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Russian Energy and Security up to 2030

Edited by
Susanne Oxenstierna and
Veli-Pekka Tynkkynen

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Susanne Oxenstierna

The debate on Russian energy has been dominated by issues related to Russia's hydrocarbon production and exports while other fuels, such as nuclear fuel, that are essential to power generation in Russia have attracted much less attention from social scientists in the West. This is true despite the fact that Russian nuclear power has been undergoing an impressive expansion since 2006 when the government launched an ambitious nuclear energy programme aiming at increasing nuclear and reducing gas power generation. The Russian State Atomic Energy Corporation, Rosatom, has announced that it will double nuclear capacity up to 2030. The accident at Fukushima Daiichi in 2011 has not changed the resolution of the Russian government to pursue this expansion. The nuclear power industry is one of Russia's few high-technology industries and was one of the priority sectors in the modernization policy launched in 2009.

The Russian nuclear energy drive also involves marketing Russian nuclear power plants (NPPs) abroad, and Rosatom has secured export contracts for building about twenty reactors abroad over the next two decades. Countries interested in Russian nuclear technology include India, China, South Africa and Turkey, among others. In June 2012, Rosatom was even looking at acquiring a USD 24-million stake in the Horizon nuclear energy project involving building two new nuclear stations in Anglesey, North Wales, and Oldbury, Gloucester, in the UK (BBC 2012).

The Russian nuclear renaissance raises many questions. Why does a country so rich in hydrocarbons expand its nuclear power? Does Russia really need such a substantial increase in nuclear capacity, and is it realistic to build so many reactors for domestic use and export in such a short time? After the Chernobyl accident in 1986, Russia had not built any new reactors for twenty-five years and the nuclear engineering industry lost many of its researchers and engineers in the 1990s. Furthermore, nuclear power is associated with high risks and the expansion raises different security issues: natural disasters are a problem and terrorist attacks on nuclear power plants are considered a realistic threat as is the illegal dispersion of nuclear material. Reactors produce radioactive waste that may be reused, not only for peaceful means, and a closed fuel cycle is still only at the research stage. There are problems with temporary storages of spent fuel at plants and of finding permanent repositories in most nuclear energy countries. Russia is no exception and has

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Smith Stegen, K. (2011) 'Deconstructing the "Energy Weapon": Russia's threat to Europe as case study', *Energy Policy*, 39(10): 6505–13, October.

Wenger, A. (2009) 'Russia's energy power. Implications for Europe and for transatlantic cooperation', in Perović J. *et al.* (eds) pp. 225–44.

World Bank (2010) *Russian Energy Efficiency Financing Project (PID) AB6196*, 8 August 2010. Online. Available: www.worldbank.org (accessed 28 March 2011).

substantial waste issues. Besides, Russia's export of nuclear power plants to some countries has been disputed, for example to India, which has not signed the Non-Proliferation Treaty (NPT), and the construction of reactors at the Bushehr power plant, despite Iran's nuclear programme remaining in dispute.

The purpose of this chapter is to discuss the role of nuclear power in Russia's internal and external energy policies. This includes the development of nuclear power plants at home and abroad and also the developments in the nuclear fuel business as well as the management of nuclear waste. The chapter also investigates the implications for safety, security and non-proliferation that follows from the Russian and worldwide nuclear expansion.

The first section studies the state of nuclear power in Russia and in the world after the Fukushiima accident in 2011. The second section describes the role of nuclear power in Russia's *Energy Strategy up to 2030*, hereafter ES-2030 (Ministry of Energy RF 2009). The third section analyses the problems with resource constraints in the expansion and the fourth section the situation for nuclear fuel production and waste in Russia. The fifth section discusses the implications for safety, security and non-proliferation matters. The final section summarizes the conclusions drawn in this chapter.

Nuclear power in Russia and the world after Fukushima

Before the accident at Fukushima Daiichi in Japan, in March 2011, the late 2000s were characterized by a boost in nuclear power in the whole world. This has been explained by the growing concern over securing sufficient energy supply for the future and protecting the environment from hydrocarbon pollution. Unlike oil and gas, nuclear power produces almost no carbon dioxide emissions. In addition, hydrocarbons will become scarcer and harder to extract in the future and energy supply needs to be diversified. However, like the accidents at Three Mile Island in 1979 and at Chernobyl in 1986, the earthquake and tsunami at the Fukushima Nuclear Power Station in 2011 again stirred public opinion in the West against nuclear power. As a result Germany, Switzerland and Belgium have decided to shut down their existing nuclear power plants and Italy and Venezuela have cancelled their initial nuclear energy programme plans. Nevertheless, most countries using nuclear power stay committed to their nuclear power programmes, and of those in the process of introducing nuclear power into their energy mix, most have stayed on course.

In 2010, there were 437 nuclear reactors in operation with a 372 GWe installed capacity (WNA 2012a). The leading countries in the nuclear energy league are the USA with 104 reactors and a 101.6 GWe installed capacity, France with 58 reactors and 63 GWe, Russia with 33 reactors and 24.2 GWe and South Korea, 23 reactors and 20.7 GWe (ibid.). Countries with nuclear power depend on it for electricity generation to varying degrees. The US and Russia have 20 and 17 per cent, respectively, of their electricity generated from nuclear power. Finland, Japan, Bulgaria, Germany and the Czech republic have around 30 per cent and Sweden, Slovenia, Armenia, Switzerland and Hungary around 40 per cent. The highest shares of nuclear power in electricity generation are found in France, 74 per cent, Slovakia and Belgium, both 51 and Ukraine 48 per cent (ibid.).

In 2012, 62 reactors were under construction in the world and of these 10 are found in Russia, 1 in the US, 2 in Finland and France, respectively, and another 6 in Eastern Europe. The remaining 42 are built in Asia, primarily in China where 26 reactors are under construction (WNA 2012a).

Expansion of the Russian nuclear sector

According to the Energy Strategy up to 2030 (ES-2030), nuclear power capacity should double by 2030 and its role in electricity generation should rise from 16 per cent in 2008 to 20 per cent 2030 (Ministry of Energy RF 2009). The expansion takes place in European Russia basically at existing sites, hydro power playing a similar role in the Far East. The Baltic plant in Kaliningrad should come into operation in 2016. This plant competes with the Lithuanian plant at Visagina,[1] and the objective is that it should be integrated with the EU grid and export two-thirds of its power to the Baltic States, Germany and Poland. Prior to the Japanese accident, Rosatom expected its Western partners to contribute 49 per cent of the equity (WNA 2012b).

