Polish Nuclear Power Programme

MINISTERSTWO GOSPODARKI

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ABBREVIATIONS AND ACRONYMS

A	
ABW	Internal Security Agency [*Agencja Bezpieczeństwa Wewnętrznego*]
AKE	Export Credit Agencies [*Agencje Kredytów Eksportowych*]
ARE	Energy Market Agency [Agencja Rynku Energii S.A.]
ASME	American Society of Mechanical Engineers
B	
BMPP	Biomass power plant(s)
BWR	Boiling Water Reactor
C	
CCS	Carbon Capture and Storage
CEZAR	Centre for Radiation Emergencies [*Centrum do Spraw Zdarzeń Radiacyjnych*]
CF	Capacity Factor
CHP	Combined heat-and-power plant
CIP	Communal Information Point
CO_2	Carbon dioxide
D	
DSO	Distribution System Operator
E	
EC	the European Commission
ECURIE	European Community Urgent Radiological Information Exchange
EEA	European Environment Agency
ENEF	European Nuclear Energy Forum
ENSREG	European Nuclear Safety Regulators Group
ESA	Euratom Supply Agency
ESNII	European Sustainable Nuclear Industrial Initiative
EUR	European Utility Requirements
EURATOM	European Atomic Energy Community
Eurostat	European Statistical Office
F	
FBR	Fast Breeder Reactor
G	
GDEP / GDOŚ	General Directorate for Environmental Protection (Poland)
GT	Gas turbine(s)

GTCC	Gas Turbine Combined Cycle
GTRI	Global Threat Reduction Initiative
H	
HTGR	High Temperature Gas-Cooled Reactor
I	
IAEA	International Atomic Energy Agency
INCT [IChTJ]	Institute of Nuclear Chemistry and Technology [*Instytut Chemii i Techniki Jądrowej*]
IDC	Interest During Construction
IFJ PAN	Institute of Nuclear Physics, Polish Academy of Sciences
IFNEC	International Framework for Nuclear Energy Cooperation
IGCC_C	Coal Integrated Gasification Combined Cycle
IGCC_C + CCS	Coal Integrated Gasification Combined Cycle with Carbon Capture and Storage
INIR	Integrated Nuclear Infrastructure Review
INPRO	International Project on Innovative Nuclear Reactors and Fuel Cycles
IRRS	Integrated Regulatory Review Service
ISO	International Organisation for Standardisation
K	
KWh	Kilowatt hour
L	
LIC	Local Information Centre
LIC	Local Information Committee
LWR	Nuclear power plants based on light water cooled and moderated reactor technology. ARE S.A. analyses use this acronym for NPPs with Light Water Reactors, incl. third-generation water reactors.
M	
MAE	International Energy Agency (OECD)
ME	Ministry of Economy (of the Republic of Poland)
MSHE	Ministry of Science and Higher Education
MWh	Megawatt hour
N	
NAEA [PAA]	National Atomic Energy Agency
NCBiR	National Centre for Research and Development [*Narodowe Centrum Badań i Rozwoju*]
NCBJ	National Centre for Nuclear Research
NCFSVCE	National Centre for Support of Vocational Continuous Education [*Krajowy Ośrodek Wspierania Edukacji Zawodowej i Ustawicznej*]
NCP	National Contact Point
NEA	Nuclear Energy Agency (OECD)
NEPIO	Nuclear Energy Program Implementing Organisation

