ALEKSANDRA GAWLIKOWSKA-FYK
ZUZANNA NOWAK

REPORT

NUCLEAR ENERGY IN POLAND

PISM | POLSKI INSTYTUT SPRAW MIĘDZYNARODOWYCH
THE POLISH INSTITUTE OF INTERNATIONAL AFFAIRS

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WARSAW, 2014

Photo:
Page 12: © Bettmann/CORBIS, www.corbis.com
Page 57: © Bullwinkle/SHUTTERSTOCK, www.shutterstock.com

Technical editor: DirectDTP
Cover design: DirectDTP
Printed by: DirectDTP

ISBN 978-83-64895-02-9 (pb)
ISBN 978-83-64895-03-6 (pdf)

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HOW TO READ THIS REPORT

Discussions of the rationale for building a nuclear power plant in Poland have a long history. But now is the time when the Polish Nuclear Energy Programme is entering a decisive stage, with nuclear technology incorporated into the country's energy policy. The Polish Institute of International Affairs (PISM) therefore deems it proper and timely to support a debate about the benefits and risks of civil use of nuclear energy, drawing on the experiences gained in this field by other European states.

The aim of the present report is to formulate conclusions and recommendations for Poland, proceeding from a comparative analysis of nuclear energy ventures in other Members States of the European Union. Crowning the research project "Nuclear Energy in Poland: Balance Sheet and Future Outlook," carried out at the PISM, the report also covers findings of public opinion research, both quantitative and qualitative, taken by the PISM (between April and June 2014) to establish the Polish public's attitudes towards nuclear energy.

Most importantly, these poll findings reveal huge public support for the construction of Poland's first nuclear power plant (64%). The high acceptance level, the authors of the present report believe, may have been influenced by the external circumstances, including such a weighty factor as the sense of compromised security—including energy security—resulting from the ongoing and escalating Ukraine-Russia conflict. This may greatly influence the perception of the nuclear power industry as a safe, stable and domestic source of energy. Without overrating this factor, it does not look like a short-lived one. Actually, the changing energy security perspective—with this security sometimes understood as nothing less than independence—may become permanently embedded in the public's approach to energy generation. The authors therefore believe that the received public support (higher than the targeted 60%, as set for 2030 in the Polish Nuclear Energy Programme) should be seen by decision-makers as a clear signal and call for further action. Efforts to keep this high level of public approval must not be abandoned; in fact, the government should build on the existing public sentiment and reiterate its determination to build Poland's first nuclear power station.

As revealed by the simultaneous qualitative study, involving in-depth interviews with 24 experts, the research community is well aware of the future energy-related and economic challenges, and of the need to diversify the Polish energy mix (the pull-quotes throughout the report come from these conversations). Experts are open to change; most of them realise that nuclear energy development in Poland is imperative, and they are aware of its long-term significance. Also, against conventional wisdom, nuclear power is not perceived as a threat to coal, but rather as its complement.

Today, with the Polish Nuclear Energy Programme formally adopted by the government (January 2014), it is high time to shift the focus from "whether" to "how" nuclear power can be put to the best use possible.

Triggering and sustaining industrial development in a country, especially on a large scale, is contingent on an array of local, social and international conditions, and in particular it requires skilled labour, adequate start-up and working capital, cheap energy, including hydro energy and electricity, domestic raw materials, convenient transport services, and professionally educated management; it craves freedom while abhorring administrative and fiscal impediments.

Dr Stanisław Głąbiński, *Lectures in Social Economics, with an outline of economic policy and history of economics, Lwów 1913.*

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NUCLEAR ENERGY IN POLAND?

IN THE SPOTLIGHT

Poland's role as a player in European's energy policy has been steadily increasing. Against the backdrop of the ongoing geopolitical changes, which may potentially threaten the security of the EU's energy supplies, it was the Polish government who initiated a pan-European energy debate. Seeking, just as other EU Member States, to meet the EU's requirements on energy security, competitiveness and sustainable development, Poland places emphasis on Member States' individualism and argues that the domestic determinants of energy production must be respected. Assuming the leadership role in this tough debate puts Poland in the limelight and opens the country up to criticism, with its energy policy, based on domestic coal deposits, seen as obsolete and inefficient, and consequently coming under constant attack. There can be no doubt that the Polish economy should undergo gradual transformation and its energy mix should be diversified.

The attainment of these goals can be sought in a variety of ways, with every country making sovereign decisions about their energy policy, in accordance with their own potential. At the same time, though, countries want to share their experiences and promote solutions they regard as the best. Germany, which is worried by Poland's energy strategy, calls for a reform of the Polish system along the lines of its own drive to transform power generation (*Energiewende*). France perceives Poland as an attractive market for its advanced nuclear technology, and so it supports the development of Polish nuclear power generation. In Russia, the Polish plans to open a nuclear station in the north

> "WHAT WE NEED IS AN ENERGY MIX THAT BRINGS POLAND THE GREATEST BENEFITS; OUR THINKING SHOULD BE ORIENTED TO THE COMMON GOOD AND CITIZENS' WELFARE, NOT TO THE LOBBIES OF THE ENERGY SECTOR, MINING, MANUFACTURING OR POLITICIANS."

of the country have raised fears about the profitability of its own plant currently under construction in Kaliningrad, and so it proposes to sell its electricity to Poland. The policy pursued by Poland is also taken into account in the energy plans of neighbouring countries, the Czech Republic, Slovakia and Ukraine, reflecting factors such as a growing number of transmission lines being built. There is no way for Poland to embrace all of the proposed models of energy sector modernisation, but an analysis of other countries' experiences will surely help to better understand the challenges to be faced in the future.

"HOW COULD ONE POSSIBLY THINK OF NOT TAPPING THE EXPERIENCES OF OTHER COUNTRIES? IF I HAVE 50 BILLION ZLOTY TO SPEND, I WILL CERTAINLY NOT BE LEARNING FROM MY OWN MISTAKES BUT WILL STUDY THE EXPERIENCES GAINED BY OTHERS. ALL SUCH EXPERIENCES ARE PRECIOUS: THE EXPERIENCES OF THE GERMANS WHO ARE WITHDRAWING FROM ATOM - WE SHOULD CERTAINLY LOOK INTO THAT - AND THE EXPERIENCES OF THE FRENCH, WHO HAVE PUT UP NUCLEAR PLANTS VIRTUALLY ON EVERY CORNER."

An energy strategy is developed for some 30-40 years, and any changes can only be made in an evolutionary manner. Poland thus has to switch to long-term thinking and a habit of consistently implementing the adopted well-thought-out decisions. The future Polish energy mix will influence not only the country's industrial development and economic competitiveness, but also technological progress, the welfare of the population, and relations with other European countries. Change is a must, and the Polish experts currently working on a new national energy strategy are well aware of this. The components of Poland's future energy mix in discussion include shale gas, renewable sources,

"WE WILL NOT BE A COUNTRY WHERE NUCLEAR POWER GENERATION COMES TO THE FORE, BUT ONE WHERE IT PLAYS A SUPPLEMENTARY ROLE"

and greater reliance on nuclear power, along with a continued robust presence of coal. Contrary to widespread opinion these options do not rule out each other, as can be noticed in the recently published outline of Poland's new energy policy to the year 2050[1]. Importantly, each of the scenarios discussed in the document involves nuclear energy-including a 10% share of primary energy in the likeliest (balanced) scenario—thus providing yet another indication that a switch towards atom has indeed taken place.

Still, the Polish nuclear energy programme continues to provoke discussions. Considering its grand scale and long gestation period, the special nature of the energy source involved, and the controversy this technology stirs, the Polish public must be given an opportunity to appraise the ongoing debate in an objective and reliable manner. Thus the aim of the present report is not to argue for or against nuclear energy in Poland, but rather to join the debate, by providing the public and the decision-makers with food for thought on economic, technological, legal and societal consequences that nuclear power will produce in Poland. The goal is also—or, perhaps, primarily—to demonstrate that, once the Go Nuclear option is embraced, action will be required here and now.

IN THE CONTEXT

Analysts of international energy policy are asking themselves the question of whether we are witnessing a renaissance of nuclear energy, or perhaps its twilight. The question has no unequivocal answer, if only because of the specific energy supply determinants in various corners of the world. And just as any field with strong political interdependencies, nuclear power generation is subject to periodic fluctuations resulting from a host of sometimes unpredictable factors. What is certain, though, is

that all over the world the humankind faces major energy-related challenges. Demand for electricity will keep rising, reflecting the growing population numbers and an increasing per capita energy consumption, especially in emerging economies such as China and India. According to World Economic Outlook projections, the global demand for energy in 2035 will be higher by a third compared to 2011[2]. If these forecasts materialise, the world's oil and gas reserves will be depleted in the space of 50 years, and coal reserves over the next 100 years[3]. Another challenge for the energy industry—which has to satisfy the growing energy requirements while facing limitations in the availability of fossil fuels—is to put a brake on climate change[4].

Nuclear power generation thus seems to be offering a solution to most of current problems. The international nuclear energy community comprises more than 30 countries, with 435 reactors in operation and a further 72 under construction. Nuclear energy's share of global electricity generation stands at 11%. A veritable boom has been taking place in Asia, where there are 119 reactors in operation, 49 under construction and 100 at the planning stage. China is the country with the greatest ambitions—even though it has just 20 reactors in operation, there are 29 under construction, 59 at the planning stage, and a further 118 on the tapis. A nuclear renaissance can be seen in Russia (10 reactors under construction), India (6), the United States and South Korea (5 each)[5].

A new era is also dawning in Gulf countries-Kuwait, Saudi Arabia, Bahrain, United Arab Emirates, Qatar and Oman—which in 2006 entered into an agreement on cooperation in the peaceful use of nuclear energy, prodded by the growing demand

Nuclear power stations in Poland's neighbourhood

for electricity (at a rate of 5-7% a year) and their total dependence on fossil fuels. Saudi Arabia, for one, has plans to build 16 reactors over the next 20 years, with the first launch expected in 2022[6].

In the European Union, where 131 reactors are already producing energy, four are under construction and a dozen more planned. The leader is France, where 58 reactors are responsible for 75% of electricity in the national grid. Around Poland, within 300 kilometres of the country's borders, ten power plants are located (with 23 energy generating units), and several more are in the pipeline. On the other hand, following some countries' shutdown plans for the coming years, a number of reactors will cease operations, especially in Germany (9), Belgium and Spain (7 each).

When analysing the nuclear power experiences of other countries, particularly those in Poland's neighbourhood, it should be remembered that in each of them the decision to go nuclear (or to shut down plants) should be traced to a particular moment in history, a particular economic situation, a particular alignment of political forces and a particular public mood. In many countries, this decision came as a natural consequence of civilian-military cooperation after World War II. In some other ones, it came in response to a deficit of electricity generating capacity and limited access to other energy sources (as reflected in the adage "No oil, no gas, no coal, and no choice"). Still other countries are now gradually abandoning nuclear power generation, citing the evolution of alternative methods,

EU countries, by nuclear energy use

EU COUNTRIES USING NUCLEAR ENERGY		
investing in new nuclear power plants	not investing in new nuclear power plants	shutting down nuclear power plants
Bulgaria Czech Republic Finland France Holland Hungary Romania Slovakia Slovenia Sweden UK	Belgium Spain	Germany

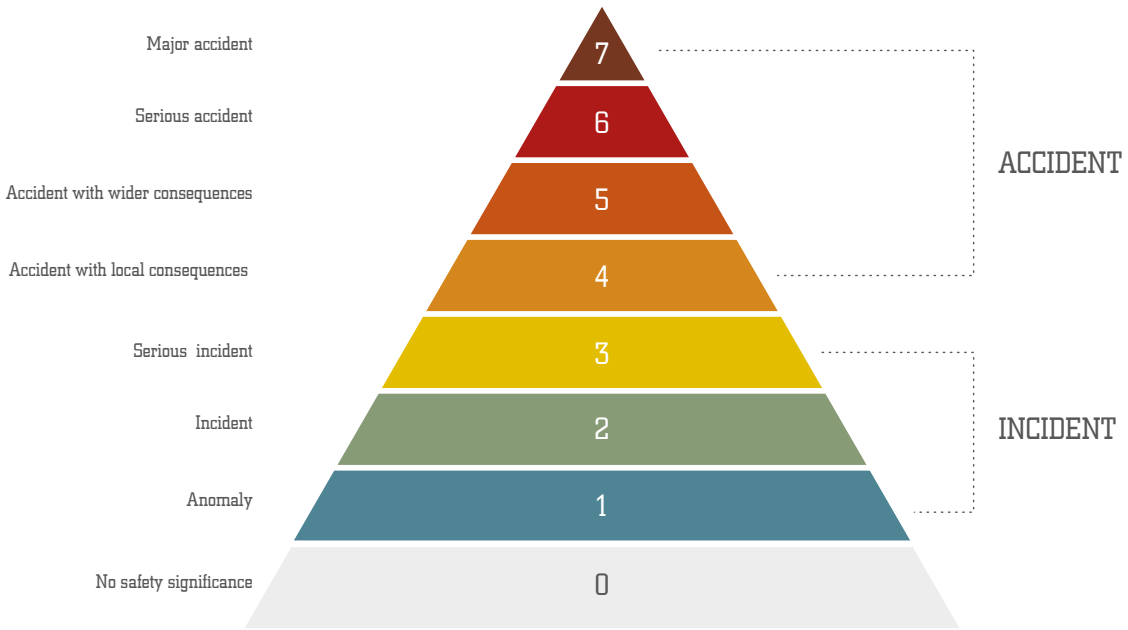
EU COUNTRIES NOT USING NUCLEAR ENERGY	
planning to build nuclear power plants	not planning to build nuclear power plants
Croatia Estonia Latvia Lithuania Poland	Austria Cyprus Denmark Greece Ireland Italy Luxembourg Malta Portugal

"OBVIOUSLY, POLAND SHOULD BE BUILDING AS MANY NUCLEAR PLANTS AS IT NEEDS. IT MAY TURN OUT, FOR EXAMPLE, THAT GERMANY WILL SOON BE IN NEED OF ELECTRICITY SUPPLIES. IF YOU LOOK AT EUROPE, YOU WILL SEE THAT THE AUSTRIANS ARE PRETENDING TO 'GO GREEN', THE ITALIANS ARE PRETENDING TO 'GO GREEN', BUT EVERYBODY IS BUYING NUCLEAR-GENERATED ELECTRICITY ON A LARGE SCALE, VERY LIKELY FROM FRANCE. SO IT MAY TURN OUT THAT POLAND WILL BE SUPPLYING ELECTRICITY TO GERMANY. THIS IS ALL A QUESTION OF PROFIT-AND-LOSS ACCOUNTING AND DEMAND FOR ELECTRICITY."

environmental concerns and fear of nuclear power breakdowns.

The growth of the nuclear energy industry around the world has obviously been cyclical and uneven. Periods of dynamic expansion, driven by an increasing demand for energy coupled with threats to the security of energy supplies, were interspersed with periods of slowdown or stagnation in the wake of nuclear plant breakdowns, especially major accidents with the gravest consequences[7]: the Three Mile Island (USA, 1979) and the biggest accident, Chernobyl (USSR, 1986) and Fukushima-Daiichi (Japan, 2011). After Fukushima, a number of countries verified their nuclear programmes. Japan closed its plants immediately and only in July 2014 did it opt to resume operations. But in Germany, the withdrawal from nuclear energy (*Atomaustieg*) and the new energy policy (*Energiewende*) are seen as irreversible, ending years of discussions about whether the country should stay on the previous course or abandon it.

The international nuclear and radiological events scale



Source: Classification according to International Nuclear and Radiological Event Scale (INES).

In a simultaneous process, nuclear energy countries have accelerated their research on security improvements. Based on EU-wide stress tests, many nuclear installations, even around the world, underwent thorough revamping over the past years, resulting in lifetime prolongations of 10-20 years for many reactors, which were opened in the 1970s and otherwise would now have to be shut down. And incumbent reactor manufacturers, teaming up with research centres in many countries (including Poland), have been developing secure nuclear technologies for the so-called new generation of reactors.

While nuclear energy's global context, which determines the future of the Polish energy programme, has been constantly evolving, many of its elements stay unchanged. In the nuclear energy recommendations presented by the Polish Institute of International Affairs in 2007, emphasis was placed on the importance of the Polish nuclear programme as a foreign policy instrument[8]. Poland, it was argued, could join the so-called civilian nuclear club and, consequently, pursue a more active energy policy in the international forum. The construction of a nuclear power plant would also help strengthen

The first Polish nuclear reactor at Świerk (photo: 29 April 1958)

bilateral relations with countries making nuclear fuel or supplying the technology. Apart from the purely political aspect the document presented the benefits from nuclear power generation in Poland, related to improved security, the economy and the environment. The list of measures required for the nuclear programme to be set in motion, drawn up at that time, retains its relevance today.

IN HISTORY

The Polish nuclear energy project is by no means a new idea, with discussions about plant construction dating back to the 1950s and US President Eisenhower's Atoms for Peace speech. But Poland was then part of the eastern bloc, and it was only in 1955—after the USSR joined the Atoms for Peace programme amidst a relaxation of international relations—that the Polish government could announce the establishment of an Institute for Nuclear Research (IBJ), thus opening a debate on the country's nuclear power prospects.

Scientists at Świerk (the IBJ's seat) then proceeded to assemble Poland's first research reactor, purchased from the USSR in 1956, which was known as EWA (the Polish-language acronym standing for experimental, water-based, and atomic; and also the Polish version of the female name). The successive reactors—Maryla, Anna, Agata and Wanda—, developed by the Poles themselves, were used for reactor-technology research, nuclear physics and verification of theoretical computations. The only research reactor still operational in Poland, the 30 MW Maria, launched in 1974, is used for the manufacture of radioactive isotopes and for an array of nuclear research projects.

In the early 1970s, in an atmosphere influenced by rising demand for electricity, rumours about an approaching peak of carbohydrates' production, and the construction of the first two Russian pressurized water reactors, the Polish government adopted a resolution on preparatory work for the construction of a nuclear energy plant. It was to be located at Kartoszyno, a Kashubian village on the Żarnowiec Lake in Pomerania region, for reasons which included favourable geological conditions, access to vast water resources, low population density (no big problems with resettlements) and an energy deficit in the northern part of the country. Simultaneously, a plan was adopted for the construction of a pumped-storage hydro station at a nearby village of Czymanowo, which would serve to stabilize the region's power network, when needed.

