opportunities for a number of European countries to potentially abandon nuclear power completely. In this case, the main danger for the “receiving side” will be the priority of keeping costs low in the name of rapid economic growth. As a result, preference may be given to the construction of older reactors of the second and second-plus generations in a number of cases.

As for poor countries, they will see the possession of nuclear power as a means of progressing to the industrial path of development. Therefore, attracting investment to construct nuclear power plants will be the top priority for these countries. It is here in the so-called “third world” that the choice in favour of “cheap, outdated and dangerous” may become most widespread.

A most import question is which development path will be chosen by the newly industrialized states, which stand in the avant-garde of the development of nuclear power. Will they replicate virtually obsolete and rather dangerous nuclear technologies, or create new power generation – modern, safe and effective? New power generation could become the “fourth strategy” of the nuclear sector, uniting not only the BRICS countries but also, under certain conditions, a number of the established industrialized states.

3. Crisis in the international system of nuclear non-proliferation

Today, the security of whole regions is determined by an accessible level of nuclear technologies and considerations of economic advantage: at one end of the scale we see the developed world, which intends to build only clean and expensive (at the initial stages) power generation, and at the other end there are the developing countries, where there is the risk of choosing according to the principle “quantity over quality”. In addition, nuclear safety is becoming a hostage of geopolitical security.

The system of international security which formed after World War II is experiencing a deep crisis. One can assume that more and more developing countries will follow Iran and strive to acquire nuclear technologies to guarantee their national sovereignty. This means that in the coming decades every significant regional conflict may be accompanied by nuclear risks, since the likelihood of a nuclear facility (including stores of radioactive material – fuel or spent nuclear fuel) falling within a zone of political or military conflict will rise.

The existing international system for monitoring nuclear technologies arose in the middle of the twentieth century and assumed that a club of nuclear powers would enjoy an informal monopoly in the development and application of nuclear technologies. The point of no return has already been passed, the nuclear monopoly no longer exists, and nuclear technologies are “leaking” into the wider world, thanks, among other things, to new demand for nuclear power.

The international expert community speaks in unison of the need to strengthen control over the nuclear industry at the international level. Even developed countries are not always able to prevent accidents at nuclear power plants or fully cope with their consequences. Meanwhile, in countries for which nuclear energy is seen as an “entry pass” to the club of nuclear powers, neglect of safety issues is substantially more possible.

However, the IAEA, which currently conducts international monitoring, is not entirely coping with the task even within the narrow bounds of its mandate – the non-proliferation of military nuclear technologies. As for the safety of industrial nuclear facilities, here, as in the well-known show by Arkadiy Raykin about a poorly sewn suit, all experts have narrow specialties: one is responsible for the sleeves, another for the pockets, while the third sews on the buttons. But nobody is responsible for making sure that the suit “hangs well”. The agency’s functions include setting international norms and approaches to ensuring safety at nuclear power plants, while the implementation of these norms – i.e. ensuring safety at nuclear power plants – is exclusively a matter of national responsibility. Like the character in the aforementioned show, we are left to ask the question: are there any complaints about the buttons? There are no complaints about the buttons – they are sewn on to the death.

Thus, one can improve the methodology of IAEA inspections of nuclear power plants as much as one wants. Without a fundamental change in the existing international treaties which govern the status and powers of that organization, effective international control of the development of nuclear power is simply impossible. Therefore, there is still a risk that the gap between the developed and developing world will continue to grow, while the system for controlling safety at nuclear facilities deteriorates.

4. Expecting a breakthrough in global energy and Russia’s special role

The Fukushima tragedy gave a new impetus to the development of alternative power based on renewable sources of energy, and a reduction in the share of fossil fuels in the energy balance of the leading economic powers. The sluggish global economic crisis adds more drama to the search for an acceptable replacement for thermal and nuclear power generation. As they wait for a scientific and technological breakthrough in global energy, many people are hoping for fundamentally new sources of energy. However, tangible results in that area require a great deal of time, major investment and targeted state policy, since the implementation of such projects purely in the corporate sectors is impossible due to the economic inexpediency of such investment for business.

Given the steadily rising level of energy consumption in the world, there are currently only two fundamental solutions which are capable, in the view of the majority of experts, of satisfying both the demand for power generation and the requirement for more safety in the energy sector.

In the short term, stakes are being placed on technological improvements within the nuclear sector itself and a switch to nuclear power plants of the next, fourth generation. Within the nuclear energy sector a unique scientific and technological reserve has been accumulated, which is able not only to fundamentally change the approach to safety in nuclear power generation, but also revolutionize global energy. The question revolves around the commercialization of these technologies.

In the long term, the greatest hopes lie in controlled nuclear fusion which, as a natural part of nuclear power, may nonetheless rid mankind of the main disadvantages of using energy from nuclear fission. Nuclear fusion can resolve the problem of industrial power generation on any scale required, yet at the same time it is many times safer than energy from uranium fission. It also uses practically inexhaustible reserves of fuel, reduces to a minimum the problem of radioactive waste and completely rules out the possibility of a situation like Chernobyl or Fukushima. However, it will probably be several decades before we can use energy from nuclear fusion industrially.

The newly industrialized countries have already expressed demand for the construction of new power stations, so the main intrigue of the next 20 years is what the nuclear supply will be. Traditionally, the most advanced technologies have been concentrated in the developed world, which is also striving to reinforce its monopoly on new technological solutions. However, nuclear power is one of the few modern, high-tech branches of industry where Russia is among the global leaders. In this field, our country has retained unique scientific and engineering potential. It has one of the most advanced

production bases in the world, and is one of the leading players in the international market for construction of nuclear power plants. Moreover, for Russia itself the development of nuclear power is an engine moving the country towards innovative development.