NFEPWM [NFOŚiGW]	National Fund for Environmental Protection and Water Management
NEPS	National Electric Power System
NPF	Nuclear Power Facility
NPMRWSNF	National plan for the management of radioactive waste and spent nuclear fuel
NPP	Nuclear power plant
NO_x	Nitrogen oxides
NRWSF	National Radioactive Waste Storage Facility
NSRP	Nuclear safety and radiological protection
NTG [KSP]	National Transmission Grid
Nuclear IV GEN	Nuclear power plants based on fourth-generation reactor technology
Nuclear LWR	(See: LWR)
O	
OECD	Organisation for Economic Co-operation and Development
OHSAS	Occupational health and safety management systems
OVN	Overnight Investment Costs
P	
PC	Pulverized Coal (PC)-fired condensation power plants
PC +CCS	Power plants using Pulverized Coal with Carbon Capture and Storage
Plenipotentiary	Government Plenipotentiary for Polish Nuclear Power
PGE	PGE Polska Grupa Energetyczna S.A.
PGI	Polish Geological Institute – National Research Institute
PKP	Polish National Railroads [*Polskie Koleje Państwowe*]
PL	Pulverized Lignite-fired condensation power plants
PL +CCS **PNPP**	Power plants using Pulverized Lignite with Carbon Capture and Storage Polish Nuclear Power Programme
PP	Power plant
PSE	Polish Power Grid - Polskie Sieci Elektroenergetyczne S.A.
PURL	Polish Underground Research Laboratory
PV	Photovoltaic power plants
PWR	Pressurized Water Reactor
R	
RES	Renewable Energy Sources
RCCM	*Règles de Conception et de Construction des matériels Mécaniques des îlots nucléaires REP* – Design and Construction Rules for Mechanical Components of PWR nuclear islands
RWDE [ZUOP]	Radioactive Waste Disposal Enterprise [*Zakład Unieszkodliwiania Odpadów Promieniotwórczych*], a State-owned public benefit corporation
S	
SO_2	Suplhur dioxide
SDR	Special Drawing Rights, an international conventional participation unit
SWOT	SWOT (Strengths/Weaknesses/Opportunities/Threats) analysis of a project

T	
TSO	Transmission System Operator
TWh	Terawatt hour
U	
UDT	Technical Supervision Office
EU	the European Union
URD	Utility Requirements Document (USA)
URE	Energy Regulatory Authority
V	
V4	the Visegrad Group (Poland, Czech Rep., Slovak Rep., Hungary)
W	
WENRA	Western European Nuclear Regulators Association
VVER	Water-Water Power Reactor (Russ., *Vodo-Vodyanoi Energetichesky Reaktor*), generic name used for Russian-designed PWRs

CHAPTER 1. INTRODUCTION

The primary objective of the state's energy policy is to satisfy the energy-related needs of the society and economy, at competitive prices and in a fashion compliant with the environmental requirements. Within the following decades, the goal thus defined is expected to be determined by investment needs related to the development of the production infrastructure and by participation of Poland in the implementation of the European Union's climate and energy policies. Consequently, the structure of electricity generation mix will have to be gradually changed from high-carbon-emission sources to zero emission and low-emission sources.[1] Nuclear power is of special importance in this context: it ensures reliable supplies of electricity with no emissions of CO_2, dusts (particulate matter – PM), sulphur dioxide (SO_2), nitrogen oxides (NO_x), and other particulate and gaseous pollutants.

An argument in favour of implementation of nuclear power technologies in the country is the need to provide appropriate energy security for Poland. This is achievable, mainly, through the diversification of the fuel base and production of energy at reasonable cost, while taking into account the environmental challenges. Modern nuclear power plants have a proven track record of satisfying these requirements.[2]

Construction and operation of NPPs will yield benefits in terms of energy security whilst having an advantageous bearing on the energy market. Development of nuclear power engineering shall:

- decelerate and, in a longer run, prevent the increases in energy prices;
- keep the prices of energy stable, as the cost of nuclear fuel is relatively stable and resistant to large fluctuations;
- ensure safe and continual supply of fuel: the nuclear fuel material (mainly, uranium) is acquired from politically stable countries, its quantity required for operation of an NPP is small and easy to store for a number of years.

The priorities of Polish energy policy regarding nuclear power have been determined in the document entitled *Energy Policy of Poland until 2030*[3], item 4 – 'Diversification of the structure of electricity generation through the launch of nuclear power technologies'.