In 2012, there were 33 operating reactors in Russia totalling 24 GWe. The oldest of these reactors are from the 1970s and 11 are of the RBMK (*reaktor bolshoi moshchnosti kanalnyi*) type, a Soviet type light-water graphite-moderated reactor, the kind involved in the Chernobyl accident. These reactors are found in St Petersburg, Smolensk and Kursk. Russia stopped producing RBMK reactors after the Chernobyl catastrophe, a last half-built fifth RBMK reactor at Kursk was cancelled in 2010, and the main type that is now being produced and installed is the VVER or V reactors which are comparable to Western PWRs, i.e. pressurized-water reactors. The latest reactor installed is the second block in Rostov.

The lifetime of the RBMK reactors has in most cases been prolonged from the original thirty years by fifteen years, and these reactors will be on line until 2035. In 2009 they provided 45 per cent of Russia's nuclear-generated electricity, which means that it is impossible just to close them down (Oxenstierna 2010: 24). Their lifetime extensions follow significant design modifications made after the Chernobyl accident. After these modifications the authorities have concluded that a forty-five-year lifetime is realistic for the 1 000-MW units.

In addition, Russia has developed small floating NPPs based on the reactor type used in Soviet icebreakers. These NPPs are intended for places that are difficult to reach. The first of these, the *Academician Lomonosov*, launched in June 2010, was designated for Vilyuchinsk, Kamchatka (WNA 2012b). Around ten further floating NPPs are on the drawing board. Five are intended for use by the national gas giant Gazprom for offshore oil and gas field development and for operations on the Kola Peninsula near Finland and the Yamal Peninsula on the Arctic shelf of central Siberia (WNA 2012b).[2]

The nuclear power industry is a priority sector in the modernization of Russian industry, and one of the few truly high technology industries that Russia has. In January 2010, the government approved the federal target programme 'New-generation nuclear energy technologies for the period 2010–15 and up to 2020', designed to bring a new technology platform for the nuclear power industry based on fast neutron reactors. There are three types, the BREST (lead-cooled fast reactor), the SVBR (lead-bismuth fast neutron reactor) and sodium-cooled types. It is hoped that the federal target programme will enable commercialization of new fast neutron reactors for Russia to be built in 2020–30. Rosatom's long-term strategy up to 2050 involves moving to inherently safe nuclear plants using fast reactors with a closed fuel cycle and MOX (a blend of oxides of plutonium and uranium) fuel (WNA 2012b). The reactors currently in use worldwide – are mainly 'Generation III' PWR reactors. The next generation of so-called 'Generation IV' reactors are expected to provide enhanced safety, minimal generation of waste, and reduced proliferation risks, and will produce hydrogen, heat and desalination of seawater (KVA 2010).

Export of nuclear power plants

In the 1990s, as a result of the Chernobyl accident and the collapse of the Soviet Union, there was an acute shortage of funds for nuclear development in Russia and a number of domestic projects were stalled. By the late 1990s, exports of reactors to Iran, China and India were negotiated and thanks to these exports it was also possible to revive Russia's domestic construction programme as far as funds allowed (Oxenstierna 2010: 30–1). Russia's policy for building NPPs in non-nuclear weapons states is to deliver on a turnkey basis including the supply of all fuel and repatriation of used fuels for the life of the plant. The fuel is to be reprocessed in Russia and the separated waste returned to the client country (WNA 2012b).

The Chinese Tianwan NPP is the largest economic cooperation project between China and Russia. The first phase of the Tianwan NPP (two VVER 1000-MW units) was constructed as part of an Intergovernmental Agreement on cooperation in the construction of nuclear plants in China, and was concluded already in December 1992. On 30 December 1997, China and Russia signed a contract to build the Tianwan Nuclear Power Plant jointly. Thailand, Indonesia and South Korea have demonstrated a keen interest in floating nuclear power plants (Bellona 2011a).

India has a cooperation scheme on nuclear plants with all the major reactor constructors in the world (Russia, the UK, France, and the USA). In March 2010, India and Russia agreed on a road map for Russian reactors in India (RIA Novosti 2010a). Apart from the four reactors in Kudankulam already agreed upon, two more are planned for the same station and two at Haripur

(India Juris 2010). India has also signed a USD 700 million deal with Russia for the supply of 2 000 tons of nuclear fuel. In October 2011, local and environmental activists protested against the construction of the Kudankulam plant with results that thousands of workers left the site, and not only was the possibility of starting the first reactor in December jeopardized but also other contracts between the countries (Kommersant 2011a). Eventually, work on the plant has been continued.

In the 2000s, Russia has succeeded in starting a new corporation with its CIS neighbours in the field. Rosatom plans to build a nuclear plant in Belarus, which did not have nuclear power during Soviet times, in the Astravets district of the Hrodna region. This nuclear plant should come on line in 2017–18 and has a total capacity of 2.4 GWh (Kommersant 2011b). Ukraine, which is heavily dependent on nuclear energy with fifteen reactors generating about half of the country's electricity, has discussed cooperation with Russia regarding nuclear expansion and Russia and Ukraine plan a joint venture on nuclear fuel production (WNA 2012a; RIA Novosti 2011b). Of the other former Soviet republics only Armenia has nuclear power, the Metsamor plant. Kazakhstan is the largest producer of uranium in the world, but does not yet have nuclear power. Discussions with Russia regarding a series of smaller reactors are ongoing (WNA 2012b).

From 2010, Russia is providing full or partial credits for the nuclear construction in at least five countries: Ukraine (Khmelnitsy 3 & 4), Belarus (Astravets 1 & 2), India (Kudankulam 3 & 4), China (Tianawan 3 & 4), Turkey (Akkuyu 1–4) and Vietnam (Ninh Thuan 1–2). Bangladesh may also rely on Russia to finance nuclear construction (WNA 2012b). The Ministry of Foreign Affairs responsible for promoting Russian nuclear technologies abroad is creating a system of Rosatom foreign representatives in Russian embassies.