In 1974 the Polish and Soviet governments signed a preliminary agreement on cooperation in building a nuclear power plant incorporating the Soviet technology VVER-440. The formal go-ahead was given by the Council of Ministers on 18 January 1982. A month later the National Atomic Energy Agency was set up, and towards the end of March the ground was broken on the Żarnowiec project. In addition to four nuclear power generating units the project included infrastructure facilities, such as a railway station, a workers' hostel, welfare buildings and warehouses, to be initially used during the construction work and subsequently serve the power plant as functional facilities, laboratories, or a radio-meteorological centre. Importantly, while the Soviet-designed reactors were to be produced by Czechoslovakia's Škoda, many key elements, such as engine-room turbines, generators, steam generators, surface condensers, piping, etc., were to come from Polish manufacturers. The launch of the first nuclear power generating unit was initially slated for 1989, but it soon became clear that December 1991 would be a much more realistic deadline.

> "WE IN OUR COUNTRY WILL ALWAYS REMEMBER CHERNOBYL AND WHAT WAS GOING ON WITH NUCLEAR TECHNOLOGY IN THE SOVIET UNION AND RUSSIA. BEING A SPECIALIST I HAVE KNOWLEDGE OF WHAT CAN HAPPEN, BUT THE PUBLIC DO NOT KNOW SPECIFICS OF THE CHERNOBYL DISASTER, THEY ONLY KNOW THAT THERE WAS THE EXPLOSION. NO-ONE REALISES THAT THEIR MODERATOR WAS GRAPHITE, RATHER THAN SOMETHING INCOMBUSTIBLE, AND NO-ONE SEEMS TO NOTICE THAT NO SUCH TECHNOLOGIES ARE DEPLOYED IN THE WEST."

A completion of Poland's first nuclear power plant was thwarted by the Chernobyl disaster, the worst in history, on 26 April 1986. Even today it is hard to evaluate its scale, the number of victims and the environmental impact, with its adverse consequences magnified by the initial lack of information and the subsequent disinformation campaign. Feeding on fears of a repetition in Poland, a wave of protests against the continuation of the power plant construction swept the country. Paradoxically, at that particular time, a new nuclear power plant project was developed—known as Warta, and planned to be sited at Klempicz, outside Wronki—but it was finally abandoned in 1989, notwithstanding the launch of preparatory work. Following heated parliamentary debates, a local referendum in Gdańskie Voivodship (86.1% against Żarnowiec nuclear power plant), and campaigning by environmentalists, the government's decision on winding up the unfinished Żarnowiec project was endorsed by the Sejm (lower house of Parliament) on 9 November 1990. But in a Sejm resolution on the outline of Poland's energy policy to 2010, room was left for the construction of next-generation power plants with improved "economic efficiency and environmental safety."

The Chernobyl catastrophe was not the only factor behind the project's discontinuation; there were also financial problems, reflecting the country's economic collapse, and doubts began to be expressed about the project's importance for the country's energy balance and about its profitability, as against the coal fired plants. At that time, questions such as environmental concerns, energy efficiency or competitiveness carried somewhat lower weight in the debate.

In retrospect, from hindsight, the abandonment of Żarnowiec power plant at an advanced stage of construction should be seen as a missed opportunity. VVER-440 reactors are still operated in several European countries (Slovakia, the Czech Republic, Hungary, Finland) in compliance with EU safety standards. Worse still, the discontinuation involved huge costs, even despite finding buyers for part of the equipment (which still can be found in operational reactors in Loviisa, Finland, and Paks, Hungary). Only a few elements of the infrastructure were disassembled, while many other ones either went to waste or were stolen. Concrete structures at Żarnowiec have been crumbling and are no longer usable, even though the Żarnowiec Lake area is still considered a possible site under the current Polish Nuclear Energy Programme. Although a vast human potential was wasted away—the engineers and specialists preparing for the project lost career prospects inside the country—research in nuclear physics and chemistry has never been closed in Poland. In fields such as manufacture of radiopharmaceuticals and radioisotopes Polish scientists have made it to the international elite.

> "I AM MORE AFRAID OF THE POTENTIAL VOLATILITY OF ELECTED POLITICIANS - WHO HAVE AMPLY DEMONSTRATED THEIR CAPACITY FOR ILLOGICAL DECISIONS - AND I ALSO DREAD THE PROSPECT OF THE PROJECT BEING DERAILED BY LITTLE GAMES OF THIS OR THAT SIDE OF THE COUNTRY'S POLITICAL DIVIDE. YES, THIS IS MY BIGGEST FEAR."

IN NEED

By 2020, a fifth (6.4 GW) of Poland's electricity generating capacity will be lost (down to 37.4 GW)[9]. Some coal-fired plants will not be modernised, in view of the tightened up requirements under the Industrial Emissions Directive (IED), other ones will retire at the end of their respective operating lifetimes[10]. Given the aging capacity (with over a half of equipment being more than 30 years' old), power generating blocs of between 13 and 18 GW will have to be opened over the next years just to replace the losses[11]. And forecasts put electricity consumption in 2030 as some 30% higher than in 2013, reflecting a growing demand from households (getting close to the EU-15 level) and the country's economic growth[12].

Poland is thus in need of adding new generating capacity. Four new-generation coal-fired blocks are currently under construction at Kozienice, Opole, Jaworzno and Turów, which may stave off the prospect of capacity deficit, but reaching a sustainable

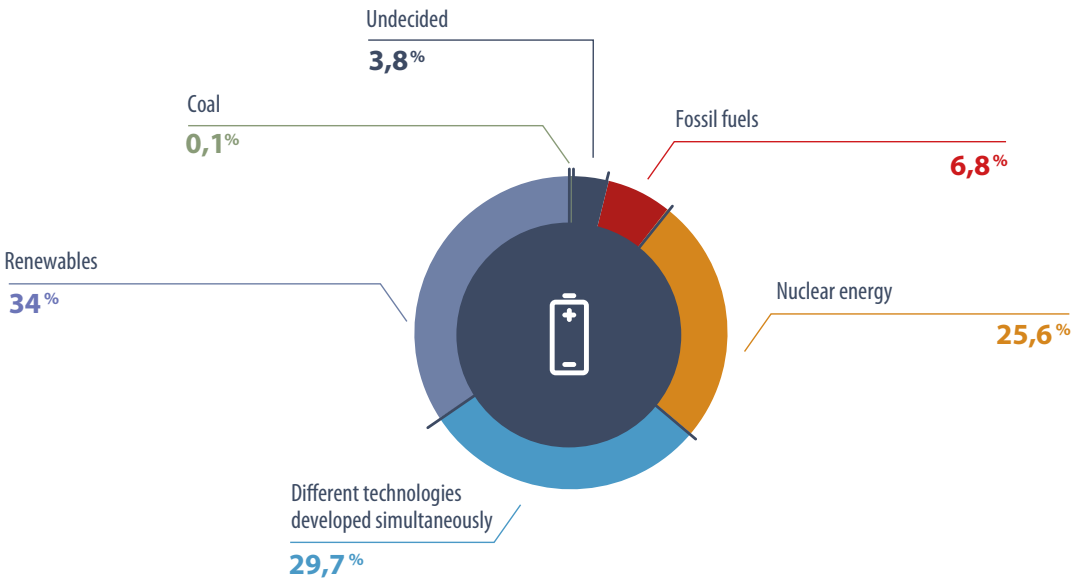
"I AM VERY ATTACHED
TO THE COAL INDUSTRY,
BUT I KNOW THAT COAL HEGEMONY
CANNOT LAST AND THAT ITS PRESENCE
IN THE ENERGY MIX WILL BE
GREATLY SCALED DOWN BY 2050.
COAL'S SHARE IS NOW 80%,
AND IF THE INDUSTRY RETAINS
A 30% PROPORTION,
IT WILL BE A HUGE SUCCESS."

and diversified energy mix—now far removed from international and EU standards—remains a long-term challenge.

Energy security and climate protection are the two problems to be tackled by the decision-makers working on the new energy policy for Poland. Thanks to large coal deposits (compared to other EU countries) Poland has one of the EU's lowest energy dependency ratios (30.7% in 2012). But the domestic coal reserves are increasingly harder to access, translating into increasing costs, which results in growing imports of coal (from 1.5 million ton in 2000 to 11 million ton in 2013, of which two-thirds came from Russia). Reserves (hard coal and lignite) are expected to last for some 40 years[13]. The present mix is untenable, primarily because of the EU's environmental goals (climate, emissions).

As demonstrated in projections drawn up for purposes of the new energy strategy, the scenario of an ambitious climate policy (translating into high prices of CO_2 emission allowances) will necessitate the adoption of low-emission solutions—and there can be no doubt that nuclear power generation is one of them. At the same time, though, it is emphasized that coal is and will continue to be an important part of the Polish energy sector. The decision to put up a nuclear power plant does not change the rationale for investing in new coal/lignite-fired plants until 2050. Only in the longer-term does coal's share drop perceptibly in the adopted models. The picture for lignite—assuming that it is is provided from newly developed fields—is different: despite the construction of nuclear power plants with a combined capacity of 6 GW, the projections do not provide for any lessening of lignite's role[14]. It is thus important to note something which

Which energy technologies do you think should be given priority in Poland? (single reply)



"BASICALLY, I AM ALL FOR DIVERSIFICATION OF SUPPLIERS AND SOURCES OF ENERGY. AS I SEE IT, IT IS IMPORTANT TO CHOOSE SUCH PRODUCTION METHODS WHICH BRING THE BIGGEST BENEFITS - FOR THE ECONOMY, THE ENVIRONMENT, ALSO FOR THE SOCIETY. BUT EACH OF THESE AREAS IS SO ENORMOUS; EACH IS A SEPARATE CHAPTER."

"GENERALLY, WE SHOULD NOT TURN AWAY FROM ANY TECHNOLOGY; WE SHOULD DISCUSS ALL OF THEM AND WEIGH UP THEIR RATIONALE, SECURITY, AND BUSINESS CONSIDERATIONS. EXTRAVAGANT TRUST IN A SINGLE TECHNOLOGY MAY CAUSE US PROBLEMS IN THE FUTURE AND PUSH US BACK. ON THE OTHER HAND, THOUGH, OUR SCEPTICISM SHOULD KNOW LITTLE BOUNDS."

is often ignored in discussions about nuclear power generation: in order to "defend" coal/lignite in relations with the European Union (on which Poland insists in its energy union proposal), the country must have access to solutions with which to satisfy the climate-related requirements. Thus, in order to keep coal and lignite in the Polish energy mix, this mix must include nuclear energy.

The concept of building a nuclear power plant in Poland was restored on 13 January 2009, when the Cabinet adopted a resolution on developing the Polish Nuclear Energy Programme, which was followed in November 2009 with the adoption of the document "Poland's energy policy to 2030," providing for nuclear power's addition to the national energy mix. The decision reflected an ambitious

Timetable for Polish nuclear energy programme

STAGE I: 1 January 2014 – 31 December 2016:	**28 January 2014.** **Polish nuclear energy programme adopted by Cabinet.** Selecting plant site and signing supply contract for nuclear technology selected for Poland's first nuclear plant.
STAGE II: 1 January 2017 – 31 December 2019:	Completing the technical design and obtaining the licences and opinions required by law.
STAGE III: 1 January 2020 – 31 December 2025:	Obtaining the construction permit, completing the plant's first block and connecting it to the national grid; starting construction work on successive nuclear power generating blocks/plants.
STAGE IV: 1 January 2025 – 31 December 2030:	Continuing and starting construction operations on new generating blocks/ launchingthe construction of the second nuclear power plant, to be completed by 2035 (6 GW, combined).

approach to the EU's climate and energy policy, and was seen precisely as a means of reaching the emissions reduction goals. It also came amidst disappointment over lack of progress with the planned nuclear project in Visagina, Lithuania, where Poland was to be a partner along with other Baltic states. Poland's period of preparations for nuclear energy generation was crowned by the Polish Nuclear Energy Programme, adopted by the Cabinet in January 2014. It should be noted that while the prime objective is for the nuclear plants to supply the country's growing energy needs in a sustainable manner, the initiated programme is also about something more. "After being a passive watcher and a consumer of advanced nuclear technology and inputs, Poland would turn into an active party to the global policy on energy security and contributor to technological change in the field of nuclear power generation.[15]"

"WE ARE NOW IN A STANDSTILL - UNNECESSARILY. UNEQUIVOCAL DECISIONS MUST MADE, AND CONCRETE STEPS TAKEN IF WE REALLY WANT TO BUILD A POWER STATION. AND IF WE DON'T, SOCIETY MUST NOT BE BEGUILED INTO THINKING OTHERWISE. WE ARE DEVELOPING AN ENERGY POLICY THAT INCLUDES NUCLEAR ENERGY, WITH ALL ITS CONSEQUENCES, AND IT'S TIME FOR ACTION NOW."

CONCLUSIONS AND RECOMMENDATIONS

- The consequences of Poland's entry in the international nuclear energy community should be analysed in both the long and the short term, and also in the social, economic, political and technological context. Implementation of the Polish nuclear energy programme has a strategic importance, as it will contribute to bringing greater energy security and to strengthening Poland's international position.

- Having proposed in the EU forum to establish an energy union, Poland should call not only for the full use of fossil fuels available in the EU area, but also for pursuing a diversified and sustainable energy mix which takes into account all energy sources, including nuclear. Poland's draft document on energy policy to 2050 is a step in this direction.

- The nuclear option, where electricity generation is combined with observance of climate protection requirements, offers for Poland a way of meeting the EU goals. With nuclear power described as part of Poland's energy mix in all projections and analyses, it is high time for the discussion to focus not on "whether" but on "how" to implement the Polish nuclear energy programme.

- Continued work on nuclear power adoption is of key importance for Poland's overall energy sector, and the timetable provided in the Polish nuclear energy programme must be steadfastly implemented. But the document itself, even with its highest status, is not in the nature of a roadmap for all the stakeholders (the way the UK's "Nuclear White Paper 2008: Meeting the Energy Challenge" is). The present report may thus open up a wider debate and inspire the publication of a Polish white book on nuclear energy.

- In every country, approval for nuclear energy is contingent on an ability to think in terms of the future. What is needed is long-term thinking and long-term investment projects. As it is, the current expenses and risks may well be offset by the future benefits and energy security.

2

ECONOMICS IS THE CORNERSTONE

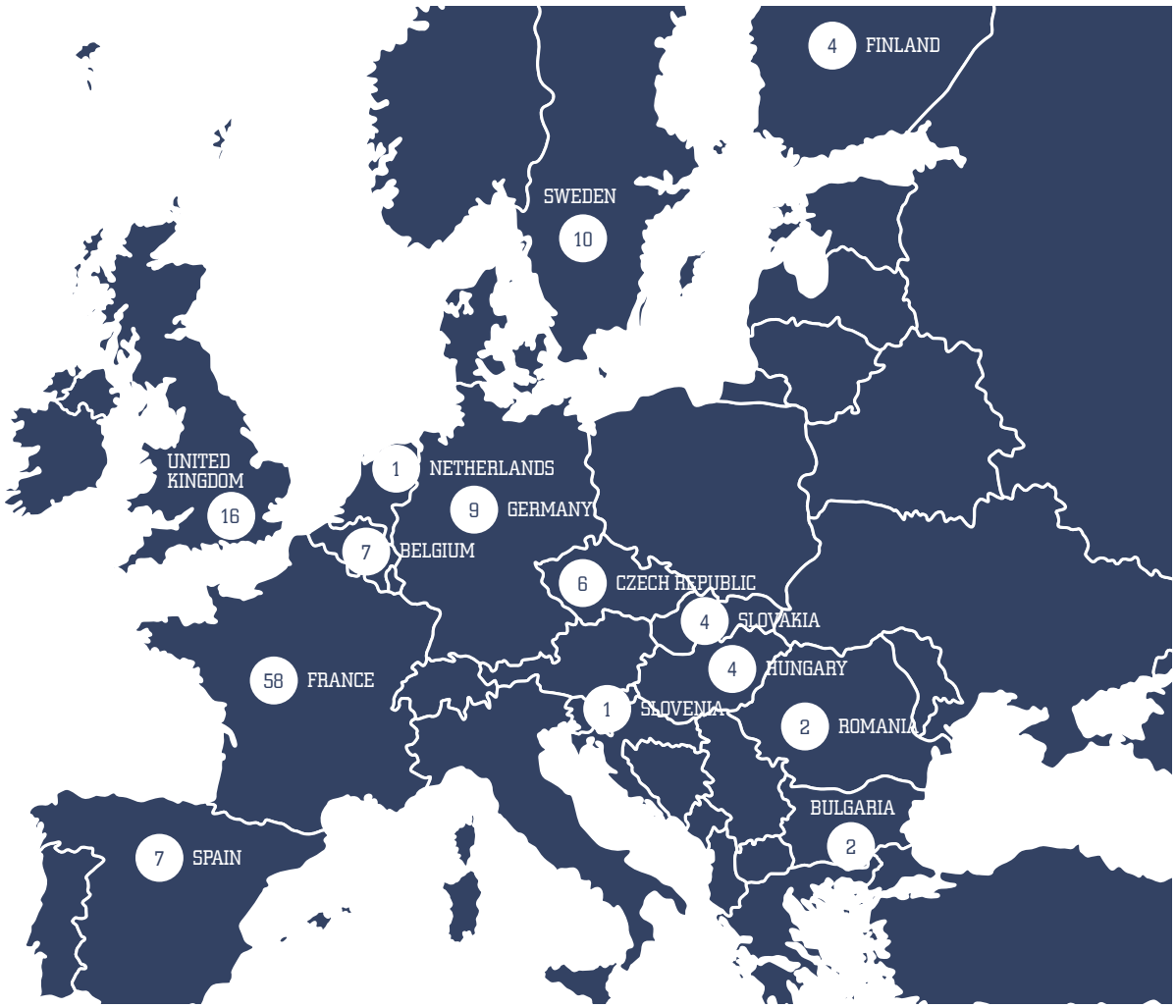
MODEL SUPPORT[16]

As demonstrated by the experience of energy sector liberalization in recent years, a lack of new capacity investments has increasingly been a problem for more and more EU Member States. Faced with a prospect of power outages in several years' time, they are giving consideration to a variety of investment support mechanisms and instruments, some of a systemic nature (capacity market), others providing stimuli for particular technologies. Thus the debate on support for new nuclear power plants has been held against a wider discussion on government vs. market in the energy sector. The choice of support instruments is constrained by EU regulations on the internal market, competition and, in particular, state aid.