It is anticipated that consumption of electrical energy in Poland will be on a rising trend, owing to the country's expected economic growth and the present relatively low consumption which is non-maintainable in the longer run. The Eurostat data as of 2011 places Poland twenty-fourth amongst EU countries with respect to annual per-capita consumption of electricity, with approx. 4,100 kWh – that is, much below the 'old' EU-15 average of approx. 7,500 kWh.

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[1] These terms follow the categorisation proposed by EC in its document *EU Energy, Transport and GHG Emissions: Trends to 2050*, December 2013, p. 46. Thus, 'zero emission' include nuclear and renewable sources, low-emission being clean coal technologies (e.g. CCS).

[2] The most recent generation III and III+ reactors comply with the safety/security requirements as set forth in the EC stress tests.

[3] As published in *Monitor Polski*, official journal of the Republic of Poland (hereinafter, *MP*), as an Appendix to the notice of the Minister of Economy of 21st December 2009 on the State's energy policy to 2030 (i.e. *MP* of 2010, No. 2, item 11). The document was approved by way of Resolution of the Council of Ministers no. 202/2009, of 10th November 2009, on the *Energy policy of Poland until2030* (unpubl.), as amended by Resolution no. 157/2010 of 29th September 2010 r. (unpubl.).

An updated forecast of demand for fuels and energy until 2030[4] has it that the demand for final electricity will increase by ca. 36%, i.e. from 119.1 TWh as of 2010 to 161.4 TWh in 2030. This means that the demand will be growing at 1.5 per cent annually on average, in spite of projects rationalising the consumption of energy being implemented in line with the EU requirements. To satisfy the growing electricity consumption needs, it will therefore be necessary to increase the output. Beside the new high-efficiency coal-fired power plants, construction of new-type capacities will be necessary – including nuclear, those based on gas and RES. As per the forecast in question, the capacity installed in generation sources ought to increase to approx. 44,500 MW by 2030, up from approx. 33,500 MW in 2010, i.e. by around 33%.

Since 1980, Poland has been a net importer of energy; with a limited potential of domestic primary energy resources, the trend will be sustained. Poland's own resources of materials indispensable for production of electric energy will not suffice to ensure energy security to the country. The ongoing work on excavation of shale gas is at too early a stage to assess whether this particular source could substantially alter the Polish energy mix.

The present-day fuel structure of Polish electrical power engineering took shape after World War 2, when the country was forced to primarily use its own resources as it faced a deficit of foreign currency for possible purchases of imported fuels. The Government's decision to quit the Żarnowiec NPP project has regrettably solidified the structure in question.

In spite of the decrease trend observable, 2012 saw the share of coal in electricity production hitting 85%.

Meeting by Poland of the EU requirements regarding 15% of renewable energy in the gross final energy structure by 2020 will imply significant increase in the share of RES in the energy mix, in spite of the prevalent high production cost for renewable technologies.

According to the aforementioned forecast regarding the demand for energy and fuels until the year 2030, which takes into account the expected effects of implementation of effectiveness projects, EU requirements for restricted emissions, and forecast prices of fossil fuels till 2030, adding nuclear power technologies in the generation sources mix past 2025 proves to be advantageous. It will enable Poland to reduce carbon emissions in the electrical power industry whilst alleviating the increases of electricity prices caused by high outlays on reduced carbon emissions. For these reasons, after 2050, nuclear power units ought to play an essential part in the mix of new baseload power plants.

Taking into account the expected increase of RES and investments made in the new coal sources defined in Chapter 4.1. hereof, the capacity structure of electricity sources ought to look in 2030 as shown in Fig. 1.1. This particular analysis is based on conservative assumptions with respect to technological and economic parameters of nuclear power industry.

Chapter 4 compares the planned investments in new production capacities against the option of realistic development of nuclear power industry.