The Russian energy strategy up to 2030

According to the ES-2030, the production of energy will increase to 1 600–1 750 Mtoe up to 2030, that is, an increase of 28–9 per cent compared to 2008 (see Chapter 2 in this volume). This is significantly higher than the IEA's assumptions in IEA (2010). When you compare the IEA's New Policies Scenario (NPS), which implies that governments undertake measures already planned to reduce energy consumption and pollution, with the high and low scenarios of the Russian ES-2030 it is evident that ES-2030 assumes that Russia will continue its extensive energy consumption. The NPS shows that Russia could attain a much lower domestic consumption of energy by implementing measures improving energy efficiency that have already been planned. As has been shown by McKinsey & Co. (2009) and in Chapter 2 of this volume, Russia's energy intensity is two or three times higher than that of any other industrial countries, which is largely due to the outdated capital stock and the legacy of Soviet policy that saw increases in energy consumption as a sign of progress (Charap and Safonov 2010: 140). Since the end of the 2000s, efforts have been

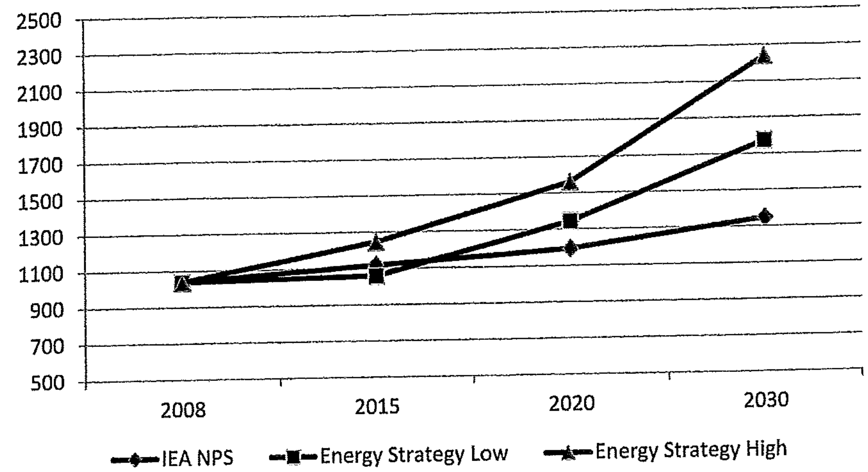

Figure 9.1 Forecast of electricity generation according to the IEA NPS scenario and the Russian Energy Strategy's low and high scenarios; *TWh*

Source: Ministry of Energy RF (2009: 158); IEA (2010: 664).

Note: NPS is IEA's New Policies Scenario.

made to change this, for example in June 2008, the President signed a decree calling for an overall reduction of the energy intensity of GDP by 40 per cent by 2020 compared to 2007 (Law on Energy Efficiency 2009).

Nuclear power is of primary interest as a source of electricity. According to the ES-2030 (Figure 9.1), the total production of electricity in Russia is expected to double by 2030 and will be between 1 800 and 2 200 TWh. This is a high estimate if we compare it with the IEA NPS for Russia, which shows a much more modest trend, up to 1 424 TWh in 2030 (Figure 9.1).

All types of power generation will increase, but the proportions accounted for by different fuels will change in such a way that nuclear power will deliver 20 per cent of power in 2030 instead of 16 per cent in 2008. According to the ES-2030, the share of electricity from thermal power stations should be reduced. These run mainly on coal and oil, which means that electricity generation should become cleaner (Figure 9.2).

How much capacity does Russia need to install?

The ES-2030 assumes almost a doubling of total electricity capacity up to the year 2030, from the present 225 GW to 355–445 GW. As can be seen in Figure 9.3, this is considerably higher than the NPS of IEA. The capacity in nuclear power should be increased by 4–9 GW up to 2015, by 13–17 GW up to the 2020s, and altogether by 28–38 GW up to 2030 (Figure 9.3).

Russia's estimates of how much electricity production and capacity is needed are based on the forecasts of the growth of the economy and the ES is based on the optimistic Russian government economic forecast *Russia 2020*

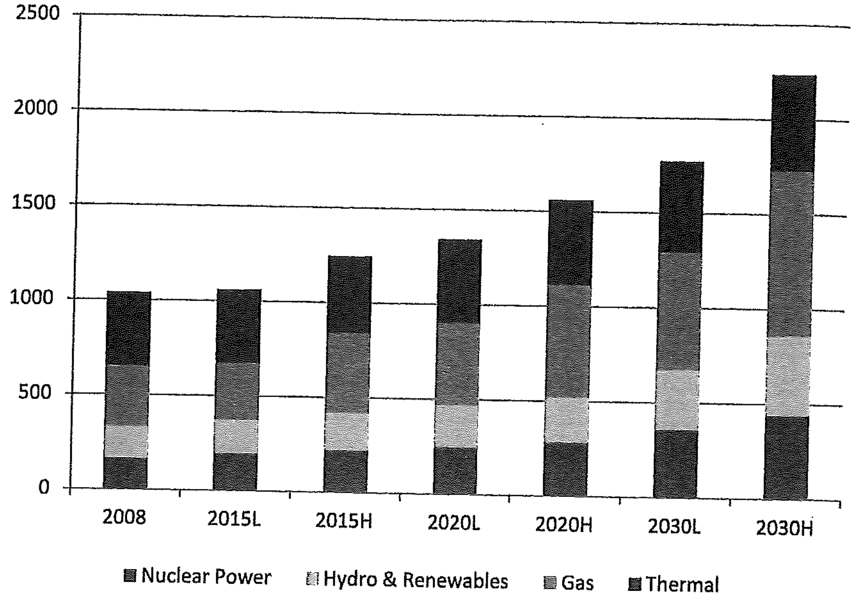

Figure 9.2 Fuel mix in electricity generation according to the Energy Strategy; low (L) scenario and the high (H) scenario; *TWh*

Source: Ministry of Energy RF (2009: 158).

Note: L denotes Low scenario; H denotes High scenario.

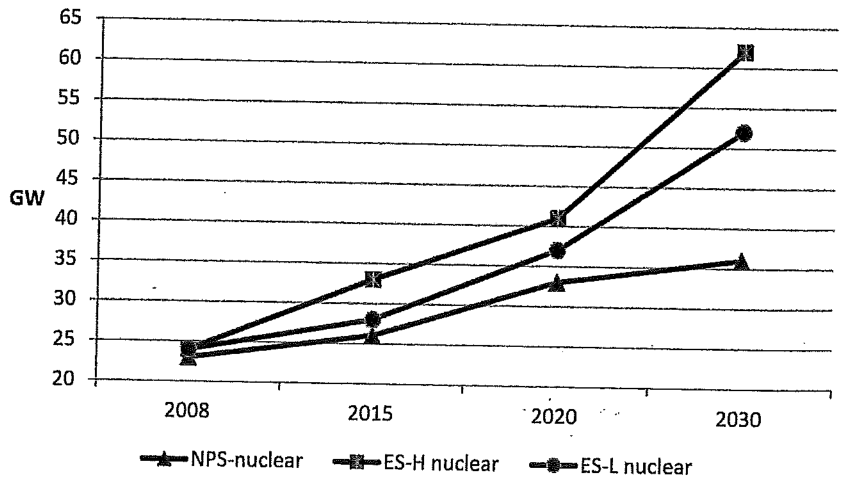

Figure 9.3 Increase in Russia's nuclear capacity according to the Energy Strategy and IEA NPS 2008–2030; *GW*

Source: Ministry of Energy RF (2009: 158); IEA (2010: 664).