Poland can pick from a pool of ideas followed by other EU countries, with the UK model attracting the greatest interest. In actual fact the United Kingdom is a trailblazer, as the first country to propose a reform with two key elements: contracts for difference (CfD) and capacity market. The goal for the former is to stabilize energy producers' revenue, and for the latter, to encourage investments in capacity[17].

> "WE CERTAINLY SHOULD OPT FOR CHEAPER SOLUTIONS —WHICH I REMEMBER BEING CALLED FOR BY SOME DECISION-MAKERS —BUT THE NOTION OF A LOW PRICE IS AMBIGUOUS. WE MUST NOT SHRINK FROM PUBLIC AID. THE EU IS WELL KNOWN FOR SUPPORTING, FOR EXAMPLE, AGRICULTURE AND FISHING. IF WE FIND OURSELVES 'POOR' IN ENERGY TERMS, WE WILL HAVE TO SUPPORT THIS FORM OF POWER GENERATION."

The British mechanism of support for the generating sector (capacity market) and renewables was approved by the European Commission in July 2014, as complying with the internal market regulations (even though constituting state aid). But the UK government's contract with an investor[18] to support



Number of nuclear reactors in the European Union

THE CONTRACT FOR DIFFERENCE

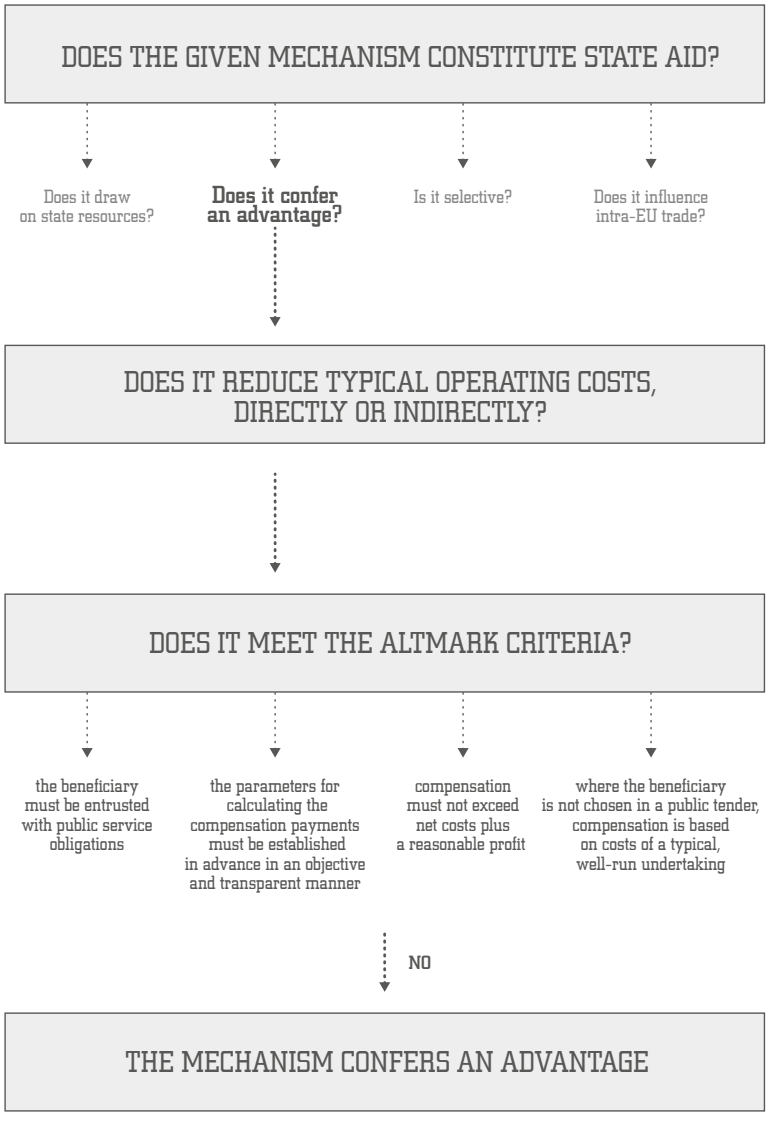
The contract for difference was introduced by the UK government in order to nudge investors towards new electricity generating ventures. The idea is to reduce the risk of electricity price fluctuations in the future. Under this financial instrument investors are compensated for a fall in market prices of electricity below the predefined strike price level (£ 92.5) in the duration of the contract (35 years for the nuclear sector), but they must pay back when the reverse is the case. In practice such contracts provide investors with a guarantee of fixed prices, incentivising them to take investment decisions.

the Hinkley Point C nuclear project has come under the Commission's scrutiny and is currently being examined as part of a separate investigation, opened in December 2013. The Commission's acceptance for some other energy sources is not yet a predictor of how it will assess support for nuclear technology. Here, the decision will be taken based on general treaty-law provisions, not on specific guidelines[19] under which simplified procedure is allowed. Consequently the question of Hinkley Point C subsidies will be examined on a case-by-case basis. It remains to be seen whether the arrangement proposed by the UK government meets the rigorous state aid requirements, and whether competition law (after all,

one of the strongest domains of the Commission) will outweigh political considerations (the threat of the UK's leaving the EU, which has been voiced also in the context of nuclear energy). And it should be borne in mind that a Commission refusal would not yet mean the death warrant for the CfD formula, but would rather reflect the terms of that particular contract and its cost and benefit analysis, as presented by the UK government.

The British approach is novel, but it is not the only one. A unique model, known as *mankala*, has been developed for the construction of a 1200 MW Hanhikivi I nuclear power plant in Pyhäjoki, northern Finland. It involves a non-profit consortium of several dozen participants, including energy sector players (e.g. electricity wholesalers/retailers), industrial companies and municipalities, who will be buying output at cost. Importantly, it is planned that the price will not exceed €50 per MWh, or otherwise "there will be no deal.[20]" The consortium holds a 66% stake in the project, with the remaining 34% owned by Russia's Rosatom State Nuclear Energy Corporation, which is tasked with arranging the financing. A similar non-profit formula involving market financing has been deployed with another Finnish nuclear plant, Olkiluoto 3. Credit guarantee was provided by the French government's export credit agency Coface[21], and that did not provoke

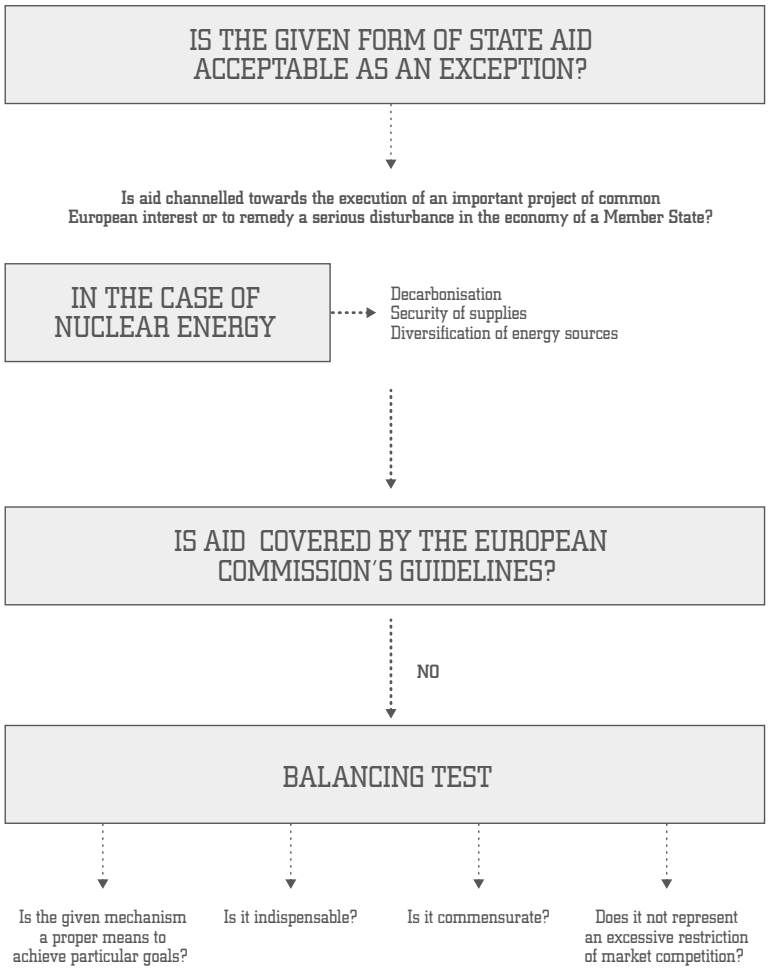
Asessment of the state aid mechanism as part of the European Commission's investigation into Hinkley Point C



COMMENTS:

Level 1: The European Commission, in assessing whether a given mechanism constitutes state aid within the meaning of Article 106 TFEU, looks into four criteria: transfer of public resources; conferral of an advantage; selectiveness; impact on intra-EU trade. For a mechanism to be deemed public aid, all the four criteria must be met. There can be no doubt that the first and third criteria are met: there will be transfer of public resources (the investment project will be subsidised by a special-purpose company established by the state) and there will be selectiveness (a particular investment project, Hinkley Point C). The fourth condition, which the Commission defines in very broad terms, contains nearly all forms of support. Consequently, the controversy over whether or not the Hinkley Point C contract constitutes state aid revolve around conferral of an advantage.

Level 2: The starting point in assessing whether a given mechanism confers an advantage is provided by the criteria defined by EU case law (Altmark). According to the Commission, the Hinkley Point C contract gives rise to many reservations regarding compliance with criteria 1, 3 and 4, and so it is doubtful if it met the conditions for it to be found as not constituting public aid.



COMMENT:

The European Commission has serious reservations, on all the four criteria used in the balancing test, as to whether the given state aid is warranted, pursuant to Article 107(c), as support for the execution of an important project of common European interest.

Asesssment of the state aid mechanism as part of the European Commission's investigation into Hinkley Point C

"FINDING A GOOD PROJECT FINANCING MODEL WILL BE CRUCIAL. IF WE SUCCEED IN FINDING ONE WHICH MAKES THE PROJECT PROFITABLE, THEN WHY NOT? SURELY, IT SHOULD NOT BE A STATE-ONLY VENTURE, AND SOME KIND OF PARTNERSHIP WILL BE NEEDED. BUT ON THE OTHER HAND, I CANNOT IMAGE ALL THIS TO BE DELIVERED BY A PRIVATE COMPANY, ALONG STRICTLY COMMERCIAL LINES. THE STATE MUST BE PRESENT HERE - REMEMBERING ABOUT ENERGY SECURITY - BUT IT SHOULD CONFINE ITSELF TO KEEPING AN EYE, INSTEAD OF RUNNING THE OPERATION."

objections on state aid grounds from the European Commission.

Commercial financing is, or was, tested in other EU countries, such as France, the Czech Republic or Slovakia. In France, the state-owned energy giant EDF, operating all of the country's 58 reactors, covers the costs of the latest project, Flamanville 3, drawing on its own resources, commercially raised capital and loans. Slovakia obtained credits from leading international banks to complete two reac-

tors at Mochovce—although some lenders, including Erste Bank and Bank of Austria later withdrew, citing the project's insufficient safety standards. And at Temelin, in the Czech Republic, the initial profitability numbers proved overoptimistic due to factors which included changes in energy prices[22]. In April 2014 the state-owned investor, CEZ energy group, requested public assistance in the form of price guarantees, along the lines of the British government's proposals[23]. When the request was rejected, the project was suspended and the procedure to select the contractor was called off.

Yet another business model was chosen by Hungary which, under a January 2014 agreement with Russia, will receive a 30-year export credit of some €8-9.5 billion to add two blocks to the Paks nuclear plant. Credit will cover up to 80% of the capital expenditureand costs of the first nuclear fuel supply. Apart from the political context and misgivings about strong dependence on Russia, the agreement raises doubts for having been concluded without public consultation, without a Parliamentary go-ahead, and even without a competitive selection procedure being followed. But the strongest doubts are about whether this form of government commitment complies with antitrust law.

POLISH DILEMMAS

The expected capacity shortage and lack of economic incentives to invest in new sources translates into a string of challenges for Poland, related to the security of supplies and state aid. Given the very high level of upfront costs for nuclear energy projects, state aid is not just warranted—it is imperative. But many dilemmas have yet to be resolved. Should the programme be entirely a market affair, or should investment support be provided? What form could such support take, and how would the state get involved—via subsidies or just credit guarantees? Should systemic mechanisms be provided (capacity market), or perhaps sectoral arrangements (contracts for differences for nuclear energy, green certificates for renewable energy sources etc.)?

Intense discussions are currently held in Poland over the notion of capacity market, a mechanism which seeks to provide additional financial incentives for generating companies, by stabilising their revenue and letting them stay profitable even at a low level of power-plant capacity utilization (shorter operational time)[24]. But Poland has yet to define in detail the tasks to be pursued by a capacity market, which come as a function of the adopted goal: when the goal is to support low-emission sources, system design will be different than when technological neutrality is sought. This dilemma is a testimony to hesitation about energy policy and about the optimal national energy mix that this country should pursue.

Still, the draft Polish energy policy to 2050[25] does provide that nuclear power will be an important part of the country's future energy balance, which means that thought should be given right now to indentifying the most effective arrangements in terms of stimulating the sector's growth and minimizing the burdens for consumers. In addition to contracts for difference, the draft document also allows for contracts for capacity (payments for generating capacity) and mixed arrangements, which shows that particular interest is taken in the British model, soon to be screened by the European Commission for compliance with EU competition law. If the Commission gives its go-ahead, a similar arrangement, though tailored to Polish conditions, will very likely be deployed in Poland, as indicated by pronouncements from the public administration[26] and the investor. That would, importantly, shorten the time in which to design support instruments and would facilitate preparations for the procedure of state aid notification (while by no means ruling out state aid as such). If the concept is adapted for use in Polish conditions, it should be remembered that the contract price in Poland will be influenced by different factors, either bringing the price down (e.g. labour costs, the level of electricity prices) or up (greenfield investments, requiring the construction of a transmission network, etc.). It is precisely the calculation of the strike price—which raises the Commission's doubts under the ongoing

> "THERE IS NO CHEAP ENERGY. NO FORM OF ENERGY GENERATION IS CHEAP."

investigation—that will pose the biggest challenge in Poland.

The expected costs of building the first nuclear power plant are put at between 40 billion and 60 billion zloty[27]. More detailed financial parameters will only be learned at the stage of competitive selection procedure, because only then will a consortium of willing companies give an initial description of its approach to capital exposure, and to project financing (which has been included into the integrated procedure)[28]. One of the weightiest problems is posed by the high investment outlays and the necessity of government involvement. It is important that the optimal arrangement be reached, both as regards the burden on domestic users and the requirements of EC assessment procedure. At the same time, the investor and the Ministry of the Economy must give reliable information to the public, explain the realities of the project, and dispel doubts about, e.g., the prices of electricity generated in the nuclear plant or direct Treasury financing of investment costs. Despite its high costs, the construction of a nuclear power plant may offer a new impulse to economic growth—according to M. Gronicki, the GDP may increase by an added 2.28%-3.57% by 2035[29] —especially after 2020, when the inflows of EU funding dry up and simple growth factors are used up.

INVOLVED INDUSTRY

If the opportunities offered by economic acceleration are to be tapped, domestic companies must contribute perceptibly to the project. In the Polish Nuclear Energy Programme, this contribution is put at 10% in 2020, 30% in 2024, and eventually at 60% (2030). Some stages of the project will be handled by a foreign investor, including the delivery of the reactor and the turbine-and-generator set (Poland does have some experience with turbosets, but not of such high output[30]). This does not rule out involvement of Polish sub-suppliers and co-production partners, especially in the construction, installation and engineering sectors.

According to preliminary research by the Ministry of the Economy[31], Polish companies could provide earth-moving and construction/assembly services, manufacture heating, ventilation and air conditioning (HVAC) systems, conduct welding operations and also produce and install: pressure vessels and piping, elements of electricity generating equipment, control and measuring apparatus, and automatics. The construction site, over several years, will give employment to between 2,000 and 3,500 workers, and the operation of one block will require a highly skilled personnel force of between 700 and 900[32].

For these opportunities to be tapped, Polish companies—many of whom have gained expe-

"NUCLEAR POWER GENERATION WILL ALSO RAISE THE LEVEL OF POLAND'S TECHNOLOGICAL ADVANCEMENT. THE INPUT FROM DOMESTIC COMPANIES - EVEN ASSUMING A 70% CONTRIBUTION OF FOREIGN PLAYERS - WILL PUSH US FORWARD TECHNOLOGICALLY."

POLISH COMPANIES WITH EXPERTISE AND POTENTIAL TO CONTRIBUTE TO THE NUCLEAR ENERGY PROGRAMME

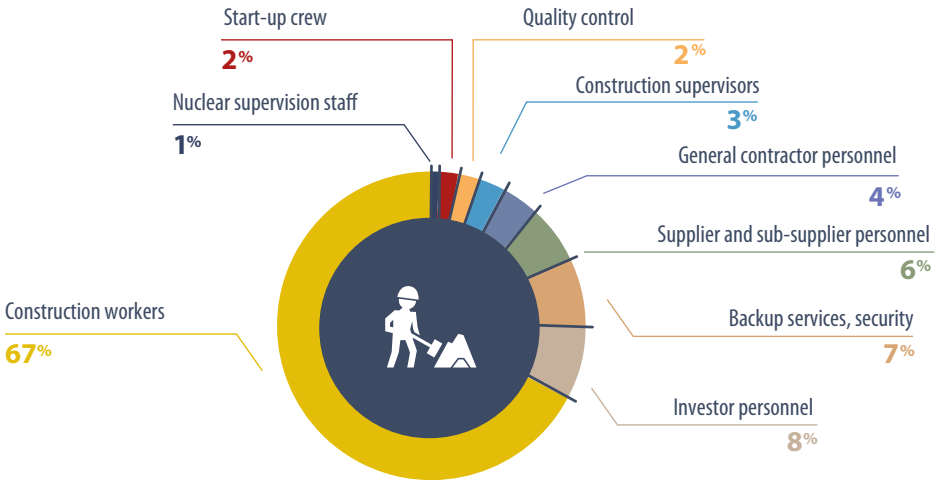
1. Companies supplying services and products to: Poland's Maria research reactor, foreign nuclear power plants (construction, repair, modernisation), research centres (CERN, ZIBJ, ITER); manufacturers of dosimetry systems—59 entities.