In spite of the increasingly stringent environmental requirements, coal will remain the most substantial energy material used for production of electric energy and heat. Within the coming twenty years, i.e. by 2030, it is assumed that the coal sector ought to ensure fuel supplies which

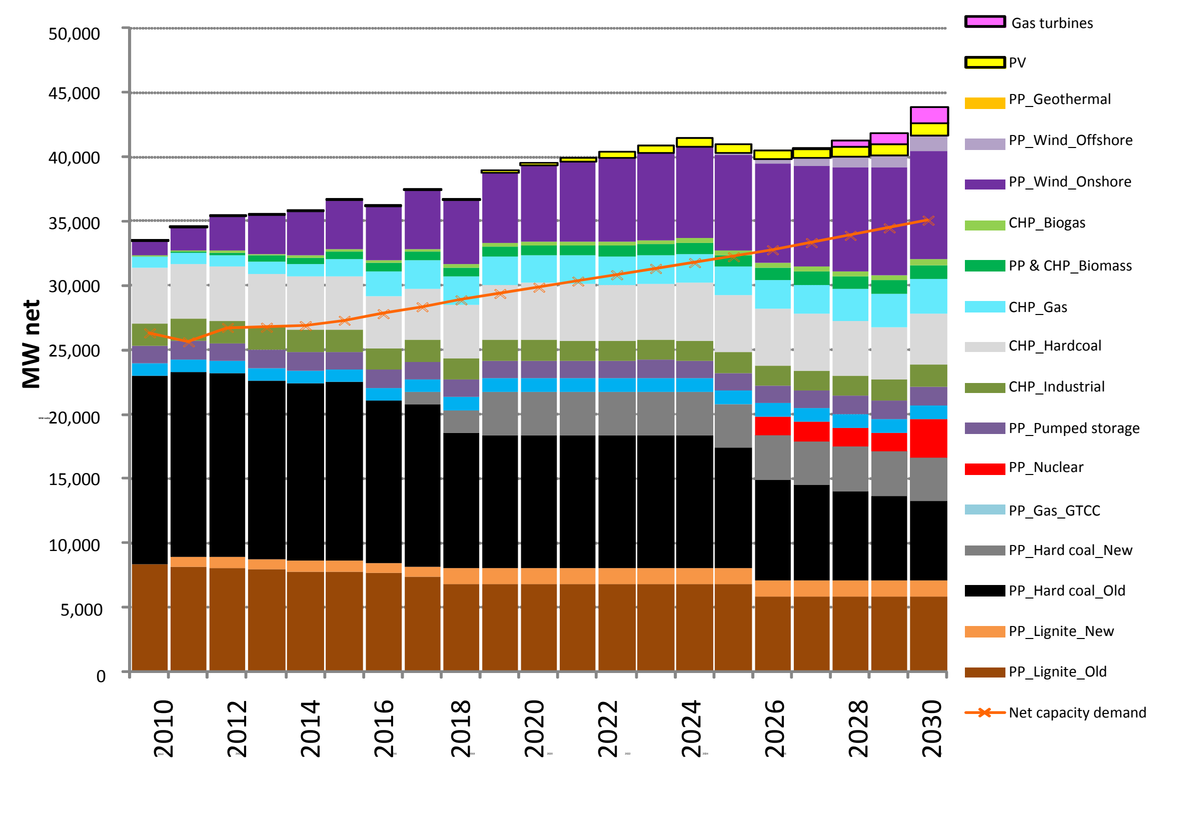
[4] *An updated forecast of demand for fuels and energy until 2030*, ARE S.A., June 2013.

would enable Poland to maintain the electricity output from hard and brown coal-fired power plants at 98.3 TWh in 2015, 97.2 TWh in 2020, and 88 TWh in 2030.

The purposefulness of implementation of nuclear power technologies in Poland in the context of carbon reductions is proved as legitimate by the McKinsey report titled *Evaluation of the potential for reduced emissions of greenhouse gases in Poland until 2030*[5]. The report implies that for a structure of fuels that would theoretically ensure the largest possible reduction of CO_2 in electricity production, use of nuclear sources is the most advantageous and profitable option.[6]

In turn, a study of the costs and expenses of electricity prepared on order of the European Commission has confirmed that scenarios based on a significant share of nuclear component (20%–30%) prove to be cheaper and safer compared to those based on increased proportion of RES.[7] Nuclear power industry is a stable and safe source of electric energy, which is nowadays taken advantage of by fifteen[8], of the twenty-five, EU Member States, and is responsible for a third of EU's electric output. On the European level, nuclear is recognised as a technology which allows for meeting the objectives set by the EU's energy action plans or roadmaps.[9]

Fig. 1.1. Structure of electricity source capacities till 2030.
A scenario based on conservative assumptions for nuclear power industry, taking into account new investments – in particular, new coal capacities.