Note: NPS is IEA's New Policies Scenario; ES-H denotes Energy Strategy High scenario; ES-L denotes Energy Strategy Low scenario.

(2008). Yet, the amount of electricity needed forecasted in the ES-2030 is much lower than that in the forecasts presented by the Russian national electricity monopoly RAO UES before the deregulation of the power sector (see further Chapter 8 in this volume).

However, observers claim that even the assumed increase of capacity in the ES-2030 is too high when the lower economic growth after 2009 is taken into account. According to a former deputy minister of the Ministry of Atomic Energy, Bulat Nigmatulin (2010), one per cent of the growth in GDP results in a 0.33 per cent growth in electricity demand. This is without taking into account energy-saving measures that will follow from the 'Law on energy saving and energy efficiency' and other measures. According to Nigmatulin (ibid.), Russia does not need more than a rise in capacity of a maximum of 40 GW up to 2020 (compared to 50–60 GW according to the ES-2030). This is more in line with the NPS (Figure 9.3).

Resource constraints

The changes envisaged in the energy sector will demand capital, R&D and human resources. The technology now available in the Russian energy industry was developed during the Soviet period and its specialists were trained during that time. Considerable investments are needed to revive the sector. Although there is considerable state involvement in the energy sector, parts of it are deregulated and a large part is organized in the form of state companies, for example the gas corporation Gazprom, the oil corporation Rosneft, and Rosatom. It follows that there will be competition for resources and lobbying will play a role in accessing state support for more investment. The possible, and probably necessary, cooperation with Western partners with superior technology will also be an interesting marker in this process.

Investments into the electricity sector will to a great extent be undertaken during the last part of the strategy, i.e. after 2022. The ES-2030 estimates that the cumulative investment cost of the whole strategy is USD 2 400–2 800 bn in 2007 prices (Ministry of Energy RF 2009: 162). This is equivalent to around twice the Russian GDP in 2007 (Oxenstierna 2010: 37). Of the total amount for investments almost 80 per cent is needed in the traditional energy industries and only 20 per cent would be used for developing alternative sources of energy and energy saving (Ministry of Energy RF 2009: 162).

Estimates indicate that investments into energy between 2009 and 2015 correspond to 6–9 per cent of the accumulated GDP over that period (Oxenstierna 2010: 38). This is a substantial share bearing in mind that Russia needs many other infrastructural investments over the next few years. The investment required in electrical power generation in the first stage corresponds to 1.2–1.3 per cent of GDP, and for nuclear power the investments will amount to 0.1 per cent of GDP (ibid.). Investment in the electricity sector is expected to be both public and private. In nuclear power, 36 per cent is estimated to come from the federal budget and the rest from Rosatom's own funds (Bellona 2011b: 12).

Nuclear power has high investment costs in comparison with other power-generating fuels, which raises questions regarding its competitiveness. According to Nigmatulin (2010: 14) NPPs are to have an overnight cost of USD 2 500 per kilowatt at the most and be built in a maximum of five years in order to be competitive with gas-fired plants. In practice, the recent construction of NPPs usually takes longer, six to seven years. Costs are approaching USD 4 000–5 000 per kW, sometimes up to USD 9 000 per kW, which is at least 4–5 times more than gas-fired plants for the same amount of electricity (Rutland 2012: 18).

The long break in nuclear development has created a deficit of human resources in the nuclear industry in all nuclear states. From an IAEA report (2007) we learn that in 2007, about 40 000 employees were working in Russian NPPs and of these about 35 000 were working directly with electricity generation. This means that about 1 000 employees are required per reactor, or 1 500 persons per installed GW. With a doubling of capacity installed up to 2020, a doubling of the number of nuclear professionals is also required. According to a Russian country report to the IAEA (2011), there is an HR policy to keep and attract personnel to the nuclear industry and special training institutions. It is impossible to say whether these measures are sufficient to provide the booming nuclear industry with enough competent personnel. It takes a long time, at least ten years, to prepare qualified personnel for the industry and the competition from other sectors will demand that the industry can offer attractive salary and benefits packages.

Nuclear fuel and nuclear waste

In 2009, Russia produced 3 564 tons of uranium, which is 1.8 times more than in 2000, when production was 2 000 tons (Oxenstierna 2010: 75). However, Russia uses much more uranium than it mines annually. In August 2010, Russia's nuclear reactors required 4 135 tons of uranium (ibid.). Natural uranium must be enriched up to 3.75 per cent of U-235 before it can be used in energy producing reactors. Russia owns about half of the world's uranium enrichment capacity and is therefore already a major international provider in enrichment services (IPFM 2007: 100). Around 40 per cent of installed uranium enrichment – capacity is used to provide low-enriched uranium (LEU) for existing reactors of Russian design in Russia and abroad. Another 20–25 per cent is used for producing LEU from weapon-grade uranium for use as power-reactor fuel in the United States (the Megatons to Megawatts project, see USEC 2012). The remaining 40 per cent of Russia's enrichment capacity is used for enriching natural uranium and for re-enriching reprocessed uranium for European customers, and for extracting the equivalent of 'natural' uranium from depleted uranium (IPFM 2007: 95).

Having adequate uranium supplies to fuel the foreseeable expansion of nuclear power will remain a crucial advantage of nuclear power. Russia also has abundant secondary supplies of fuel to support the expanded electricity generation by NPPs. Spent fuel may be reprocessed and used again. The Megatons to Megawatts project between Russia and the USA is an example of how lethal weapons can be used for peaceful means. The project has been continued in a new agreement for 2013–22, which also includes building an enrichment factory in the US (Rosatom 2011; USEC 2012). The Russian nuclear fuel manufacturer, TVEL, aims at 30–32 per cent of the global nuclear fuels market compared with 25 per cent in 2012 (WNN 2012a).

Nuclear waste management

Nuclear waste in Russia does not come only from NPPs. Russia has inherited a major nuclear waste problem from Soviet military activities and there are also many research reactors in operation that produce plutonium and waste. In 2003, there were 500 million cubic metres of liquid radioactive waste in Russian nuclear establishments. In addition, there were 180 million tons of solid radioactive waste at storage sites such as Mayak at Chelyabinsk, the Siberian Chemical Combine at Tomsk, and the Mining and Chemical Combine in Zheleznogorsk (Bellona 2004: 42–4).