2. Companies engaged in serious preparations for interactions with the global nuclear industry—25 entities.

3. Polish subsidiaries of foreign corporations, supplying services and products to foreign nuclear power plants—21 entities.

4. Companies with an expertise which, after taking some adjustment measures, may be put to use in nuclear industry projects—more than 180 entities.

Source: A. Sidło, *Program polskiej energetyki jądrowej. Przygotowanie polskiego przemysłu,* presentation compiled for a meeting on 24 June 2014.



Workforce pattern at nuclear plant construction

rience with various kinds of nuclear projects, not only plant construction—will need to put in a great deal of fact-finding and preparatory effort[33]. To become eligible, they should run adequate quality management systems, employ trained personnel with required qualifications (command of English is a matter of course), and be familiar with nuclear design and construction standards, such as the French code RCC-M and the US code ASME. Changes towards meeting these conditions should be completed prior to the launch of construction work, or otherwise foreign suppliers (e.g. Areva, Westinghouse, GE-Hitachi) will not be able to subcontract Polish partners. Company management systems and organisation will have to be adjusted to the international nature of the project, and the complex supply chain, involving a multitude of entities, will require very effective logistics. All this necessitates changes in the paradigm of company operations, which may prove a tough challenge for those companies whose experiences are confined to the domestic market.

Participation in the construction of the first Polish nuclear plant will obviously require many years of preparations and a commitment of financial resources, and therefore it is important that the decision to embark on the project be taken as early as possible, in addition to being irreversible. Polish companies should perceive the preparatory effort as an added chance to expand into new geographical and product markets. The companies which already cooperate with international players in the nuclear industry have higher ratios of export-to-total revenue, and they have clients in many sectors, including energy (conventional electricity generation, renewable energy sources, mining, petrochemicals, gas engineering), shipbuilding and steelmaking[34].

The decision on building the nuclear plant in Poland will also have indirect consequences, by influencing preparations for project implementation on the part of technology supplier and investor. For any investment project, the process of signing up suppliers must be initiated much in advance, but in the case of a nuclear plant this is crucially important, for at least two reasons. First, for a number of nuclear-block elements there are several producers/suppliers present on the international market-reflecting growing competition in step with increasing numbers of new projects. Second, production for a nuclear project requires extreme accuracy, unique components, tight control, adequate quality management systems, and certification. According to US estimates[35], many elements have to be ordered up to three years before the launch of construction work.

PUBLIC-PRIVATE PARTNERSHIP

Over the coming 20—30 years, the global market for new nuclear power generation is expected to

top US$1.3 billion[36], and the Polish programme outlays are put at 40-60 billion zloty[37] (US$12.5-18.8 billion). This offers a chance for Polish companies, and for the Polish economy as a whole. Suppliers play an important role in planning nuclear-plant costs and construction stages, influencing a project's timetable and profit-and-loss accounting. Therefore, ensuring that such companies undergo adequate preparations and are brought into the Polish nuclear power development effort must be part of the government's strategy, involving a public-private partnership and building on synergies from many players. But it remains a challenge how public administration, business, industrial confederations, research institutes and academe will join forces to make the best use of business opportunities offered by the domestic and global nuclear market. Meanwhile, many examples of such collaboration can be found in other countries.

> "NUCLEAR AND RELATED TECHNOLOGIES WILL INCENTIVISE CUTTING-EDGE INDUSTRIES. ACTUALLY, THERE IS NO SECTOR WHICH WOULD NOT GAIN FROM THE PROJECT."

It has assumed the most comprehensive character in France where it involves all stages in the nuclear energy value chain, reflecting the country's long history of nuclear industry development. As many as 71 business clusters are in operation in France, to mobilise key competitiveness drivers (deploying innovations, contributing to economic growth, providing jobs, promotion abroad). In 2005, five companies and four academic centres set up a nuclear industry cluster (Pole Nucleaire de Burgogne, PNB), which currently comprises more than 170 participants, among them universities, large energy groups and small businesses. Cluster members exchange information about ongoing projects and benefit from the strength-in-numbers effect when it comes to influencing government decisions, generating publicity, engaging in a wide range of activities, pursuing a special patent policy, etc. With half of the cluster's budget coming from member contributions (and the other half from government), its successes largely reflect the membership's ability to mobilise and jointly implement nuclear project.

The United Kingdom currently seeks to revive its nuclear sector, to be supplying both domestic and international demand. For example, the Nuclear Industry Association (NIA) aims to improve the industry's commercial performance by supporting member companies to develop their businesses in the UK and oversees.

Another objective is to engage with the public media and political spheres to promote better understanding of nuclear energy and its role within a low carbon energy mix. The association represents more than companies across the supply chain. The diversity of its membership enables effective and industry-wide constructive interaction.

Similarly, Spain's Foro de la Industria Nuclear Española, established in 1962 to bring together companies involved in the civilian use of nuclear energy, seeks to integrate and coordinate their interests, as well as keeping the highest levels of safety and dependability in nuclear plant operations. Spain is a good example to follow, given the effectiveness of its programme and a very high involvement of domestic industry. Towards the end of the 1980s, when ten new reactors were being built, Spanish companies contributed as much as 85% to project value[38].

With many Polish companies already involved in nuclear plant construction around the globe, it would be a right path for Poland to set up a business cluster, an association or a similar forum, thus helping to outline long-term prospects for the development of domestic nuclear power generation, enter into cooperation with similar organisations abroad (e.g. PNB in France, NAMRC in the UK, Finnuclear in Finland, Nijni Novgorod Cluster in Russia), and also boost Polish companies' competitive edge and foreign expansion. Actually an initiative to establish a first such cluster of companies with nuclear project experience and academic centres, known as EuroPolBudAtom, has already been launched. Its members promote knowledge about nuclear energy, but if it is to provide effective support for all those seeking to land contracts related to Polish nuclear plant construction, the group is advised to

"IF POLAND IS TO DEVELOP NUCLEAR POWER GENERATION, DOMESTIC INDUSTRY MUST BE A PART OF THE PROJECT, OTHERWISE IT WILL MAKE NO SENSE. DOMESTIC INPUT WILL BE LOW INITIALLY, BUT IT WILL GROW WITH TIME."

have its status transformed to that of a chamber of industry.

As demonstrated by other countries' experiences, a solid public-private partnership is imperative in order to facilitate Polish companies' participation in the nuclear energy market, and ensure that they derive maximum benefits from nuclear technology development in Poland. Given the scale of the project and the extent of preparations, state involvement is highly desirable. The Ministry of the Economy is already working to mobilise Polish companies and help build their competitive advantage. It is worth to mention about the project "Analysis of Polish industry's capacity to contribute to nuclear energy development and of the criteria involved," financed by the National Centre for Research and Development. Over two years (2012-2013), with a view to supporting the Polish nuclear energy programme, analyses were made of all stages and elements of the investment process, industry standards and regulations, and company offers. It transpires that a whole gamut of companies, large and small, are capable of participating in the country's first nuclear power plant project. But their success is contingent on how they will be prepared for interacting under a nuclear public-private partnership at home and making use of their acquired competencies abroad.

CONCLUSIONS AND RECOMMENDATIONS

- The biggest challenge for the investor and the government is to find such a financing model for new blocks' construction which will produce a positive return on investments and will not be classified by the European Commission as illegal state aid. The contracts for difference represent a solution, which reduces risk for an investor, being at the same time part of a market model.

- The arrangements to be provided for the nuclear energy sector must not ignore the future model of the Polish electricity market; they must take into account the wider debate on the launch of capacity market and must coexist with other technologies, based on coal, renewables, and gas.

- Partnership and involvement of the widest possible group of stakeholders are key to reaping the biggest benefits for domestic companies and the Polish economy as a whole. But if the existing potential is to be successfully tapped, preparations should already begin for a push to mobilise Polish companies and build their competitive position in the marketplace. What has been done so far in this respect is neither sufficient nor satisfactory.

- One possible solution is to draw up a roadmap—a kind of textbook for Polish companies intending to operate in the nuclear sector—which would specify the demand for particular products, key requirements, procedures to be followed by contractors (e.g. certifications), and the potential Polish entities. The synergy effects benefitting an array of industries should also be identified, including reorientation of declining industries (such as shipbuilding) and of sectors where output is limited by natural factors. Support for Polish business must be accorded priority treatment while the Polish Nuclear Energy Programme is underway.

3

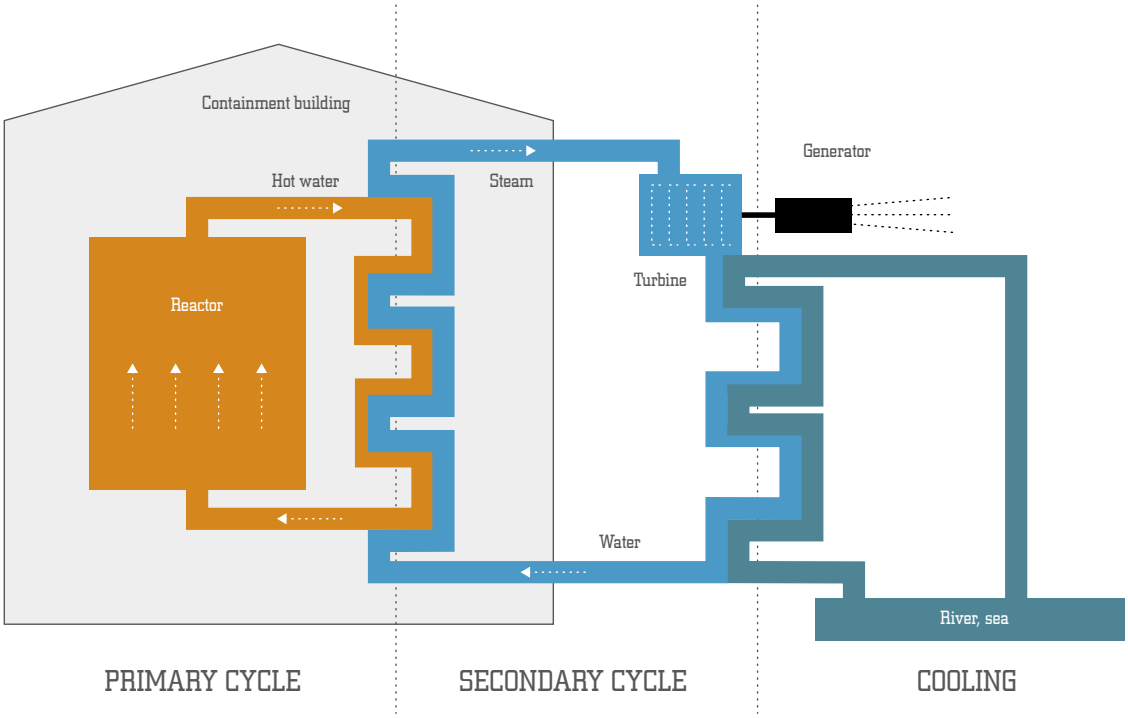
TECHNOLOGY IS THE FUTURE

KEY DECISIONS

As is the case with many other technologies, nuclear power generation epitomises the human desire to harness the nature, down to its smallest particles; it is a manifestation of human creativity and dedication by generations of scientists; the result of arduous efforts and never-ending scientific pursuits. But the processes involved in chain reaction inside a reactor are much subtler than, for example, burning coal, even if both technologies are in fact deployed for the same reason, to generate heat. Just as any conventional power plant, the nuclear station comprises the part where the fuel's energy is converted into the energy of compressed steam, and the part where expanding steam is turned into the mechanical energy of rotational movement of the turbine and the generator, thus producing electricity.

The decision to launch this complex technology in Poland gives rise to a series of more detailed conclusions. First and foremost the type of the nuclear plant must be chosen, which is contingent on what kind of resources are used in reactor control. Three factors are of the essence: the fuel used to produce energy (mostly, uranium, plutonium or thorium), the moderator to slow down neutrons (water, heavy water or graphite), and the coolant to absorb heat from the reactor core and pass it to the steam generator (water, heavy water or gas). Thus the most frequent types of reactors are light water reactors (LWR) and heavy water reactors (HWR), their designations describing the moderators used to control neutron energy inside the reactor core.

The light water reactors, accounting for more than 80% of all reactors across the globe, use water as both moderator and coolant, which means they have to be sited near large water reservoirs. This group includes pressurised water reactors (PWR, and its Russian equivalent, VVER) and boiling water reactors (BWR), which differ in steam circulation designs. The domination of PWR reactors in global nuclear power generation (62%) reflects the circumstance that they are also used to propel submarines and ice-breakers, thus attracting interest and funding from the military. But a problem with PWR reactors is that water is highly capable of absorbing neutrons, which means that uranium has to be enriched before being used-



Construction scheme of a pressurised water reactor (PWR)

in other words, the fissile isotope content in the uranium must be increased so as to make chain reaction possible.

In HWR reactors (some 10% of the total), the coolant and moderator functions are performed by heavy water (D_2O). It is better, more stable than light water, and therefore these reactors can use natural uranium fuel, with no need for enrichment. The technology is thus popular with countries endowed with large uranium deposits. Canada is the most renowned producer of these reactors (CANDU), with the technology being deployed in Romania, India and other countries. While the economic benefits of not having to use enriched uranium are considerable, huge costs are generated by the production of heavy water.

In terms of advancement and standards there are several generations of reactors, even if the evolutionary nature of technology development makes it difficult to accurately assign particular reactor types to particular generations. But it is possible to identify the main tendencies and describe their major characteristics.

The Żarnowiec project, Poland's first attempt at building a nuclear power plant, was to incorporate Russian-made pressurised water reactors involving second-generation technology, such as are still operational in a number of European countries. The current nuclear legislation in Poland requires that reactor designs should draw on tested solutions and ensure stable, simple and safe operation. Consideration is thus given to the light water reactor, as reflected in the location of potential sites near water reservoirs: in Krokowa—Gniewino, Gąski and

"THE WESTERN TECHNOLOGIES CURRENTLY DEVELOPED ARE SAFE, AND THERE IS NO DANGER OF ANYTHING BLOWING UP. BUT WASTES AND THEIR MANAGEMENT IS A REAL PROBLEM - AND SOMETHING THAT SHOULD BE TALKED ABOUT."

GENERATIONS OF NUCLEAR REACTORS

The first generation of nuclear reactors were experimental, low-capacity (up to 250 MW) devices taken over from military programmes and built between 1940 and 1950. Only in the late 1950s did a private nuclear sector take off, and a civilian use of nuclear energy began.

The notion of second generation reactors is applied to those which are most common in commercial use, usually of the LWR type. Following a conceptualisation phase in the 1960s, the bulk of them were built in the 1970s, with lifetimes initially planned at some 30-40 years but later prolonged due to improvements. Their safeguards, though, proved insufficient, as powerfully demonstrated by the Fukushima breakdown (boiling water reactors made in the 1970s).

The advanced nuclear power reactors of the third generation incorporate evolutionary improvements developed to overcome the imperfections of the second generation. They feature passive safety systems, an improved thermal and fuel efficiency, a shorter time and lower costs of construction. Some of the newest reactors, made possible by public-private research conducted in the 1980s and 1990s, are referred to as generation "III+". The third generation technology is seen as well tested and safe, accounting for a largest proportion of the nuclear installations currently under construction.

Research into fourth generation reactors, launched towards the close of the 1990s, represents a radical departure from the second- and third-generation technologies. Designs seek to eliminate faults constraining the spread of nuclear power generation. They are aimed to help minimise climate change, reduce the amount and radioactivity of waste materials, improve nuclear systems' safety and reliability, lower core damage frequencies, boost a competitive advantage over other energy sources, cut down construction times and costs, and make the technology more proliferation-resistant. But the commercialisation of these unique, innovative improvements is a distant prospect indeed.

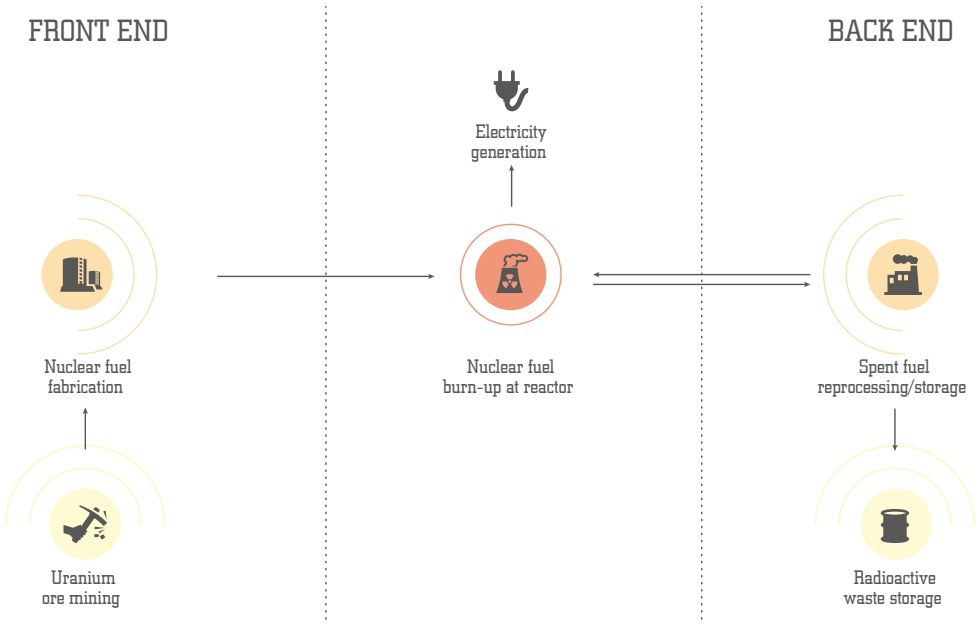
Lubiatów. But before the winning bidder is selected (the tender will be launched in 2015) it will not be known if this is a pressurised-water or boiling-water reactor. As of now the project's investor, Polska Grupa Energetyczna SA (PGE), has agreements with manufacturers of third generation reactors: Electricité de France (so-called European pressurised reactor, EPR), GE Hitachi (boiling-water reactors ABWR and ESBWR), and Westinghouse (pressurised boiling water reactor involving passive safety design, AP 1000 PWR). There is no way to adjudicate which offer is the best technologically, so the selection process will also draw on other factors such as price, full safety analysis and domestic content.