Source: ***An updated forecast of demand for fuels and energy until 2030*, ARE S.A., June 2013.**

Being an advanced technology, nuclear power implies the necessity to provide highly qualified human resources displaying not only high technological/technical and managerial culture but also

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[5] Compiled in 2009 on commission of the Ministry of Economy.
[6] See Chapter 4.2., Fig. 4.4.
[7] *Increase/decrease trends in electricity costs and expenses, a KEMA 912-704 final report for DG ENER*, January 2013.
[8] Including Croatia, which holds a 50% share in NPP Krško in Slovenia.
[9] *Energy Roadmap 2050*, COM(2011) 885, a CE Communication of 15th December 2011.

shaped by a system of values that is rooted in the sense of responsibility for safety, security, and assurance of quality and standard of life of the present and the coming generations.

If Poland opts for nuclear energy, it will be enabled to fulfil its sustainable development obligations and to ensure supplies of electricity at reasonable cost, observing the environment requirements. This implies effort taken to prepare the appropriate regulations encouraging such investments but also taking into account a long-term vision of functioning of the nuclear power sector and its long-term effects.

It is of high importance that an independent, competent and professional nuclear supervision be in place. The quality of the technology applied and the transparency of the process of its implementation, with an inbuilt reliable information component, give grounds for soliciting social acceptance for this technology at each stage of preparation and delivery of the nuclear power development programme.

Taking into consideration a future prospect of development of nuclear technologies, it is essential that cooperation is in place for the development of a next generation of power reactors with enhanced operational parameters as well as for spent nuclear fuel and radioactive waste handling solutions. Reasonable, safe, and socially acceptable radioactive waste management is one of the key elements of the functioning of the nuclear power industry.

The nuclear power sector bears full responsibility for the functioning of this particular branch of economy – from the moment the investment is prepared, through to its implementation phase, safe and economical operation and utilisation of nuclear power facilities and their subsequent decommissioning, and implementation of the spent fuel and radioactive waste management solutions. Such responsibility on the part of the investor(s) and operator(s) starts the moment the investment decision is made, and it only ceases after the decommissioning of NPF has successfully been completed.

The preparatory actions related to the launch of nuclear power in Poland have to be carried out within the specified legal framework established with respect for the international laws and EU regulations as well as in line with the recommendations of the International Atomic Energy Agency (IAEA). Such actions also draw upon the experiences of those countries which have implemented nuclear power with success and under social acceptance.

Taking into account the scale of the means to be involved, the nuclear power development programme is the greatest undertaking in the history of the Polish energy sector and in the post-war economy as a whole. Apart from the economic questions, the potential benefits of its implementation embrace a broad spectrum of phenomena across various areas of life. A powerful nuclear sector is a source of progress, innovation, and higher professional standards in areas such as electrical engineering, materials engineering and technology, mechanics, automatic control/control engineering, information technology, chemistry, and medicine. The programme is an expression of an economic policy that identifies the significance of equable development of all the perspective sectors of economy, including the high technologies industry.

Owing to its comprehensiveness and scale, the venture under discussion must be implemented with support of international organisations having the necessary knowledge and experience, illustrated by a rich collection of standards, guidelines and recommendations; even more importantly, such organisations ought to be willing to share such knowledge. In particular, IAEA, OECD-affiliated

Nuclear Energy Agency (NEA) are the case, as is cooperation within international initiatives (also implemented under the auspices of such organisations).