The Duma finally passed the Law on Radioactive Waste Management in June 2011 and it was written into law (WNA 2012c). From then, Rosatom and the national operator for the management of radioactive waste, RosRAO, are responsible for the disposal of radioactive waste. Russia does not have a final solution to the problem of how to store radioactive waste from its nuclear power plants. No waste repository is yet available, though sites on the Kola Peninsula and in the Nizhnekansky Rock mass in the Krasnoyarsk region have been put forward. The Russians are opting first of all for a facility that can hold 20 000 tons of intermediate-level and high-level waste that will be retrieved (ibid.). So far, spent nuclear fuel is kept in cooling ponds on the premises of the nuclear plants. These ponds were dimensioned to store three years' worth of spent fuel and a reserve corresponding to a full load of the reactor core (Bellona 2004: 38). A problem now is that some of these ponds are overfull, and this complicates further production at the plants. Spent fuel from the RBMK plants is exclusively stored in ponds at the plants (IPFM 2007: 96). From some VVER-440s, naval and research reactors, the spent fuel is reprocessed at the Mayak reprocessing facility at Chelyabinsk (ibid.). In reprocessing, 95 per cent of spent fuel can be recycled to be returned to use in nuclear power plants. Fuel from the VVER-1000 is transported to the storage facility at the Mining and Chemical Combine in Zheleznogorsk.

Repatriation of fuel used abroad

The Soviet Union repatriated all spent fuel from Soviet-built reactors in other Soviet republics, Eastern Europe and Finland. Spent fuel from VVER-440 reactors in Bulgaria, the Czech Republic, Finland, East Germany, Hungary and the Slovak Republic was shipped back to the Soviet Union. Russia continues this policy and takes back spent fuel of Soviet/Russian origin. In the early 2000s, however, only Ukraine[3] and Bulgaria still shipped spent fuel to Russia (Bellona 2004).

The building of the nuclear power plant at Bushehr in Iran was severely delayed, one reason for this being the Iranians' reluctance to agree to return used fuel to Russia. Finally, in 2005, the parties signed two agreements implying that Iran would get all its fuel from Russia and the spent fuel would be returned to Russia after use for reprocessing and storage. In August 2010, the process of loading fuel into the first unit of the Bushehr NPP began under the supervision of inspectors from the IAEA (WNN 2010). The reactor was connected to the Iranian grid in September 2011 (WNN 2012b).

Security and non-proliferation

The IAEA (1994) Convention on Nuclear Safety was adopted in Vienna on 17 June 1994. Its aim is to legally commit participating states operating land-based nuclear power plants to maintain a high level of safety by setting international benchmarks. Russia signed this convention in September 1994 and it came into force in October 1996. There are several safety aspects monitored by the Convention, for instance: national nuclear safety infrastructure; regulatory effectiveness and independence; long-term management of radioactive sources; management of spent fuel and radioactive waste; education and training; exposure to releases from radioactive substances; decommissioning; safety of transports of radioactive material.

It follows that the safety issues around nuclear energy are extremely complex. Several aspects concern the hard-core technical safety of the reactors, transports and spent fuel storage. Others concern broader security issues that encompass outside threats to nuclear facilities, such as cyber sabotage and terrorist attacks. The IAEA distinguishes between safety issues and security issues in its work in the following way:

> In the safety area, they cover nuclear installations, radioactive sources, radioactive materials in transport, and radioactive waste. A core element is setting and promoting the application of international safety standards for the management and regulation of activities involving nuclear and radioactive materials.
>
> In the security area, they include nuclear and radioactive materials, as well as nuclear installations. The focus is on helping states and companies prevent, detect, and respond to terrorist or other malicious acts – such as illegal possession, use, transfer, and trafficking – and to protect nuclear installations and transport against sabotage.
>
> (IAEA 2013)

Hence, *safety* refers to mainly technical aspects of making nuclear power safe, while *security* refers to a broader family of threats.

Safety and security

Chernobyl drew attention to the importance of a 'safety culture' referring to the impact of managerial and human factors on safety performance. The term was first used in the International Nuclear Safety Group in a post-accident review meeting on the Chernobyl accident (INSAG, 1988). This concept was introduced as a means of explaining how the lack of knowledge and understanding of risk and safety on the part of the employees and the organization contributed to the outcome of the disaster.

By the early 1990s, a number of Western assistance programmes were in place, which addressed safety issues and helped to fundamentally alter the way things were done in the USSR and later in Russia. Design and operating deficiencies were tackled, and a modern safety culture started to emerge. The IAEA and World Association of Nuclear Operators (WANO) that came into existence as a result of Chernobyl contributed greatly to improving the safety and reliability of Soviet-era nuclear plants. In the first two years of WANO's existence, 1989–91, operating staff from every nuclear plant in the former Soviet Union visited plants in the West on technical exchanges and Western personnel visited every Soviet plant. How well Western assistance has worked to encourage a different and internationally monitored safety culture to penetrate the Russian nuclear establishment is not quite clear. A safety culture in any area is to some degree correlated with the safety culture in the society. When it comes to technical safety, after the Fukushima accident, Russian reactors underwent safety tests and were proved to be able to withstand a 14-metre tsunami and a magnitude 9 earthquake (*RIA Novosti* 2011a).

Nevertheless, Russian environmental groups have voiced strong concern especially regarding the prolonged service life of RBMK ('Chernobyl') reactors. On the 26th anniversary of the Chernobyl accident in 2012, activists gathered in Moscow under banners like 'Save the world from the peaceful atom' (Bellona 2012a), 'the peaceful atom' being the popular name of the Russian civil nuclear programme in the 1950s. In 2008, members of the environmental organisation *Ekozashita* demonstrated outside the building of *Rostekhnadzor* (the Federal Technical State Inspection), which is the supervisory body on ecological, technological and civil nuclear issues. They demanded 'Close old nuclear plants' and were temporarily detained by the police (Bellona 2008). In 2009, Rostekhnadzor noted over four hundred violations of safety codes in the planning and construction of nuclear power installations. But since 2008 Rostekhnadzor has been subordinated to the Ministry of Natural Resources and the Environment, which gives it a weak position in relation to Rosatom – a strong state agency under the government. In 2005, the Murmansk Prosecutor declared that the granting of a prolonged operating licence for the Kola NPP reactors 1 and 2 was illegal since it had been granted without the ecological expert assessment required by Law (Bellona 2005). In 2012, an internet campaign favours the closing of the Kola NPP (2012). However, the authorities have so far ignored these recommendations.