The selection of the reactor does not necessarily determine the future course of national nuclear power generation and subsequent technology choices. If the Polish nuclear programme expands and the country opts to build successive plants, two paths will be possible: specialisation and continuation of the incumbent technology (as followed by France and Romania) or deployment of different technologies (as in Finland and the UK).

The future of the Polish nuclear sector will also be influenced by the work on a fast gas-cooled reactor, carried out at the National Centre for Nuclear Research in collaboration with colleagues from Visegrad Group countries under the motto "V4G4: Visegrad four for fourth generation reactors[39]." Technology change has been proceeding at a rapid pace and Poland, by entering the global nuclear club, may increasingly be a part of this process.

LONG-TERM COMMITMENTS

With the selection of a particular nuclear technology vendor, a country assumes the long-term obligation to use a particular reactor, and this largely determines the purchases of many services related to the nuclear fuel cycle (which includes a series of steps, from the extraction of ores containing



Nuclear fuel cycle

fissionable materials, to nuclear fuel production, to fuel burn-up and the final stage of either spent-fuel storage, in an open cycle, or reprocessing in a closed cycle).

As a rule, the supplier of technology also delivers the nuclear fuel over the first several years of reactor operations. To avoid the pitfalls of monopoly, the supplier is required to share fuel fabrication data with other potential fabricators, to make possible the choice of suppliers of successive fuel chain services, based on their respective market offers. A stable execution of successive steps in the nuclear chain guarantees the safety of nuclear power generation and continuity of electricity supplies. The light water reactor planned to be installed in Poland requires shipments of uranium concentrate, access to fuel cycle services, and reliability of uranium transportation at all stages of fuel fabrication.

More than a half of global uranium output comes from Australia, Kazakhstan and Canada, with Russia, Niger and Namibia also high on the roster. In Poland, companies dealing with uranium prospecting, mining, processing and exports operated between 1948 and 1972. The country's largest deposits—even if minute on a global scale—are in the Sudety and Góry Świętokrzyskie ranges, and according to ongoing geological research, uranium could also be obtained from Vistula Spit sandstones. This is a very distant prospect, though, remembering that in addition to availability, uranium extraction is also contingent on its market price. Uranium mining is highly capital-intensive, and its kilogram must cost no more than US$80 for the deposits to be considered commercially viable. This is why the KGHM company is considering acquisition of shares in mine operations based abroad, where extraction is more profitable. In addition to that, uranium mining is highly invasive environmentally, a result of its low density in the rock and the need to undergo a series of metallurgical processes. On average, in

> "NUCLEAR ENERGY IS THE RIGHT CHOICE. IN TERMS OF STABILITY THIS IS THE MOST PREDICTABLE OPTION. THERE ARE NO PROBLEMS WITH SUPPLIES, AND CLAIMS ABOUT SCARCITY OF URANIUM ARE JUST LIES. URANIUM CAN BE FOUND IN MANY NEUTRAL COUNTRIES. IT IS OUTRIGHT IMPOSSIBLE FOR THE URANIUM MARKET TO BE MONOPOLISED."

order to obtain 1 ton of yellowcake from 0.1% uranium ore, some 1,000 tons of rock must be processed.

The next stage in the nuclear cycle for a typical light water reactor is the conversion of uranium concentrate into gas (UF_6), followed by enrichment to raise the percent composition of uranium-235 from 0.7% to above 3%. The four largest uranium converting companies, meeting the bulk of global demand, operate in Canada, France, Russia, the UK and the US. Europeans usually buy from the French company Comurhex and the UK's Cameco. When it comes to uranium enrichment, one half of the market is held by companies based in Europe (France, the United Kingdom, the Netherlands, Germany) and the United States, while the other half is the domain of Russian players. As agreed under a series of US-Russia disarmament accords, enriched uranium for power generating reactors may also come from the recycling of nuclear weapons.

The stages of uranium conversion and enrichment are followed by the fabrication of nuclear fuel proper which—far from being a commodity transaction-is more like a highly specialist service, especially so as the leading fuel producers are also the chief suppliers of nuclear technology. The top fuel fabricators are based in the EU (Germany, France, Spain, Sweden, the United Kingdom), the United States and Russia. Countries running Russian-design reactors obtain final nuclear fuel (with no split into individual cycle stages) directly from Russia.

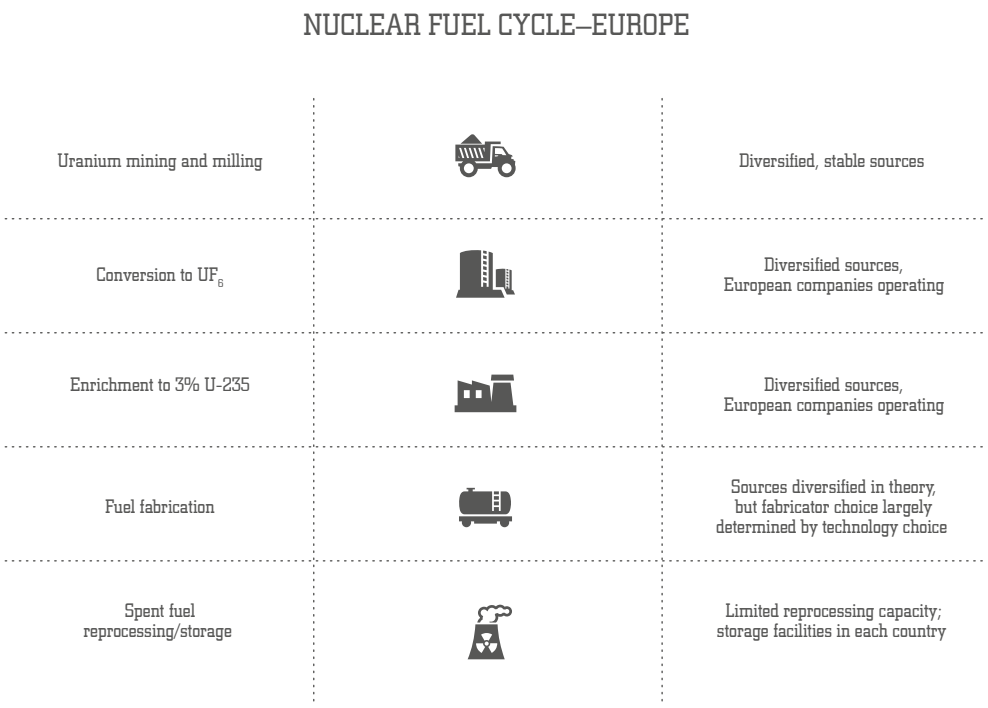
NUCLEAR FUEL

Powdered uranium or, to be more precise, UO_2, is formed into fuel pellets. A single pellet, 1 cm high and 1.5 cm in diameter, is capable of producing as much energy as one ton of coal. The pellets are loaded into long tubes, usually clad with zirconium, and after being filled and sealed are known as fuel rods. Bundled and formed into the final fuel assembly structure, the rods are placed in the reactor as its fuel. Such fuel assembly stays in the reactor for, usually, 18-36 months, until it is burnt up and no longer contains fissionable material. Although not capable of producing energy, the used fuel pellets contain large quantities of uranium and plutonium-239 (from chemical reactions). They can be reprocessed and used again for nuclear fuel manufacture.

The last stage in the fuel cycle has to do with spent fuel—either its reprocessing or storage. Fuel from light water reactors can only be reprocessed in France, the United Kingdom, Russia and Japan, but their capacity is limited. Thus, if a given country's strategy skips reprocessing, the spent fuel has to be stored—an arrangement adopted in most European countries and also to be embraced in future by Poland. The low- and intermediate-level radioactive waste coming from the Polish research reactors has since 1961 been stored in Różan, Mazowieckie Voivodship. Public consultations are under way on a new national storage site for radioactive waste, with the State Atomic Energy Agency proposing five potential locations: Łanięta, Kłodawa, Damasławek, Jarocin and Pogorzel. Research has been conducted on deep geological burial of high-level radioactive waste and spent fuel, but as indicated by other countries' experiences, such storage areas will be needed only some 50 years from the launch of the first reactor.

"FUTURE TECHNOLOGICAL SOLUTIONS WILL ENTIRELY ELIMINATE THE PROBLEM OF LONG-TERM SITES FOR RADIOACTIVE WASTE DISPOSAL, BECAUSE THE THING NOW CONSIDERED A NUCLEAR WASTE WILL THEN BE USED AS NUCLEAR FUEL."

Many European Union countries have advanced nuclear industries covering most stages of the cycle, from conversion to reprocessing. This eliminates the risk of dependency on uncertain suppliers at successive nuclear chain stages, all the more so as the Euratom Supply Agency is tasked with ensuring regular access to fuel and developing a common supply policy for EU users. In addition to that, each country must take a strategic decision to create fuel reserves. An average light water reactor requires some 20 tons of fuel, a relatively small and easy-to-store amount compared to millions of tons of coal, cubic meters of gas, or great numbers of windmills and solar panels needed to produce comparable



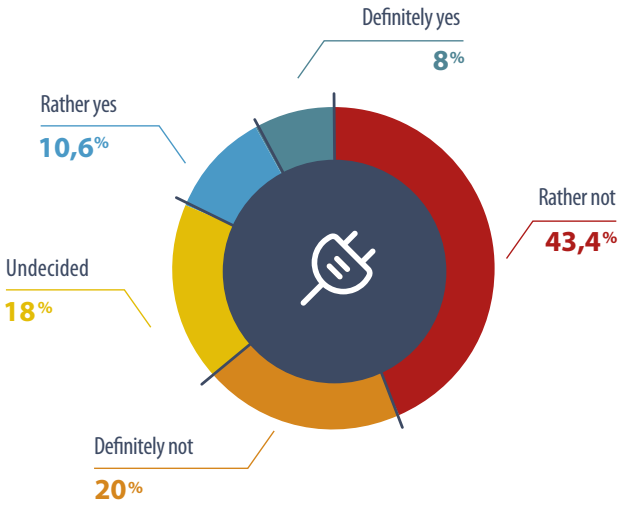
Nuclear fuel cycle—Europe

amounts of energy. Furthermore, nuclear fuel can be stored at different stages of its handling, in accordance with agreements signed with suppliers.

> "TECHNOLOGICAL CHANGE IS EXPONENTIAL, AND IN THE FUTURE PEOPLE WILL SURELY DEVELOP A METHOD TO NEUTRALISE NUCLEAR FUEL."

The final selection of the nuclear partner (technology and reactor vendors) is dictated not only by business, but also by political considerations. Also, many countries take into account the credibility and reputation of the supplier. For example, the Ukraine crisis has had the effect of reducing Europe's interest in Russia technology: the Czechs suspended an expansion of the Temelin plant and also the British turned more restrained in their talks on collaboration with Russia. In a situation where Russia is in practice the sole source of nuclear fuel shipments to VVER pressurised water reactors (Ukraine being an exception, testing US fuel in its reactors), many countries have misgivings about the risk of so strong dependence over more than 40 years of plant operations. But given the expertise and reputation of the companies which take interest in the Polish nuclear programme, and also remembering about alternative nuclear fuel sources, there are little grounds to fear problems with vendor credibility or security of nuclear fuel supplies to Poland.

The most distant, longest-term obligation for Poland resulting from the use of nuclear technology will be plant close and decommissioning. The operational life of first generation reactors was around 30 years, and for those currently produced it is some 40-60 years. But at some moment these lifespans will prove no longer extendable. Restoring the plant site to the greenfield condition is an arduous and costly process, which may take decades to complete. All radioactive elements must be carefully dismantled and stored in a way precluding any risk of contamination or loss to unauthorised parties. Thousands of tons of concrete and steel, kilometres of piping and wiring, all this must be removed. To-date more than a hundred nuclear power units have been decommissioned, with several returned entirely to "green grass" status, thus yielding a wealth of experience in the dismantling



Should Poland, in your opinion, give up nuclear power generation if cheap electricity could be purchased from other countries?

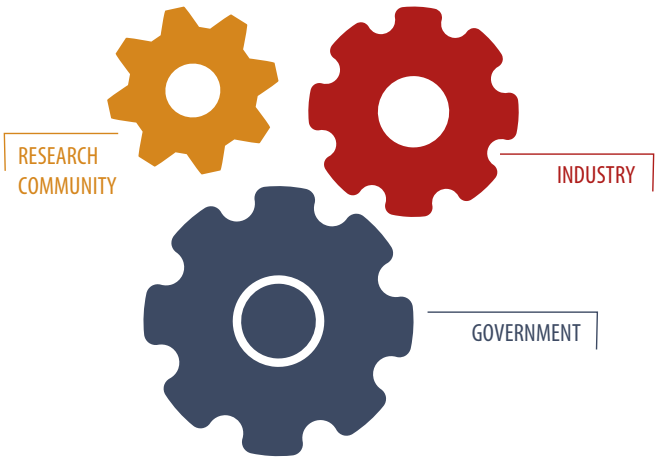
of nuclear installations in countries such as the United States, the United Kingdom, Germany and France. In Poland, too, the retired experimental reactors were successfully decommissioned by domestic effort. These experiences demonstrate that a nuclear power plant, once built and operated, can also be shut down and dismantled, the scale and the costs involved are so huge that they should be taken into account right at the conceptual stage.

STRATEGIC CONNECTION

The investment process is by no means confined to nuclear plant construction; it is equally important to have safe access to the transmission grid. In the absence of large-scale electricity generating operations in the region (there is only a 716 MW hydro plat at Żarnowiec), Pomorskie Voividship's grid is poorly developed and this means that considerable investments in transmission and distribution infrastructure will soon be needed. Different variants of connecting options and of the plant's impact on the operation of the national power grid are being analysed by PGE EJ1 company (tasked with preparing the nuclear plant's investment process). And the national grid operator, Polskie Sieci Elektroenergetyczne SA (PSE SA)—responsible for connecting new generating units, and also for the grid's expansion and safety—amended its plans as soon as nuclear power development was incorporated into Poland's energy policy in 2009.

Grid connection is subject to detailed regulations, and the issuance of grid connection consent/conditions will be of key importance not only for successive stages of the Polish nuclear energy programme[40], but for grid expansion, too. The two are thus linked by mutual interdependence, with delays in one element affecting the other. The present timetable is very ambitious, providing for the issuance of grid connection conditions towards the end of 2017, which means in practice that PSE SA has 6-7 years in which to expand the grid. Seeking to extend this time limit, PGE EJ1 plans to present the finding of its variant analysis as early as late 2014[41].

The connection of the new nuclear plant to the national power grid in that particular place is strategically important. One of the motives behind siting the plant in northern Poland is the deficit of generating capacity in the region. There is the Dolna Odra power station (1362 MW) in the north-west of the country and the Ostrołęka plant (647 MW) in the north-east-and the importance of their operations (in addition to electricity generation in itself) lies in that they stabilise the whole system in that part of Poland (the so-called must-run function). Thus the investment in new generating capacity in



Interaction between government, research community and industry

the north of the country, the expansion of the grid, and system interconnectors (LitPol Link between Poland and Lithuania) are elements of Poland's energy security, in a broad sense of the notion. The expansion of the nation grid, it should be noted, is necessitated not only by the Polish nuclear programme.

There are also international determinants, namely the construction of two nuclear power stations near the country's borders: in Russia's Kaliningrad exclave and in Belarus. The electricity from these stations will for the most part be exported, possibly also to Poland. Consideration should thus be given to a scenario where electricity is supplied from those two directions, using e.g. the LitPol interconnector, to be opened in 2016. This would further require that strategic decisions be taken about such electricity sources which best serve the Polish interest, and that a clear-cut declaration be made about the construction of domestic power-generating capacity. If no supplies are available from a Polish nuclear plant, it may turn out that electricity will be imported from nuclear plants in neighbouring countries in the east[42].

PROMISING COLLABORATION

Innovations are the driving force behind the nuclear sector and a guarantee of its continued development. The form and scale of the Polish nuclear energy programme will largely depend on how effective partnership is established among the key players in this field, namely innovators (research institutes, universities), the nuclear industry (technology vendors, small business), and government. It is vital for nuclear power generation that methodical research is carried out in many areas, often requiring huge outlays and international contacts. The three parties must cooperate effectively for adequate resources to be allocated to the pursuit of the common goals—the construction of the nuclear power plant and a continued development of nuclear energy generation in Poland.

The role of research initiator and a magnet to attract investments should be assumed by the government and its agencies. Without the political will, there can be no nuclear development in Poland. The government defines roadmaps and R&D priorities, helps to consolidate efforts, and defines the framework of financing. At least at the initial stages of nuclear development in Poland public funding will play a crucial role, which it will later be ceding to the private sector, e.g. under the formula of private-public partnership. Such government policy, seeking to promote the spirit of enterprise, helps to bring together the interests of scientists/researchers working on innovations, and industrialists seeking to solve particular technology-relates issues.

The Polish government has often been accused of favouring nuclear projects in fund allocation, which purportedly constrains the development

"THE CONSTRUCTION OF A NUCLEAR PLANT REQUIRES THAT CERTAIN COMMITMENTS BE MADE AND KEPT. IN POLAND, IT SEEMS, THIS ASPECT IS THE MOST DIFFICULT TO ACCEPT. AS A SCIENTIST I AM AWARE OF THE VERY LOW - MUCH TOO LOW - LEVEL OF RESEARCH FINANCING, ESPECIALLY FOR NUCLEAR RESEARCH."

of renewable energy sources and shale gas. While financial resources are obviously not limitless and must be distributed between different kinds of technological research in a just and well-thought-out manner, the experiences of other countries demonstrate that research projects in various energy segments actually complement each other. France's Commissariat d'Energie Atomique, (CEA), which for years focused on research into nuclear energy's civil and military use, was reformed in 2009 along the lines which are reflected in its new name, Commissariat à l'Énergie Atomique et aux Énergies Alternatives. In actual fact, a strong nuclear sector breeds progress, innovation and higher standards in an array of other fields. This spillover effect may be pretty wide, extending to electrical engineering, information technology, medicine, geology, mechanical research, etc. Moreover, a competition between various energy technologies for access to investment capital (whether private or public) comes as an added stimulus to innovation and technological change.