At the same time, Russia possesses promising inventions which could form a new nuclear market not only in the coming decade but also in the longer term. Russian research in the middle of the previous century laid a foundation for the modern era in the study of the possibilities of nuclear fusion. The latest Russian inventions in this area are competing successfully against Western ones, and are superior to them in a number of cases. Thus, the project to construct the ITER international experimental nuclear fusion reactor was launched at Russia's initiative.

Therefore, the quality of supply on the nuclear energy market and the quality of the "new wave" in the development of global nuclear power depend to a large extent on the quality of Russia's participation in international nuclear cooperation.

5. Contours of the new global energy sector

The risks associated with the spread of nuclear technologies are going to grow in the near future as new demand for nuclear power generation also grows. Therefore, there is a clear need today for an absolutely new platform for interaction and new forms of cooperation in the development of nuclear power, which could unite everyone who has an interest in the development of the "peaceful atom". If there are no voluntary measures at the international level, the new round of development in the nuclear power sector threatens to become the multiplication of rather dangerous technologies of the past.

The creation of a new international organization, in addition to the IAEA, is necessary. It would facilitate control of nuclear technologies, as well as cooperation and the development of new energy on the basis of the nuclear industry. The new format for cooperation between states developing nuclear power should ensure a solution to two of the most topical issues of today. First, the new platform for interaction should make it possible to build a system of nuclear safety at nuclear power plants that would involve constant international monitoring of all the nuclear power stations in the world. Second, it should help to establish a new, fair technological world order in the nuclear industry, setting the conditions for spreading technological achievements in the construction of nuclear power plants to developing countries. At the same time it is clear that donor countries should receive fair remuneration for the transfer of new, safe nuclear technologies.

In light of the failure of old formats of international cooperation in nuclear energy, a new platform for interaction will also be required. Given the observed competition between Russia, the West and the developing industrial world, and considering the accumulated fundamental and technological reserves of Russia, India and China, it would be logical if that international platform were to be linked to the main vector of demand for nuclear power generation; in other words, if it were created within the framework of the BRICS.

This leads to a conclusion about the expediency of nuclear cooperation within the framework of the Customs Union (CU) of Russia, Belarus and Kazakhstan as well. In 2011, Kazakhstan became the world leader in extracting uranium. A decision has been taken there to found an Agency for Nuclear Energy in order to improve management of the sector. Belarus also intends to develop its nuclear energy and build a new nuclear power plant. In addition, when these states are integrated further into a Single Economic Space, it would be optimal to unify approaches to the organization of the sector. This would not only improve safety and make the functioning of enterprises more effective, it would also create new opportunities for growth on the basis of reintegrating the whole nuclear sector within the Customs Union states which was once a single whole.

6. The nuclear challenge and Russian questions

In the coming international competition, the fundamental task for Russia is to maintain its position in the camp of technologically advanced powers. Reality is such that the nuclear energy sector – the reserves created in Russian science, technologies and engineering schools – is one of the few sectors that matches Russia's aspiration of having a high scientific-technological status.

In order to keep the advantage that was earned by the Soviet generations, Russia's existing strategy for development of the nuclear sector in the coming decades must clearly be appropriately amended. In our view, three issues are crucial here: personnel, management and innovation.

The main asset of Russia's nuclear sector is human capital. There is still a high level of professionalism and productive culture here which is steadily being lost in other sectors. However, in the coming years the old professionals who carry the productive, engineering and scientific culture will be replaced en masse by specialists who were raised in the new era with new standards of education. It is clear that this "personnel gap" carries a risk for the safety of nuclear power.

Many Russian experts are very concerned about the quality of training for specialists in the sector in our country, particularly in conditions of the current reform of the education system, which has repeatedly been subjected to very sharp criticism by the general public. Nuclear energy is an area of knowledge where the introduction of a programme of uninterrupted education is the most expedient and topical. Incentivizing the work of personnel in the sector also requires a systematic approach – from the nuclear power plant operator to scientists and motivating personal professional growth.

In addition, nuclear energy is an area of human activity which can only take place with the highest levels of organization and discipline. The slightest reduction in requirements is fraught with the risk of national and global disaster. This is why the quality of management in the sector has to meet the toughest international standards. This concerns not only the introduction and certification of a quality management system at all Russian nuclear power plants. In nuclear energy, as in medicine or the army, a professional code of ethics plays a huge role. This means that improving corporate relations in the sector,

ensuring transparent reporting and reliable social protection for nuclear energy workers and many other things demand serious attention. Today, the nuclear sector is capable of setting the “highest bar of achievement” for all Russian industry and becoming a driver of development in education and medicine. But for this, it has to demonstrate a model management culture.

Demand from the developing world for the latest technological developments of the “peaceful atom” is going to grow steadily. Our country can become a leader of the “new wave” of nuclear power if it enters the world market with an innovative set of products that includes both traditional and new nuclear technologies. On the other hand, it is vital to ensure a rapid transition to a new generation of reactors with a high level of passive safety within Russia itself. All these tasks require an innovative development path in Russian nuclear industry, a boost to the development of nuclear engineering and the maintenance of a strong technical elite.

Here, we are touching on the issue of a targeted state policy in the sector. The very existence of nuclear industry in a country sets high requirements for the level of the political elite and the level of responsibility among all branches of power.

Is Russia capable of keeping and developing its competitive advantages in the nuclear sector on the international market? Is our country capable of ensuring strict oversight of safety in the sector, conducting due modernization and making sure that highly professional personnel are trained for it? Unlike many other countries, Russia has a population which is ready to support the further development of nuclear power. Now the fate of all current “nuclear issues” depends on whether the state is ready to resolve them.

APPENDIX. SURVEY PARTICIPANTS

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