Incidents are recorded at Russian NPPs as in plants of other countries. In September 2012, for example, a three-hour fire inside the third reactor's protective cement barrier had to be extinguished at the Rostov NPP. Apparently the fire was caused by sparks from welding tools, the reactor still being under construction (Bellona 2012b). In connection with demonstrations in 2012 in Moscow, a major power break at the Kola NPP in 1993 was also recalled, which is claimed to have been serious since the reserve diesel-powered generators were out of order and could have caused a meltdown as the reactors lose coolant, which is what happened at Fukushima (Bellona 2012a). According to Khripunov and Holmes (2004: 2) in the 1990s, there were successful and attempted diversions of nuclear material from Russian nuclear facilities. In particular, such incidents occurred when the personnel failed to recognize how important it is to follow all procedures to the letter and to actually use systems available for protecting nuclear materials. The substantially improved economic situation in Russia in 2012 compared to the 1990s, and the fact that the nuclear sector now has more resources and political priority, has probably diminished the incentives for individuals to divert nuclear materials and sell them.

It appears that Russia has improved its safety culture well beyond what it was on 26 April 1986, the date of the Chernobyl accident, and attempts to improve the image of a safety concerned international player continues. In 2012 Rosatom employed the ex-director general of Finland's Radiation and Nuclear Safety Authority, Jukka Laaksonen, as deputy director of Rosatom Overseas (Helsingin Sanomat 2012; Rosatom 2012). Hereby Rosatom improved its credibility regarding safety and got a greater prospect of influencing nuclear safety around the world. Yet accidents like that at the Sayano-Shushinskaya hydroelectric station in September 2009 shows that there is still a culture in Russia of highly trained engineers breaking vital safety rules and causing lethal damage. In addition, the militant attack of 21 July 2010 on the hydropower station in Kabardino-Balkaria also raises concerns regarding the security against terrorist attacks on nuclear power stations which is an issue in Western nuclear development as well. Moreover a major challenge is to secure nuclear plants and radioactive waste from methods of sabotage that are still unknown.

When it comes to broader security issues, the Russians deal with the same kind of scenarios as elsewhere. After 9/11, threats from the sky have been a high priority and in the West, security around nuclear plants increased, in particular, the vulnerability of NPPs to deliberate aircraft crashes has been a continuing issue (Holt and Andrews 2012). The 2010 wildfires around Sarov (*RIA Novosti* 2010b), formerly Arzamas-16, one of the main nuclear facilities in the Soviet Union, have probably made Russian nuclear safety experts think more about fire protection and whether nuclear facilities should be located deep in forests. A problem with safety and security set-ups is that they can only prepare and defend against risks that are known or deemed to have a relevant probability to occur. As the Fukushima case shows, the event of an earth quake and tsunami of such magnitude simultaneously had obviously not been attributed a sufficient probability in risk estimations. Hence, it is important to combine hard security with routines and creative approaches to security threats.

Non-proliferation of fissile materials

The nuclear renaissance has stirred experts in the non-proliferation and disarmament area, since the expansion of nuclear energy changes the whole setting in these areas. The basic international document regulating the proliferation of nuclear materials is the Treaty on the Non-Proliferation of Nuclear Weapons (NPT).[4] However, the NPT is not considered sufficient to offset the risks of proliferation of fissile materials that is implied by the current expansion of civil nuclear power. It is the open fuel cycle in civil nuclear generation that is the problem. The former Director General of the IAEA, Mohamed ElBaradei, has called the spread of enrichment and reprocessing capabilities the 'Achilles heel' of the nuclear non-proliferation regime. As of 2012, a dozen states have enrichment capability (WNA 2012d). As the commercial reactors use enriched uranium as fuel, it follows that states must be able either to enrich uranium themselves or to purchase enriched uranium on the international market.

Several international actors have addressed the question and come forward with recommendations. According to the International Security Advisory Board of the US Department of State (ISAB), strengthening proliferation protection under present conditions demands concrete measures at the level of those countries that supply and use nuclear power. In particular, it is recommended that the spread of enrichment and reprocessing capabilities to nations that do not have these technologies be restricted. ISAB (2008) additionally recommends that (1) nations without their own enrichment capabilities should be guaranteed reliable and economic supplies of nuclear fuel. Fuel banks are one element in this 'attractive offer'; (2) states supplying nuclear technologies should work together to establish guidelines and sanctions for recipients who must forgo the opportunity to develop their own enrichment and reprocessing capability; and (3) the suppliers of nuclear technology should be given greater responsibility in non-proliferation efforts and should be backed by states.

The International Commission on Nuclear Non-proliferation and Disarmament (ICNND), stresses the need for effective control of internationally agreed arrangements for effective control of sensitive nuclear technology, such as enrichment and reprocessing. It is essential that the mechanisms for supply of nuclear fuel and fuel management services should be long-term, so that states will not feel compelled to develop national fuel-cycle capabilities. ICNND further finds that the nuclear industry should develop a comprehensive Code of Conduct ranging from responsible uranium supply to support for the development of proliferation-resistant fuel-cycle technologies (Letts and Cunningham 2009). So far, governments have tended to manage non-proliferation as a political issue with virtually no industry involvement. The ICNND considers that industry should be a more involved and active partner to governments in the drafting of regulations and treaties that affect their activities (ibid.).

Russia, by its present policy of providing the fuel to its nuclear plants abroad and repatriating spent fuel, as well as hosting one of the international fuel banks (at Angarsk outside Irkutsk), supports non-proliferation along the lines of these recommendations. On the other hand, Russia is building nuclear plants in countries that have not signed the NPT, and in others where there have been clandestine uranium enrichment efforts. There has also been concern about the export of the floating nuclear power plants that can be moved and are more vulnerable to attack than ordinary NPPs.

Conclusions

The nuclear sector is one of the few sectors where Russia has advanced technologies and a considerable comparative advantage due to its historical military nuclear research. The overview of Russian plans up to 2030 shows that nuclear-generated electricity will play an increasing role in Russia, with a projected increase in capacity of over fifty additional reactors by 2030. The role of fossil fuel-generated electricity will decrease. However, coal and gas will still provide 60–70 per cent of Russian electricity in 2030, while nuclear power will provide 20 per cent. Nuclear power will play an important role, particularly in European Russia, in replacing some gas in domestic electricity generation. More nuclear power is a way to spare more gas for export, which is obviously a central aim of Russia's energy strategy. The domestic nuclear expansion also provides Russia with reference plants at home that can be shown and tested for sales in export markets. Russia exports to India, China, Turkey and Iran, among others.