Highly skilled personnel is imperative for the operation of the Polish nuclear plant and research into nuclear reactors of new generations and spent fuel management. An exquisite way to attract young specialists and channel their energies into the development of Polish nuclear energy generation is offered by such research programmes which foster original solutions to current and future problems. The government, seeking to reduce to the minimum the need for contracting foreign nuclear experts and make the greatest use possible of Polish potential, should provide encouragement to training in nuclear technology right from the earliest levels education, e.g. by expanding the physics and mathematics curricula at primary and junior secondary schools.

"A NUCLEAR PLANT PROJECT MEANS BIG MONEY FOR SUPPLIERS, HUGE SPENDING ON RESEARCH AND PERSONNEL TRAINING, AND JOBS IN SOPHISTICATED SECTORS. THE NUCLEAR INDUSTRY DRIVES TECHNOLOGICAL PROGRESS AND STIMULATES THE ECONOMY."

Polish universities and colleges are free under Polish law to define their courses and programmes, but there is no obstacle to "placing orders" for these, so as to ensure a sufficient supply of science graduates. Seeing the future in nuclear power development, eleven Polish institutions of higher learning have already opened courses related to this technology[43], and other ones have plans to follow suit. The young people studying in this field aim high and they expect to be able to contribute their knowledge to the Polish nuclear energy programme. It would be wrong if, once again, Polish nuclear potential were wasted and ambitious abandoned. The Polish nuclear sector must be ensured stability and predictability.

The energy industry and its individual companies, pursuing their own interests, also can exert influence on the education of required specialists. Large companies with adequate capital resources can promote interest in nuclear power generation by sponsoring conferences and information campaigns, financing schools' physics and chemistry laboratories, offering internships for students, etc. A number of agreements on training specialists for the generating and nuclear industries have been signed by corporate partners and universities, including one between Areva and the Warsaw University of Technology (2012). And a Science and Technology Park is in the process of formation at Świerk, aiming to facilitate knowledge and technology transfer and improve the process whereby

"THIS IS A NEW TECHNOLOGY WHICH WILL BRING THE COUNTRY TO A HIGHER TECHNOLOGICAL LEVEL. AND THIS IS A VERY IMPORTANT ARGUMENT. OBVIOUSLY, IT IS NOT ONLY ABOUT PLANT CONSTRUCTION, BUT ALSO ABOUT RESEARCH INFRASTRUCTURE, PRODUCTION OF COMPONENTS FOR THE PLANT, ETC. IT IS ALL ABOUT A WHOLE RANGE OF KNOWLEDGE."

scientific research findings are converted into technology innovations.

The importance of long-term approach, investment in innovation, and continuous training of specialist personnel was painfully brought home to a number of European nuclear countries, such as France, the United Kingdom or Finland. After a nearly 20-year-long break in new reactor projects in Europe, in response to the Chernobyl disaster, the knowledge of how to build nuclear infrastructure has somewhat deteriorated, while in the meantime the technological and safety requirements changed. With training programme numbers on the wane and the status of nuclear education declining, some worrying trends could be noticed, such as the aging and retirements among nuclear plant staff and disinterest in nuclear-related courses among undergraduates. It is only now that those countries have taken steps to restore the role of nuclear power generation and draw talent to nuclear programmes. Fruitful collaboration between government, research centres and industry makes it possible to share financial burdens, optimise resource utilisation, avoid a doubling of efforts, build on synergies, and improve the mobility of specialists and exchange of knowledge among them.

CONCLUSIONS AND RECOMMENDATIONS

- An inherent feature of the nuclear sector is that the choices made have long-term repercussions. When taking any decision, it must be remembered that its potential consequences will be felt over the reactor lifespan, i.e. for 50-60 years. The selection of a particular technology, while not necessarily fixing the nuclear sector's future, does have influence on its development and further investments. Hence the need for a judicious selection of partners in the Polish nuclear energy programme.

- Nuclear power generation is a well-recognised technology. Knowing how nuclear reactors operate, how they are classified, what the fuel cycle is, etc. allows to understand that nuclear energy use is safe, fuel sources are diversified, and radioactivity research benefits everybody (even though people may not always be aware of this).

- A civil nuclear programme will not stand a chance without a strong political will. The form and scale of nuclear technology development is determined by politicians, who define and allocate research subsidies. An equally important role is played by smooth collaboration between government, industry and the scientific community. Only in this way can synergies be obtained and innovations launched.

4

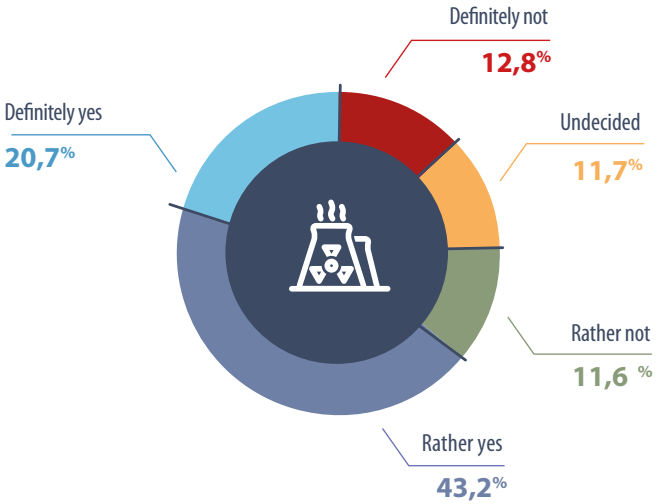
SOCIETY IS A CHALLENGE

PUBLIC OPINION[44]

For many Poles, aware of the country's heavy dependence on Russian oil and gas shipments, energy security is seen as an increasingly urgent priority[44]. Asked how to achieve this goal, most respondents point to renewable energy sources (58%) and nuclear energy (48%). Only later come shale gas (21%) and coal/lignite (8%)[45].

A fall in support for construction of Poland's first nuclear power plant should no doubt be attributed to the Ukraine crisis, Fukushima, and some countries' (especially Germany's) decision to abandon atomic power, thus providing yet another indication that this support among Polish society is linked to international developments. At present more than a half of the Poles have a positive view of the plans to build a nuclear plant (64%)—mostly young people, with secondary and higher education, in the highest income brackets, living in the largest cities. The respondents declaring to be moderately in favour (43%) outnumber those whose support is steadfast (21%). The nuclear plant construction is associated mostly with the country's energy independence (57%), and only

"WE HAVE ENJOYED A STABLE POLITICAL SITUATION FOR A LONG PERIOD, WITHOUT WARS OR ANY MAJOR TENSIONS - BUT IN UKRAINE A RED LIGHT IS FLASHING, REMINDING US THAT FREEDOM AND STABILITY ARE NOT GIVEN ONCE AND FOR ALL. 'IF YOU WANT PEACE, PREPARE FOR WAR.' MAY IT NEVER HAPPEN. ENERGY GENERATION IS AMONG THE MOST SENSITIVE ELEMENTS OF OUR STATEHOOD AND INDEPENDENCE. AT A TIME OF PEACE, LET US NOURISH THIS SECTOR, WORK TOWARDS ENERGY INDEPENDENCE AND DEVELOP IMMUNITY TO INTERNATIONAL FLUCTUATIONS."

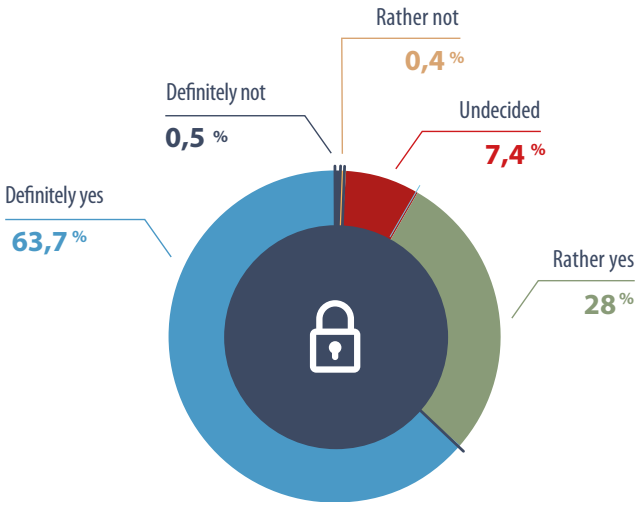


Do you support nuclear plant construction in Poland?

later with economic benefits: job creation (42%), technological advancement (26%), and contributions to the project from domestic companies (24%)[46].

The fear of nuclear has been gradually subsiding, with more than a half of the Poles believing that nuclear power is an attractive and tested method of electricity generation (71%), that it poses no threat to the country (57%), and that the nuclear plants operated in Poland's vicinity do not threaten the environment, security and public health (64% each). The lowest level of fear is among the respondents who are young, have higher education, earn high incomes and live in big cities. Among potential problems which nuclear development may bring for Poland, plant breakdowns and poor waste management were highest on the list, much ahead of radiation around the plant and the possibility of a terrorist attack. Interestingly, most of those questioned would not support hypothetical environmentalist protests against nuclear plant construction (52%), with 23% declaring a passive attitude and 9% saying they would take an active part in such protests.

In your opinion, should Poland seek to increase its energy security?

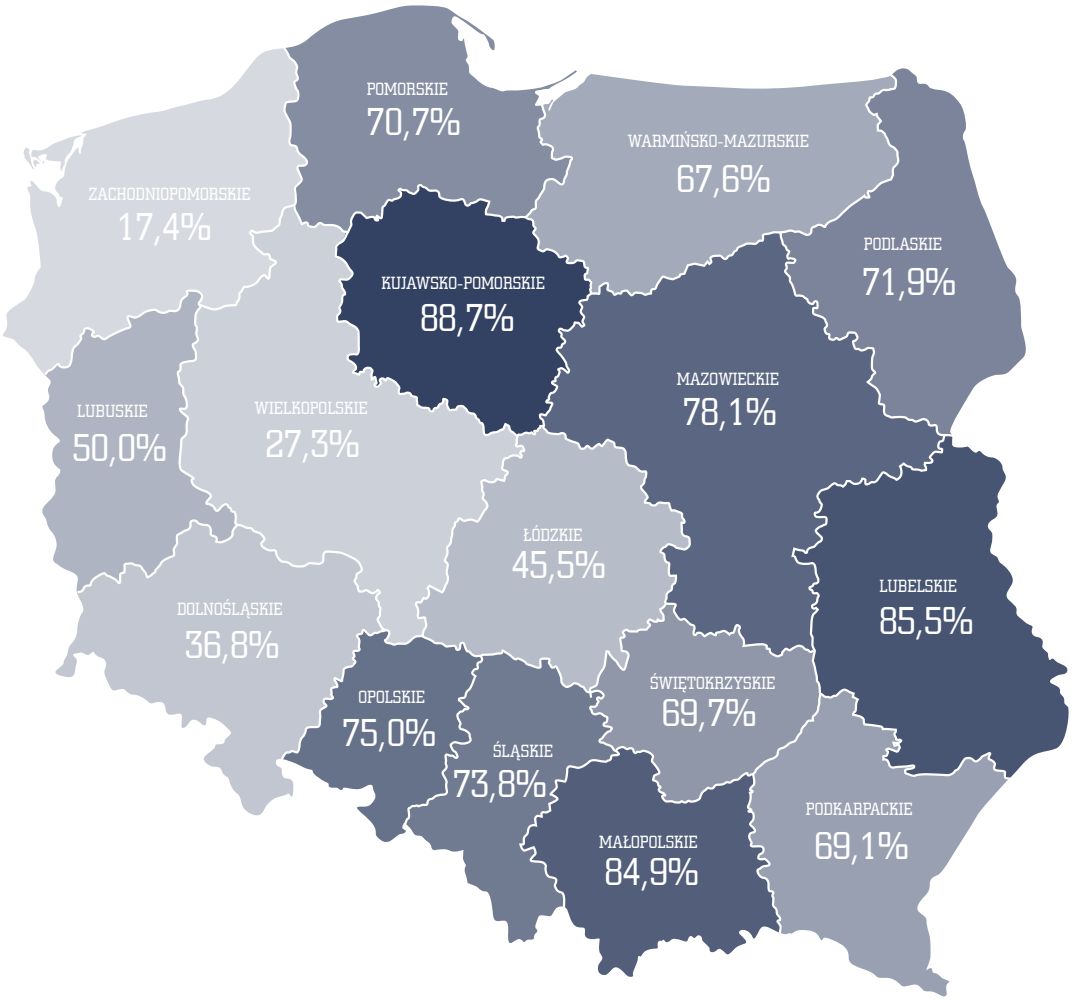


Although an overwhelming majority agree that nuclear energy use may bring Poland economic benefits, they are not certain if this is indeed the most attractive energy source for Poland from among all available sources (an almost equal split between those replying "yes," "no" and undecided). Also in short supply is awareness of fossil fuels' availability: 42% are certain there are no considerable deposits of oil, coal or gas in Poland; 25% think differently, and 33% are undecided.

Perceptible differences in attitudes towards nuclear energy can be seen between the eastern and western parts of Poland. Support for plant construction is the highest in these voivodships: Kujawsko-pomorskie (89%), Lubelskie and Małopolskie (85% each), Mazowieckie (78%), Opolskie (75%), Śląskie (74%), Podlaskie (72%), Pomorskie (71%), Świętokrzyskie (70%), Podkarpackie (69%) and Warmińsko-mazurskie (68%), while it is much lower in Lubuskie (50%), Łódzkie (45%), Dolnośląskie (37%), Wielkopolskie (27%) and Zachodniopomorskie (17%). People in the west of the country are strongly convinced that the nuclear plants operating near Poland's borders do harm to the natural environment, health and security of Poles, and they are more apprehensive of the threats of the Polish plant's breakdown or a terrorist attack against it. In the east, more respondents are convinced about the benefits of plant construction and operation, and more of them fear that absence of funds may prove the biggest obstacle for the project.

Not surprisingly most Poles (88%), no matter where they live, find it self-evident that Poland should make a sensible use of other countries' experiences with safe construction and operation of their plants and the most cost-effective prepara-

Support for nuclear energy by voivodship



tion of the investment project. They point to the advanced countries where such infrastructure has been in operation for years, most notably Germany (49%) and France (27%). On the other hand, equally developed nuclear countries, but situated further from Poland, scored less: Japan 18%, the United States 14% and the United Kingdom 12%. Quite possibly, it is this geographical, and consequently cultural, distance that influenced those countries' positions in the rankings. And the very low identification with the opinion that Poland should tap Russia's nuclear power experiences can be seen as revealing not only the Polish public's disapproval of that country's involvement in the current developments in Ukraine, but also of the overall Russian approach to economic contacts with European partners.

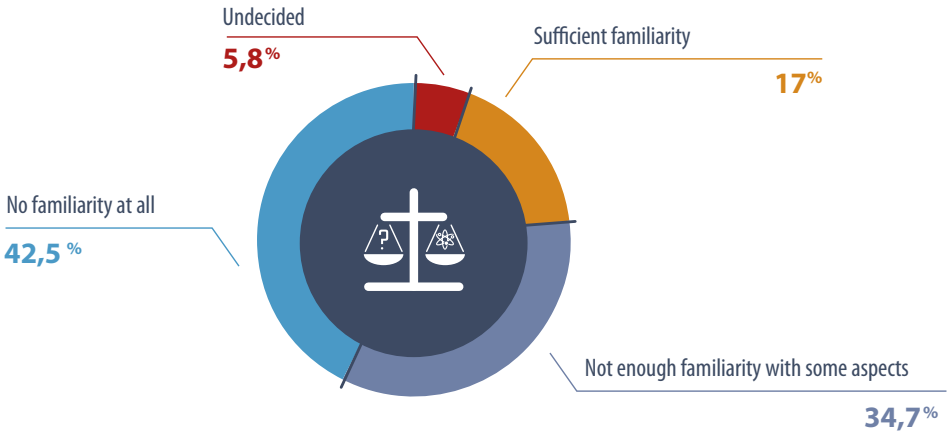
A RHETHORICAL QUESTION

Public trust and acceptance is vital for technological innovations, but as shown by opinion poll findings a big problem is posed by Poles' limited familiarity with questions about the rationale for nuclear energy investment and the consequences of choices to be made. More than 40% of the respondents declare not having enough knowledge of nuclear power generation, and they often formulate their preferences based on emotions rather than rational arguments. This highlights the importance of providing citizens with access to credible materials and answers to questions most frequently asked in public discussions, such as:

- is nuclear technology safe?
- are nuclear fuel prices and supplies stable?
- how high are the costs of nuclear plant construction, operation and decommissioning?
- what is the influence of nuclear power generation on the environment?
- is nuclear power generation in compliance with the EU's energy policy?
- is there in Poland any alternative to nuclear energy?
- is its development compatible with the development of other energy sources?

In promoting nuclear power generation, if one wants the message to be comprehensive, transparent and impartial, not only the advantages should be presented but also the public's concerns and misgivings. The purpose of the debate should not be just to win over the public to one's arguments, but rather to provide reliable information so that people can weigh up the pros and cons. Only then, in accordance with the dominant opinion among the public, will the government have the legitimacy

How do you assess the level of your familiarity with the subject of nuclear power generation in Poland? (single reply)



"PUBLIC DEBATE IN POLAND HAS LONG CEASED TO BE ABOUT SUBSTANCE, AND IT IS NOW ABOUT EMOTIONS. WHEN DISCUSSING NUCLEAR ENERGY, QUESTIONS SUCH AS HOW LONG THE REACTOR WILL OPERATE OR HOW MANY JOBS WILL BE CREATED ARE NOT TAKEN UP AT ALL."

to pursue nuclear energy policy and focus on how to put this energy to the best use.