The findings with regards to the constraints on the nuclear energy expansion are inconclusive because information on investment resources, capacity constraints in the nuclear engineering sector and manpower is scarce. Also, there does not seem to be a serious economic discussion in Russia on how investments should be allocated within the energy sector. The ES-2030 is a technical document that does not take into account the relative prices of different fuels, investments costs or the bargaining power of different economic actors. Under the first step of the ES-2030 alone, the period up to 2015, 6–9 per cent of GDP would be required for the necessary modernization, of which investment in electricity would account for about one per cent. NPPs have very high investment costs compared to gas-fired plants, but if the political leadership wants to replace parts of domestic gas consumption with nuclear power in order to release gas for export the sector will probably get support to pursue the expansion even if it will take a longer time.

The timetable of the expansion plans as presented does not seem realistic. Russia had a long Chernobyl interlude, over two decades, which means that the manufacturing industry hardly has the necessary capacity to produce all the technology for the new NPPs at home and abroad. The availability of manpower that has the training for constructing and running nuclear plants is uncertain. Rosatom supports training for nuclear engineers, and the sector has become more popular again, but it will take time to turn the trend of bright people choosing business schools instead of the sciences and technical subjects when making their choice of profession. Hence, it will take time to surmount the twenty-five years of nuclear silence, but if the nuclear industry continues to receive support from the political leadership the Russian nuclear expansion will continue up to 2030 and beyond.

The securitization of nuclear power implies that it no longer is a national security issue but an international one. Russia takes an active part in all international initiatives to improve safety and security around the use of civil nuclear power. After the Fukushima accident it has increased its efforts to be perceived as a safety-concerned nation. All Russian reactors have undergone stress tests and Rosatom recruits high-level management on the international market. There is no evidence in open sources that Russian NPPs should be less safe than others. Russian environmental organizations protest against NPPs, in particular against the RBMK reactors that have had their service life extended. However, in the Russian population there is still support for nuclear power even if it is not as strong as the political leadership might expect. An opinion poll from June 2011 tells us that 50 per cent of the respondents would in fact for sure, or probably, support a decision to close down the NPPs, as in Germany, while only 20 per cent say they definitely would not (VTsIOM 2012; Rutland 2012).

The 'Achilles heel' of the non-proliferation of fissile materials is the open fuel cycle. The NPT states focus on deterring new nuclear technology states from acquiring enrichment and reprocessing facilities. Russia's policies of providing the fuel to its nuclear plants abroad and repatriating spent fuel, as well as hosting one of the international fuel banks, are in line with the recommendations of how to support non-proliferation. Reactors with a closed-fuel cycle are anticipated at the end of this decade.

Notes

1 The Lithuanian NPP in Ignalina (an RBMK NPP) was shut down in 2000, a condition for Lithuania's EU accession. Ignalina provided 85 per cent of Lithuania's electricity and the area has since basically been served by a gas-fired plant in Kaliningrad.

2 The fuel used for floating nuclear power plants is uranium enriched to 40 per cent uranium-235. See further Bellona (2011a) for technical details.

3 At the end of the 1990s Ukraine had five nuclear plants that produced over one-third of Ukraine's electrical energy. All aspects of the fuel cycle remained under Russian control. The waste and spent fuel from the Rovenskaya station in Kuznetsov belong to Chelyabinsk-40, and the waste of the ten reactors in South Ukraine (the Zaporozhskaya and Khmelniskaya stations) goes to Krasnoyarsk-26 (Josephson, 2000: 270).

4 The NPT came into force on 5 March 1970, and currently 189 states are parties. Five of these are recognized as nuclear weapon states – the USA, Russia, the UK, France and China, the five permanent members of the United Nations Security Council. The NPT allows for the transfer of nuclear technology and materials to

NPT signatory countries for the development of civilian nuclear energy programmes in those countries as long as they can demonstrate that their nuclear programmes are not being used for the development of nuclear weapons.

References

BBC (2012) 'Wilma: Russian operator Rosatom "eyeing horizon nuclear power"'. Online. Available: www.bbc.co.uk/news/uk-wales-north-west-wales-17682322 (accessed 16 July 2012).

Bellona (2004) *The Russian Nuclear Industry: The Need for Reform*, Bellona Foundation, Online. Available: www.bellona.org/reports/Russian_Nuclear_Industry (accessed 22 August 2012).

——(2005) 'Kola Nuclear Plant operating illegally'. Online. Available: www.bellona.org/english_import_area/international/russia/npps/kola/40588 (accessed 23 September 2012).

——(2008) 'Three arrested in Moscow protest prolonging operations for aged reactors'. Online. Available: www.bellona.org/artcles/articles_2008/rostekh_arrests (accessed 23 September 2012).

——(2011a) *Floating Nuclear Power Plants – Russia*. Online. Available: www.bellona.org (accessed 22 August 2012).

——(2011b) *The Economics of the Russian Nuclear Power Industry*, Bellona Foundation. Online. Available: http://bellona.org/filearchive/fil_Economics-of-the-Russian-Nuclear-Power-Industry-English.pdf (accessed 23 August 2012).

——(2012a) 'Demonstrators in Russia use 26th Chernobyl anniversary to insist on righting pervasive nuclear defects'. Online. Available: www.bellona.org/articles/articles_2012/chernobyl26_news (accessed 23 September 2012).

——(2012b) 'Comment: fire at Rostov NPP blazes for three hours, burning up millions on hasty construction project'. Online. Available: www.bellona.org/articles/articles_2012/rostov_NPP_fire (accessed 23 September 2012).

Charap, S. and Safonov, G.V. (2010) 'Climate change and role of energy efficiency', in Aslund, A., Guriev, S., Kuchins A.C. (eds), *Russia after the Global Economic Crisis*, New York: Peterson Institute for International Economics, Center for Strategic and International Studies, New Economic School.

Ministry of Energy RF (2009) *Energeticheskaya strategiya Rossii do 2030 godu* [Energy Strategy of Russia up to 2030] Directive No. 1751. Adopted by the government 13 November. Online. Available: http://minenergo.gov.ru/activity/energostrategy/Strategiya/Energostrategiya-2030.doc (accessed 5 November 2012).

Helsingin Sanomat (2012) 'Retired Finnish nuclear boss hired by Russian nuclear energy company', 6 February. Online. Available: www.hs.fi/english/article/Retired+Finnish+nuclear+safety+boss (accessed7 January 2013).

Holt, M. and Andrews, A. (2012) *Nuclear Power Plant Security and Vulnerabilities*, Congressional Research Service, 28 August, RL34331. Online. Available: www.fas.org/sgp/crs/homesec/RL34331.pdf (accessed 5 November 2012).