But the public, often unable to assess the credibility of the presented technical, legal and economic content, tend to focus on such elements of the nuclear discussion as the form of the message (direct, indirect via a medium), its purpose/function (informational, political, etc.), affiliation (government, science, etc.) and the qualities of the messenger (professionalism, credibility, etc.). Personal sympathies, political views, and even religious beliefs also have an impact, and all this means that what counts is not only what is said, but also how and by whom.

The Polish Nuclear energy programme lists four major players in charge of, both, project preparation and communications with the public: the Minister of the Economy, the investor, the head of the Polish Atomic Energy Agency, and the Radioactive Waste Management Facility (Polish acronym: ZUOP). Scores of other bodies, offices and government agencies are also involved. Until 11 April 2014, the project's administrative coordinator and its public face was the government plenipotentiary for nuclear energy. After that date, in the absence of a distinctive institutional leader of programme implementation, the public would be justified for feeling perplexed about the delineation of competences, the determination to go on with the project and the cohesion of government activities. Meanwhile one would think that the government's and the programme's interests would be best served if the messages sent were clearly formulated and public dialogue fostered. That implies the appointment of a new plenipotentiary for nuclear energy.

PARTIES IN CHARGE OF PUBLIC COMMUNICATION—RESPONSIBILITIES

The Minister of the Economy: to create indispensable legal and organisational conditions for the development of nuclear power generation and its use to meet the country's socio-economic needs, and to conduct a campaign of public information and education.

PGE nuclear plant investor and operator: to provide necessary financial resources for the construction, operation and decommissioning of the nuclear power station, for nuclear security and for the establishment of Local Information Centre.

The head of the Polish Atomic Energy Agency: for issuing licenses to build the nuclear plant; supervising plant security and operation; imposing fines/sanctions when security requirements are not met; communicating with the public about nuclear safety.

Radioactive Waste Management Facility (ZUOP): for safe and rational management of radioactive waste, and for communication with the public about its operations.

An increasingly important role in public nuclear education has been played by leading scientists and experts from Polish universities and research institutes, such as National Centre for Nuclear Research in Świerk, Institute of Nuclear Chemistry and Technology, Institute of Nuclear Physics of the Polish Academy of Sciences, and universities (including technical universities) in Gdańsk, Warsaw, Katowice, Kraków, Łódż and other cities. Seeking to make their message understandable to the general public, these science workers devote much time to increase understanding of nuclear physics and chemistry and stimulate interest in these disciplines among primary and secondary school pupils. But the sad reality is that the quality of science teaching in Poland has been steadily declining, with the time assigned for nuclear energy in classroom practice being counted in minutes. What is needed is teacher training programmes, efforts to raise nuclear energy's allure for pupils, and presentations of practical nuclear uses. Once young people's interest is attracted, familiarity

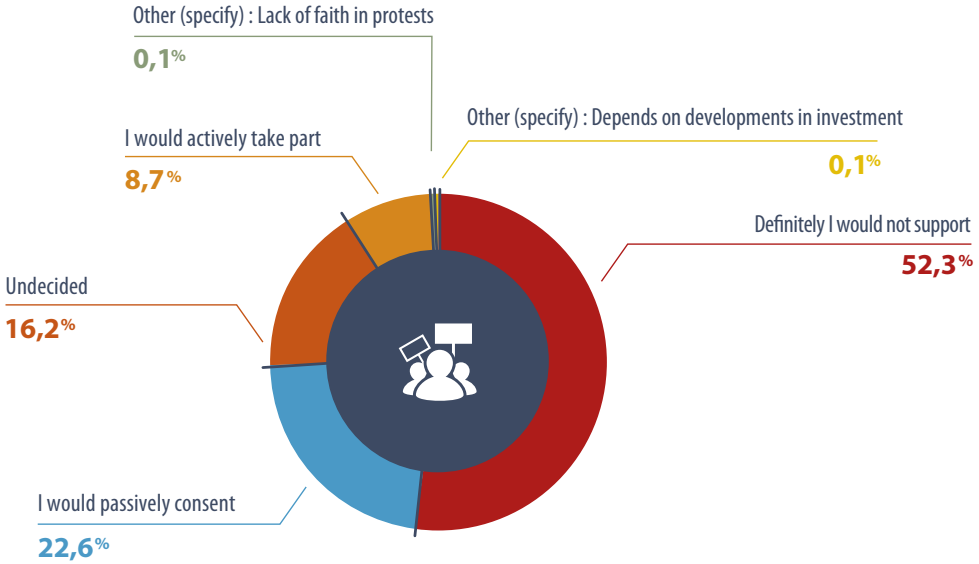
"RIGHT CHOICES AND ASSESSMENTS CAN ONLY BE MADE IF ONE HAS KNOWLEDGE AND INFORMATION. WE HAVE THE DUTY TO KEEP ALL CITIZENS OF OUR COUNTRY INFORMED, TO PROVIDE THEM WITH KNOWLEDGE. AND WHEN WE ARE ALL ADEQUATELY INFORMED, THEN PEOPLE CAN BE ASKED IF THEY OPT FOR A LOCAL APPROACH OR THE GLOBAL APPROACH, IF THEY SIDE WITH THIS OR THAT ARRANGEMENT. WHEN SUCH INFORMATION IS LACKING, MOST DISCUSSIONS HELD IN POLAND ABOUT ENERGY ARE ANYTHING BUT SUBSTANTIVE DISCUSSIONS."

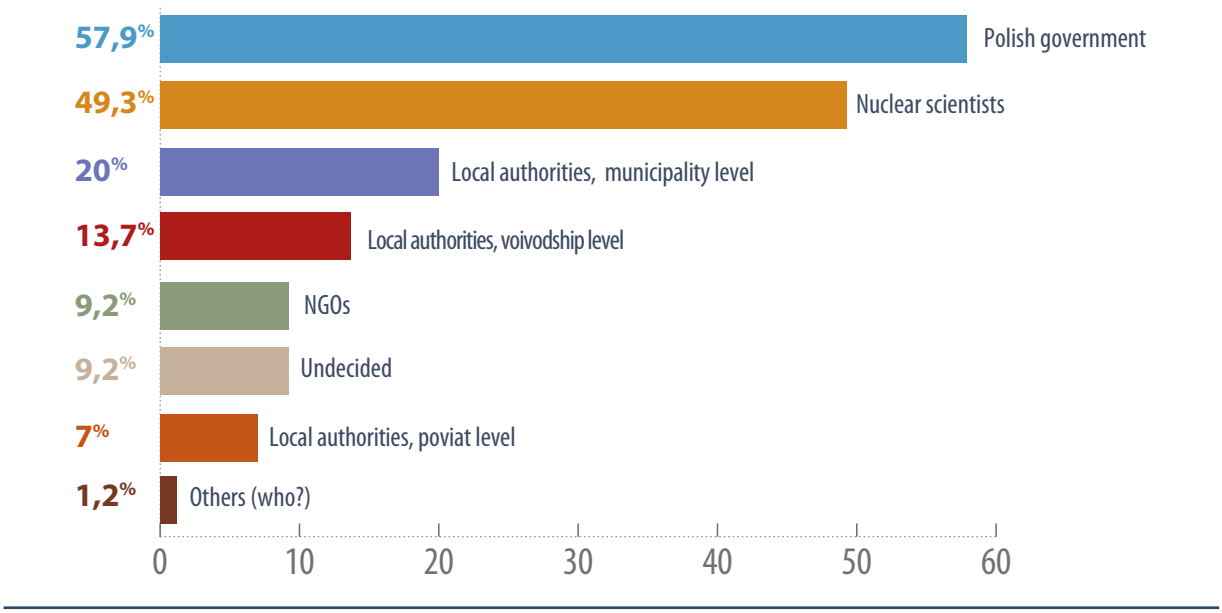
"WE HAVE HAD SOME FOREIGN ACTIVISTS WHO SOUGHT TO MANIPULATE PEOPLE AND FRIGHTEN THEM. QUITE FREQUENTLY, IT WAS NOT HONEST INFORMATION BUT JUST SCARE-MONGERING, AS FOR EXAMPLE WITH SHALE GAS. IN A VIDEO YOU COULD SEE SOMEONE TURNING ON A WATER TAP, AND WHAT FLEW OUT WAS NOT WATER BUT BURNING GAS. HOW MUCH TIME HAD TO BE SPENT AND HOW MANY MEETINGS HELD TO CONVINCE PEOPLE THAT THAT WAS NOT THE CASE? SUCH STORIES ABOUT COWS GETTING HAIRLESS, CHICKENS DYING, HOUSES CRACKING AS A RESULT OF SOME SEISMIC RESEARCH TEND TO GO VIRAL."

with the subject among the public at large is set to increase.

Also present in the Polish public space are non-governmental organisations, associations, pressure groups and lobbyists, Polish and foreign, quite frequently presenting rather one-sided opinions. Broadly, they can be divided into pro- and anti-nuke, acting on a variety of motives, from ideology to money. The arguments voiced by nuclear energy opponents are no doubt strong and largely emotional, and their anti-nuclear actions-protest campaigns, picket lines, collections of signatures for petitions—

To what extent would you be prepared to support hypothetical environmentalist protests over nuclear plant construction in Poland?





Who, in your opinion, should communicate with the public about nuclear energy benefits and threats? (two replies)

happen to be quite spectacular and often fairly successful. Another example of anti-nuclear activism has been a visit to Poland by a representative of the Germany foreign ministry[47], seeking to persuade the Polish government to change its plans.

Among proponents of nuclear energy, the expected results are sought to be achieved by means of rational arguments and a sustained information push. For example, the foreign-based energy companies hoping to sell nuclear technology to Poland sponsor training programmes run by Polish universities and colleges. Pro-nuke associations send proposals and expert opinions to the relevant authorities and government agencies. But given the wide differences in arguments and perceptions, encounters between the pro- and anti-nuclear parties very rarely end in agreements or constructive conclusions. This is partly because the Polish debate is still stuck with the question of whether—not how—to build a Polish nuclear energy sector.

Taking the lead among nuclear energy whistleblowers are the media, both traditional (press, radio, TV) and social, such as blogs and social networking websites, which seek to inform the public about developments in Poland and abroad. Assessing the power of the media, political decision-makers, scientists and activists increasingly turn to multichannel media strategies to reach all the demographics.

The multitude of the parties involved helps to acquaint the public with a wider range of arguments about nuclear energy, but on the other hand this may also lead to confusion, information overload, and disorientation of the public. Even though a nuclear plant is always built by a variety of entities, the public feels the need to identify with unambiguous, well-trusted authorities. What is needed is a leader who, assuming a huge responsibility, would take care of the nuclear project in Poland. As demonstrated by the example of the UK—with its widespread public consultations and information campaigns-a centralised and harmonised effort by all the parties involved in the nuclear project can make a great impact on public perceptions. The Fukushima accident notwithstanding, the proportion of nuclear energy opponents in the UK shrank from 37% in 2005 to 29% in 2013[48]. There can be no doubt that the Polish entities dealing with nuclear energy should exert themselves if support for nuclear technology in Poland is to continue at the present high level.

CORPORATE SOCIAL RESPONSIBILITY

Although the responsibility for nuclear energy use lies with a number of players, including plant operators, state administration and regulators, it is the technology vendors who have special interest in spreading the message that nuclear energy will be used responsibly, safely and sustainably. This is in line with the current trend in management of global challenges, where the public is brought

into the centre of companies' attention. Thus the most important and largest industry sectors, such as energy and pharmaceuticals, increasingly place emphasis in long-term business strategies on their reputation as being socially responsible.

Corporate Social Responsibility (CSR) is a management concept involving activities which are multi-directional and sustainable. The company is to be oriented not only to financial profit; it should also take into account the public interest and the environmental impact of its operations. There can be no doubt that the business operations of energy companies do make an impact on the environment, and a nuclear plant accident may well become a global problem, as graphically proved by the Fukushima catastrophe in 2011. But whatever lessons may have been drawn from it by various countries around the world, new nuclear power plants will continue cropping up. It is thus imperative that the process be carried out safely and responsibly, whether in developed countries or emerging economies.

PARTIES TO THE INITIATIVE NUCLEAR POWER PLANT EXPORTERS' PRINCIPLES OF CONDUCT

Areva
ATMEA
Babcock & Wilcox Company
Candu Energy
GE Hitachi Nuclear Energy
Hitachi-GE Nuclear Energy
JSC Rusatom Overseas
KEPCO
Mitsubishi Heavy Industries
Mitsubishi Nuclear Energy Systems
Toshiba
Westinghouse Electic Companies

Even though nuclear power generation is among the most regulated global industries, the leading technology vendors voluntarily embrace ever more stringent requirements, as a means of minimising nuclear accident risks. In the document Nuclear Power Plant Exporters' Principles of Conduct, produced after self-regulation discussions held in 2008-2011, the international energy corporations, usually competing against one another, opted to channel rivalry into an effort to raise global CSR standards in the nuclear industry. They made a shared commitment to observe the agreed standards and best practices in the areas of safety, security, environmental protection and spent fuel management, non-proliferation, compensation in the event of nuclear-related damage, and business ethics. In addition to international coordination, each company follows its own CSR strategy attuned to its particular line of operation. Commitment to social and environmental values is also declared by the potential suppliers of nuclear technology to Poland.

The path of corporate social responsibility brings companies tangible benefits, such as increased stakeholder loyalty; new investors, who prize credibility (not only in financial and also in

"INTERNATIONAL COLLABORATION ON NUCLEAR ENERGY IS TO BE WELCOMED. SCIENTISTS UNDERSTAND THAT THIS IS A GLOBAL QUESTION, AND THEY READILY EXCHANGE INFORMATION. A NUCLEAR ACCIDENT IN ONE COUNTRY CAN WELL IMPACT DEVELOPMENT PROSPECTS IN ANOTHER. THERE IS NO RIVALRY HERE, NO DESIRE TO KNOW MORE AND KEEP IT TO OURSELVES, AND NO SATISFACTION FROM OTHERS MISTAKES."

social terms); a positive image and increased trust, helping to improve relations with local communities and authorities. In the absence of public support, companies may actually face a fair share of trouble. Consequently, local protests backed by international and domestic environmental advocacy groups, have quite often prodded modifications in the plans pursued by nuclear technology exporters.

By its nature, a CSR strategy can neither be short-term nor unilateral. All activities taken by an energy company must be strongly embedded in the public space. Vendors often solicit public trust by raising transparency, cohesion and ethical standards, and by continuously fostering progress in the field of security, which they describe in their CSR reports, published along with the financial statements.

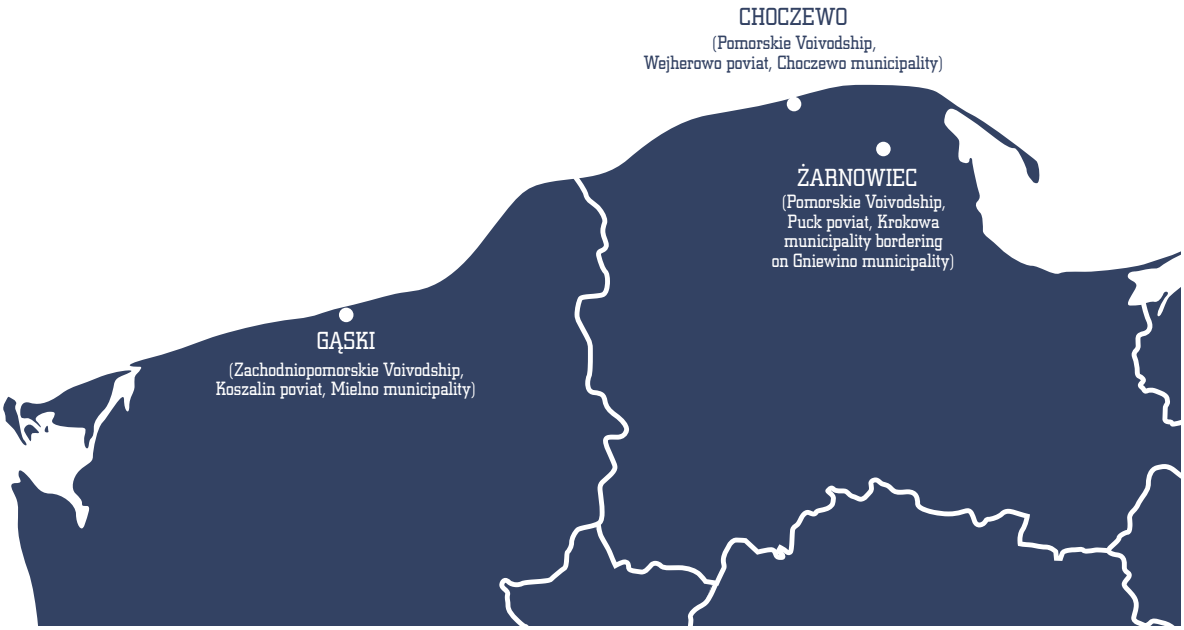
In addition to that, companies in the nuclear energy sector have been taking various kinds of measures for the benefit of local communities, including charity, support for local initiatives, environment-oriented projects, public campaigns and human capital development (e.g. through workforce training programmes). Thus the communities around nuclear power plants may become both direct beneficiaries and active participants of such measures. Success turns on two-way communication, which yields shared ideas, trust, and benefits for all nuclear plant stakeholders.

"THE US EXAMPLE DEMONSTRATES HOW PUBLIC SERVICES IMPROVE AROUND A NUCLEAR PLANT. THE MUNICIPALITIES INVOLVED SIMPLY DO NOT KNOW WHAT TO DO WITH THE MONEY THEY GET. THERE CAN BE NO DOUBT THAT THE LOCAL COMMUNITIES WILL BENEFIT, WITH RISKS CLOSE TO ZERO."