IAEA (1994) *Convention on Nuclear Safety*. Online. Available: www-ns.iaea.org/convention/nuclear-safety.htm (accessed 5 November 2012).

——(2007) *Russian Federation National Report on the fulfillment of commitments resulting from the convention on nuclear safety*.

——(2011) *Russian Federation, Country Profiles*. Online. Available: www.pub.iaea.org/MTCD/publications/PDF/cnpp/countryprofiles/Russia/ (accessed 5 November 2012).

——(2013) *Pillars of nuclear cooperation. Promoting safety and security.* Online. Available: www.iaea.org/OurWork/SS/index.html (accessed 25 January 2013).

IEA (2010) *World Economic Outlook 2010*, Paris: IEA.

India Juris (2010) *Nuclear Energy in India & Foreign Investment*. Online. Available: www.india.juris.com (retrieved 5 November 2012).

INSAG (1988) *Basic Safety Principles for Nuclear Power Plants 75 ISAG-3 rev.1*, IAEA. Online. Available: www-pub.iaea.org/MTCD/publications/PDF/P082_scr.pdf (accessed 23 August 2012).

IPFM (2007) *Global Fissile Material Report 2007*. Online. Available: http://fissilematerials.org/library/gfmr07.pdf (accessed 23 August 2012).

ISAB (2008) *Report on Proliferation Implications of the Global Expansion of Civil Nuclear Power*. Online. Available: http://2001–9.state.gov/documents/organization/105587.pdf (accessed 24 September 2012).

Josephson, P.R. (2000) *Red Atom*, Pittsburgh, PA: First University of Pittsburgh Press.

Khripunov, I. and Holmes, J. (2004) *Nuclear Security Culture: The Case of Russia*, University of Georgia, GA: Center for International Trade and Security.

Kommersant (2011a) 'India ne idet na kontrakt' [India does not agree to sign the contract], 26 October. Online. Available: www.kommersant.ru/doc/1803132 (accessed 22 August 2012).

——(2011b) 'Belorusskaya AES startuet bez deneg' [Belarusian NPP starts without money], 11 October. Online. Available: www.kommersant.ru/doc/1792297 (accessed 26 September 2012).

KVA (2010) *Energy Resources and Their Utilization in a 40-year Perspective up to 2050. A synthesis of the work done by the Energy Committee at the Royal Swedish Academy of Sciences*, May, Royal Swedish Academy of Sciences' Energy Committee, Stockholm: Royal Academy of Sciences (KVA).

Law on Energy Efficiency (2009) '*Ob energosberezhenii i o povyshenii energeticheskoi effektivnosti i o vnesenii izmenenii v otdelnye zakonodatelnye akty RF*', FZ 261. Adopted by the government 18 November.

Letts, M. and Cunningham, F. (2009) 'The role of the civil nuclear industry in preventing proliferation and in managing the second nuclear age', *paper prepared for the Second Meeting of the ICNNPD*, Washington, 13–15 February.

McKinsey & Co. (2009) *Energoeffektivnaya Rossiya* [Energy efficient Russia], December, McKinsey.

Nigmatulin, B.I. (2010) 'Otlichat porozhenie ot pobedy', *Proatom*, 29 March. Online. Available: www.proatom.ru/modules.php?name=News&file=article&sid=2252 (accessed 23 August 2012).

Oxenstierna, S. (2010) *Russia's Nuclear Energy Expansion*, Stockholm, FOI-R-3049-SE, December.

RIA Novosti (2010a) 'Indian nuclear energy chief: Russia has an advantage: it has a reactor, others can only show papers', 10 March. Online. Available: http://en.rian.ru/analysis/20100310/158148685-print.html (accessed 23 September 2012).

——(2010b) 'No radiation threats over fires near Russia's Sarov nuclear center – Rosatom chief', 14 August. Online. Available: http://en.rian.ru/russia/20100814/160201171.html (accessed 24 September 2012).

——(2011a) 'Stress tests confirm safety of Russian nuclear plants', 19 April. Online. Available: http://en.rian.ru/russia/20110419/163601616.html (accessed 24 September 2012).

——(2011b) 'Russia, Ukraine to build nuclear fuel production plant', 8 June. Online. Available: http://en.rian.ru/russia/20110608/164516250 (accessed 2 January 2012).

Rosatom (2011) 'TENEX and USEC signed multi-year contract for LEU supply', 23 March. Online. Available: www.rostatom.ru (accessed 28 March 2011).

——(2012) 'Jukka Laaksonen, Vice president of Rosatom Overseas: "The safety has no secrets"', 9 July. Online. Available: www.rosatom.ru/en/presscentre/interviews/69e561804be9548aaefdaec2e353ce28 (accessed 7 January 2013).

Rutland, P. (2012) 'Russian nuclear energy in the wake of Fukushima', *Russian Analytical Digest*, 113: 18–23, May.

USEC (2012) *USEC–Russian contracts 30 June 2010*. Online. Available: www.usec.com/russian-contracts (accessed 23 August 2012).

VTsIOM (2011) 'Russian attitudes on nuclear energy'. Online. Available: http://old.wciom.ru/press-vypuski/press-vypusk/single/111693.html (accessed 23 September 2012).

WNA (2012a) 'Policy response to the Fukushima accident', 24 February. Online. Available: www.world-nuclear.org/info/default.aspx?id=29733&terms=Germany%20ener. (accessed 17 July 2012).

——(2012b) 'Nuclear power in Russia', June. Online. Available: www.world-nuclear.org/info/inf45.html (accessed 17 July 2012).

——(2012c) 'Nuclear fuel cycle in Russia'. Online. Available: www.world-nuclear.org/info/inf45a_Russia_nuclear_fuel_cycle.html#Used_Fuel_and_Reprocessing (accessed 23 August 2012).

——(2012d) 'Uranium enrichment', June. Online. Available: www.world-nuclear.org/info/inf28.html (accessed 24 September 2012).

WNN (2010) 'Fuel loading starts at Bushehr 1', *World Nuclear News*, 23 August. Online. Available: www.world-nuclear-news.org/NN-Fuel_loading_starts_at_Bushehr_1-2308104 (accessed 23 August 2012).

——(2012a) 'Tvel plans to grow and diversify', *World Nuclear News*, 26 January. Online. Available: www.world-nuclear-news.org/C_TVEL_plans_to_grow_and_diversify_2601121.html (accessed 23 August 2012).

——(2012b) 'Iran still not cooperating with IAEA', *World Nuclear News*, 27 February. Online. Available: www.world-nuclear-news.org/NP-Iran_still_not_cooperating_with_IAEA-2702127.html (accessed 23 August 2012).

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