LOCAL DEVELOPMENT

Public information campaigns about nuclear energy's pros and cons are different when conducted nationally and at a local level. Engaging in a dialogue with the community is often a much bigger challenge when done locally, where a formidable obstacle to clear is the NIMBY (not in my backyard) syndrome. People fear plant breakdowns, environ-

"TAKE GĄSKI, WHICH WE SEE AS THE BEST OF THE PROPOSED SITES, NEAR THE SEA, AND WITH THE MOST FAVOURABLE CONDITIONS. A POLITICAL DECISION WAS TAKEN, AND PEOPLE WERE JUST TOLD ABOUT IT WITHOUT FIRST BEING CONSULTED. IT TOOK JUST SEVERAL RABBLE-ROUSERS, AND THERE WAS NO LONGER ANY SPACE FOR DISCUSSION. JUST 'NO', PURE AND SIMPLE. PEOPLE THERE DO NOT WANT TO MEET AND DO NOT WANT TO TALK. NO ARGUMENT WILL BE TAKEN. THE SITUATION WOULD SURELY BE A BIT DIFFERENT IF SOMEONE HAD CONTACTED THEM AT AN EARLIER TIME."



Potential sites for the Polish nuclear power plant

"WE HAVE HAD QUITE MANY MEETINGS. ASSOCIATIONS AND PRIVATE FOUNDATIONS ARE BEING SET, THERE ARE CONTACT POINTS, AND WE ARE ENGAGED IN PUBLIC DIALOGUE WHERE WE MEET PEOPLE, TALK WITH THEM, CRITICISE THE CENTRAL GOVERNMENT FOR FOOT-DRAGGING, AND EXCORIATE PGE FOR THE LOSSES OUR MUNICIPALITIES INCUR NOT KNOWING WHICH WAY TO GO. INVESTMENT-GRADE AREAS ARE BLOCKED, WHICH MEANS WE CAN ALREADY COMPUTE THE INCOMES LOST. THERE IS ALSO ANXIETY AMONG THOSE INVESTING IN TOURISM: HOW THEIR OPERATIONS WILL BE AFFECTED? WILL THERE BE A TOURISTS EXODUS? THERE ARE MANY SUCH PROBLEMS ON A DAILY BASIS, AND VIRTUALLY THERE IS NO DAY WHEN WE WOULDN'T HAVE SOME MEETING, GO TO WARSAW, SIGN CERTAIN DOCUMENTS, WORK ON A LETTER OF INTENT, ETC."

mental damage, deterioration of living conditions, and also an adverse impact on tourism.

When in 2011 PGE announced its selection of three potential nuclear sites[49], people in Mielno municipality firmly rejected the idea, delivering a more than 94% "no" vote in a 2012 referendum and demonstrating how intense public emotions nuclear power generation may provoke. The Mielno case also highlights the importance of conducting an honest, in-depth debate, in order to prevent a project from being killed off by public opposition.

The picture is much different at Choczewo and Żarnowiec, where the local authorities' personal commitment, well handled consultations, respect for public concerns, and information campaigns by technology vendors have combined to attract a nearly 60% public support for nuclear plant construction. People are aware that a large project located in their neighbourhood will stimulate the municipality's growth, both in terms of infrastructure and human capital; and they also have actually awaited for such an outcome since the discontinuation of the previous Żarnowiec plant. The municipality councils in Choczewo, Gniewino and Krokowa can't wait to learn where exactly the new plant will be located, and they are counting the losses from the delays in preparatory work.

Sizewell beach, UK

For those local communities and authorities, building a nuclear plant in Pomorskie Voivodship offers a big chance indeed. Investors are required to carry out projects that will benefit the whole region, such as road network expansion and modernisation, upgrading of water supply systems and electricity distribution infrastructure, etc. The construction also translates into much increased demand for locally supplied products and services, including from skilled, high-earning workers arriving from around the country (even 500 newcomers would produce a big change). New shops and service outlets will likely be needed, along with sports clubs, restaurants, pubs, etc.

Another advantage comes with job opportunities for local people, from cleaning staff and drivers to engineers and specialists in a variety of fields. Given the long-term operation of the nuclear plant, the municipalities involved can expect stable, longstanding support from the investor for local initiatives involving schools, libraries, cultural and sport events. Local public transport operators, hospitals, social welfare facilities, etc. also stand to benefit.

> "I HAPPEN TO VISIT BRITAIN FROM TIME TO TIME, AND I MUST SAY THAT THE SIGHT OF A POWER STATION SITUATED NEAR A BEACH COULD GIVE YOU GOOSE BUMPS."

Paradoxically, the nuclear plants operated abroad, far from scaring off tourists, actually are seen as tourist attractions—and this circumstance will be of importance in Pomorskie Voivodship, already a major tourist destination. In Europe and around the world, many nuclear power stations run information services for visitors who are allowed to watch some of the facilities. The reactor itself is off limits, but a mock-up model is usually displayed. Under the Polish nuclear energy legislation, once

"HERE AT THE REGIONAL LEVEL - BUT ALSO AT THE LOCAL AND NATIONAL LEVELS, INCLUDING CENTRAL GOVERNMENT - WE HAVE TO LOOK AT THIS WITHOUT EMOTIONS. WE REALLY DO NOT GO BY ANY OTHER INTEREST THAN PUBLIC INTEREST, WHICH IS TO GUARANTEE ENERGY SECURITY AND CONTINUITY OF SUPPLIES."

the site of a nuclear plant is finally selected, the investor must set up a Local Information Centre for public education and promotion of nuclear energy. And the municipality council involved may open its own information stand. Indeed, information may well prove to be the key to success.

"I HAVE A VISION OF LOCAL DEVELOPMENT BASED ON ENERGY GENERATION. I BELIEVE THAT EVERY REGION SHOULD DO ITS UTMOST TO USE ENERGY GENERATION AS A DRIVING FORCE FOR DEVELOPMENT. OTHERWISE, OUR LOCAL POMORSKIE-REGION MONEY WILL END UP SOMEWHERE IN WARSAW. EVERY REGION HAS ITS STRENGTHS, BE IT BIOMASS, WIND CONDITIONS, EXPOSURE TO SUN, THERMAL WATER, ETC., SO EVERY REGION SHOULD INVEST AND MAKE USE OF THOSE SOURCES WHICH THEY HAVE IN THEIR RESPECTIVE AREAS."

CONCLUSIONS AND RECOMMENDATIONS

- The high level of Polish society's support for nuclear energy largely reflects the current international developments, including in Ukraine, which produce a sense of danger and anxiety. In this context, the construction of a nuclear power station is frequently seen as enhancing sovereignty and energy security, and only later as an economically viable investment. The latter aspect must be communicated to local inhabitants as part of the public information campaign.

- With strong feelings about nuclear power generation often resulting from ignorance, there is an urgent need for honest debate on nuclear pros and cons in Poland. A wide-scale public information campaign should reach all social groups and demographics.

- Public approval is a condition of success for the Polish nuclear programme. Maintaining a high level o support requires a simultaneous and well coordinated involvement of many parties, central and local government, business, NGOs, and the research community. A national leader should be named to conduct the nationwide debate, as well as taking care of implementation of the Polish nuclear energy programme.

- The debate and the need to take local community requirements into account are challenges that must taken seriously by the technology vendor, the investor and the government. These three players' collaboration with the local community at the preparatory stage is of crucial importance for, both, the development of the municipality and a continued supply of electricity for the whole country.

5

CONCLUSIONS: NUCLEAR ENERGY IN POLAND

Polish nuclear energy in centre of Europe. The Polish government's announcement that it is launching a nuclear programme is a sign of confidence in the benefits of peaceful nuclear energy use. This is not to say that the technology is spotless, only that this option protects Poland's energy future. Collaborating with European partners in programme implementation, Poland will find itself stronger and more secure, as support from the Europeans will help the country to cope with the challenges involved.

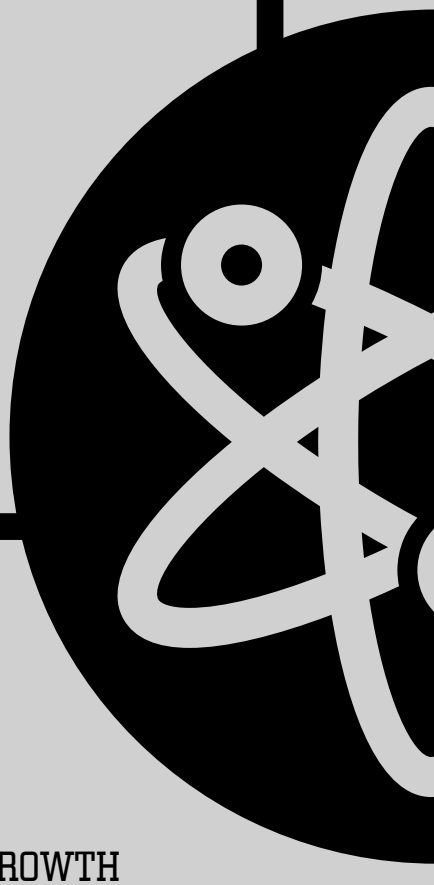
Nuclear energy compatible with other sources. In implementing the Polish nuclear energy programme, as part of the government's energy policy to 2050, Poland is pivoting to an energy mix where nuclear energy plays an important part but only as one element, alongside coal, renewables and gas. Adding nuclear to the Polish energy mix is an attempt to respond to the energy challenges facing the country, in the context of a balanced development policy.

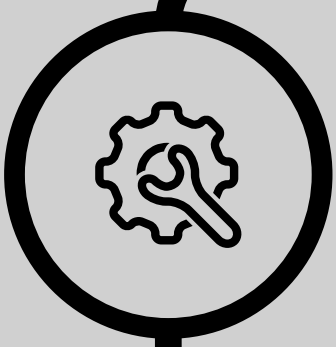
Nuclear energy drives innovation and economic growth. Implementation of the Polish nuclear energy programme must not end with just good intentions. For the political will to be translated into reality, Poland must allocate adequate resources to the project. It should also be communicated to the public that today's nuclear technology is the technology of the future, and that the investment in innovation will bring about tangible benefits for the present and future generations of Poles, reinforcing the country's economic clout.

Nuclear energy contingent on public support. A successful implementation of the Programme requires the domestic scientific community and industrial partners join forces in the pursuit of its goals. Gutsy political leaders are also needed, along with commitment from the civil society, prepared to take the floor and share their thoughts and concerns. If the high level of public support for the Programme is to be maintained, the public must be informed about, both, the advantages and threats of nuclear energy. As the pioneer in this field, Marie Curie, said: "Nothing in life is to be feared, it is only to be understood."

POLISH NUCLEAR ENERGY IN CENTRE OF EUROPE

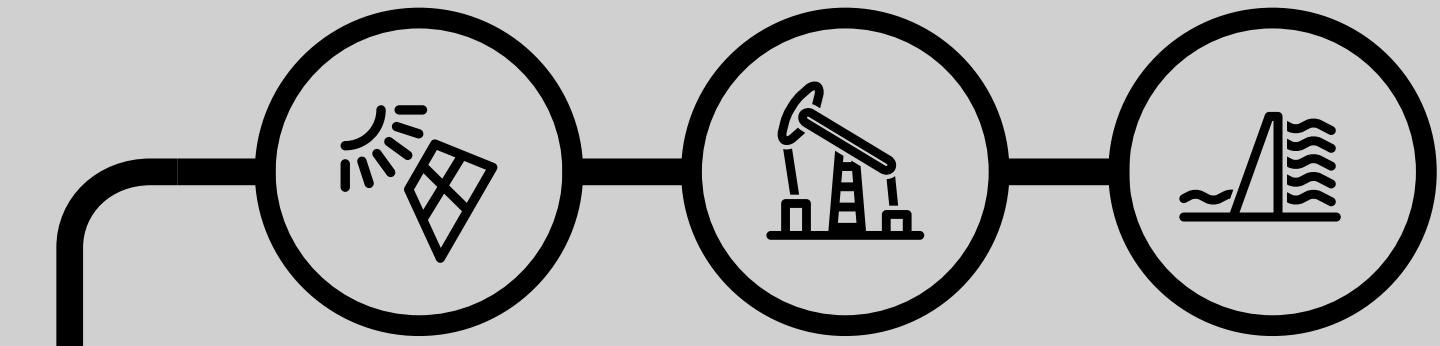
- International nuclear energy community:
  - 30 countries
  - 436 reactors
  - 11% of global electricity output
- European Union:
  - 14 countries
  - 131 reactors
  - 30% of Europe's electricity output
- Poland's neighbourhood:
  - 10 nuclear plants, 23 reactors
- By entering the **civilian nuclear club**, Poland will be able to pursue a **more active energy policy** internationally, including in the EU forum where the Polish government has kick-started an energy union debate. The construction of a nuclear power station may also contribute to a **tightening of bilateral relations** with nuclear fuel producer countries and technology vendors.





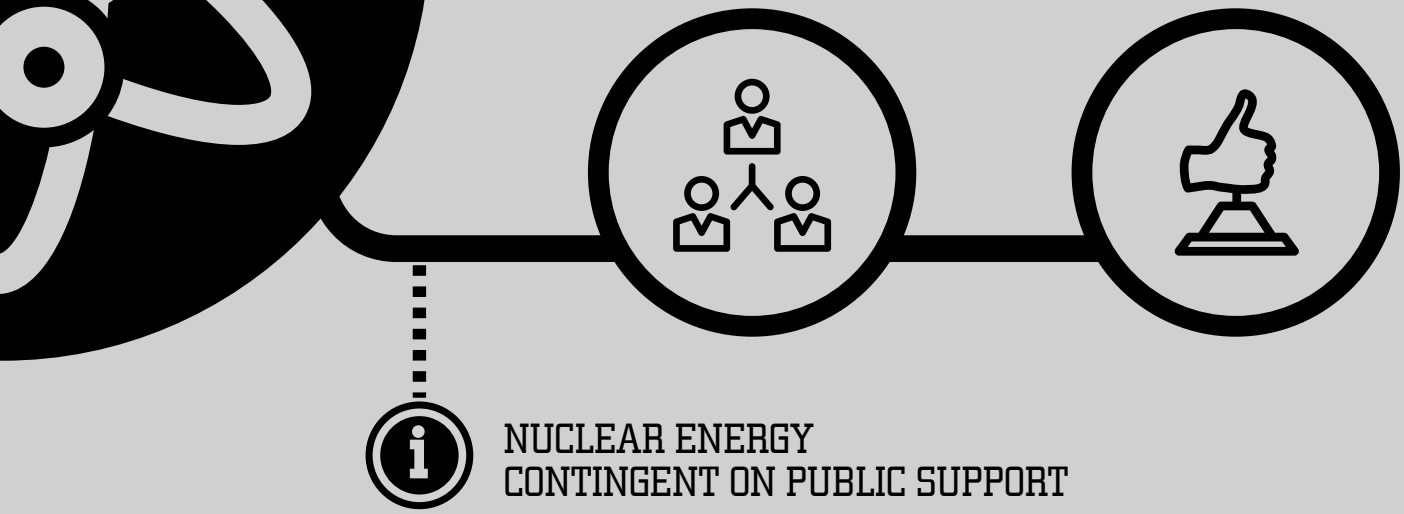
NUCLEAR ENERGY DRIVES INNOVATION AND ECONOMIC GROWTH

- **Investments** in putting up the country's first nuclear power plant **expected at 40–60 billion zloty**
- Despite the huge spending, **nuclear plant construction offers a chance to accelerate economic growth**
- **Major contribution from domestic companies is imperative:**
  - 10% domestic input in entire project by 2020
  - 30% domestic input in entire project by 2024
  - 60% domestic input in entire project by 2030
- **Innovation is what drives nuclear industry growth** and guarantees its continued development. The form and extent of the Polish nuclear energy programme will be largely dependent on whether an **effective partnership** is established between the leading players: "producers" of innovation, i.e. research centres/universities; the nuclear industry (manufacturers, technology vendors, small and medium-sized enterprises); and government agencies.



NUCLEAR ENERGY COMPATIBLE WITH OTHER SOURCES

- By 2020, **Poland's electricity generating capacity will have shrunk by a fifth:**
  - some coal-fired plants no longer to be modernised
  - ageing plant
  - 30% growth in electricity consumption by 2030
  - new energy blocks needed of capacity between 13 and 18 GW
- Elements of Poland's future energy mix:
  - shale gas production
  - increased use of renewables
  - nuclear technology
  - continued robust presence of coal
- **Coal is and will continue to be an important part of the Polish energy sector.** The decision to build a nuclear plant will be no means affect—until 2050—the rationale for investing in new coal-powered plants. Given the requirements of the EU's climate and energy policy, it may turn out that **keeping coal in the Polish energy mix will be contingent on also going nuclear**.



NUCLEAR ENERGY CONTINGENT ON PUBLIC SUPPORT

- **64% of Poles welcome plans for nuclear plant construction**
- **71%** of Poles see nuclear technology as an attractive and tested way of electricity generation
- **57%** of Poles believe that **nuclear energy poses no threat to the country**
  More than **40% of Poles** declare **not having enough knowledge about nuclear energy**
- Technology innovations, such as nuclear power generation, must enjoy public trust and approval. **In the absence of a distinctive institutional leader to spearhead the Programme, the public may feel confused** about delineation of competences and the will to go on with the Polish nuclear energy effort.

ENDNOTES

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[18]NNB Generation Company (NNB GenCo) is a subsidiary of EDF Energy, which has been contracted in the UK to build and operate two nuclear plants, Hinley Point C and Sizewell C.

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[27]Estimated investment outlays on the preparation for, and construction of, Poland's first nuclear power plant with a capacity of 3000 MW. „Program polskiej energetyki jądrowej," Ministerstwo Gospodarki, Warszawa, 2014, p. 10 – http://bip.mg.gov.pl/files/upload/16134/PPEJ_2014_01_28_po_RM.pdf.

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[32]J. Wojtkowiak, *Energetyka jądrowa – za i przeciw w warunkach polskich* – www.ee.put.poznan.pl/Prof-J-Wojtkowiak-wyklad-inauguracyjny.pdf.

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[38]*Political shift for Spanish nuclear*. See: http://world-nuclear-news.org/NP_Political_shift_for_Spanish_nuclear_2311111.html.

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[44]Findings of an opinion poll on nuclear energy perception in Poland, conducted in April 2004. The quantitative research took the form of face-to-face interviews with a printed questionnaire (PAPI) on a representative sample of 1,000 adults. The qualitative research consisted of in-depth interviews with 24 energy generation experts.

[45]Respondents could indicate two answers.

[46]Respondents could indicate any number of answers.

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NOTES

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THE POLISH INSTITUTE OF INTERNATIONAL AFFAIRS

ISBN 978-83-64895-02-9