The primary areas of such cooperation definitely include:

- safety and security, including nuclear safety, physical protection of nuclear facilities and materials, and safeguarding of nuclear materials;
- educating highly qualified labour force for nuclear power industry, on the investor's and public/civil service part;
- ensured accessibility of nuclear fuel and safety of its supply;
- handling of spent nuclear fuel and radioactive waste.

IAEA's Integrated Nuclear Infrastructure Review (INIR) is a specific example of a scheme providing support to all the countries implementing the nuclear power option.[10]

It has to be remarked that, given the geopolitical determinants of today, the development of nuclear power is also connected with the need for Poland to meet its obligations regarding prevention of proliferation of nuclear weapons and nuclear materials.

The existing analyses of legitimacy of implementation of nuclear energy industry in Poland, the international development trends in this industry, and the experiences of the countries that have been operating nuclear power facilities (NPF) for a number of years show that nuclear power is a safe technology that enables production of electricity at a reasonable cost, which proves to be lower than that of other generation technologies. Nuclear power technologies are, moreover, zero emission technologies – a factor of crucial importance for meeting GHG emission reduction targets established for Poland.

The governmental decisions of 2009 have initiated the activities aiming at implementation and development of nuclear power. However, the way from the decision to prepare the programme till the start-up of the first nuclear unit is a time-consuming process; hence, an effective action programme needs to be prepared in order to reach the target in the shortest time possible.

The present *Polish Nuclear Power Programme (PNPP)* shows the scope and organisational structure of the actions indispensable for the launch of the nuclear option, for ensuring safe and efficient operation and utilisation of NPFs, their decommissioning after the operation period is over, and for ensuring safe handling of spent nuclear fuel and radioactive waste.

[10] For details of INIR's mission to Poland, see Chapter 5.

1.1. SUMMARY OF ACTIONS TAKEN TO DATE

Independently of the work on the PNPP, since the adoption by the Council of Ministers of Resolution no. 4 'on the actions to be taken to develop nuclear power engineering industry' of 13th January 2009, actions preparing Poland for development of nuclear power industry have been consistently implemented.

The following actions have been completed, in the respective areas:

1. Institutional framework enabling development of nuclear power sector:

- Government Plenipotentiary for Polish Nuclear Power has been appointed;
- Prime Minister's Interdepartmental Task Force for Polish Nuclear Power has been set up;
- Social Advisory Team to the Government Plenipotentiary for Polish Nuclear Power has been established;
- Nuclear Energy Department has been set up as part of the Ministry of Economy (ME) of the Republic of Poland, tasked with substantive coordination of the Minister's tasks and actions related to the use of nuclear energy for the country's social and economic purposes;
- the National Atomic Energy Agency (NAEA; Polish abbr., PAA) has been restructured and its personnel potential reinforced in view of adaptation to the needs of nuclear supervision for the nuclear power industry.

2. Legislative framework:

- an amended version to the Act titled the [Polish] Atomic Law has been compiled and enacted (in force as from 1st July 2011);
- a Law on preparation and delivery of investment projects in the area of nuclear power facilities and their accompanying projects (in force as from 1st July 2011);
- a total of twenty pieces of secondary legislation to the Polish Atomic Law have been prepared and issued, determining in detail the nuclear safety and radiological protection (NSRP) requirements for specified types of actions and facilities, among other aspects;
- Poland has actively participated in the work on the draft Council Directive 2011/70/Euratom;
- a draft amended Act – 'Polish Atomic Law' implementing Council Directive 2011/70/Euratom has been prepared;
- Poland, through NAEA, is taking active part in the compilation of draft Directive amending Council Directive 96/29/Euratom;
- Poland, through NAEA and ME, is taking active part in the compilation of draft Directive amending Council Directive 2009/71/Euratom;
- Poland, through NAEA and ME, has been involved in reviewing the IAEA guidelines and giving opinions thereon.

3. Educating and training of human resources for nuclear power-related institutions and enterprises:

- In the period of 2009 to 2012, Polish ME, in cooperation with the Commissariat à l'énergie atomique et aux énergies alternatives (CEA; the Atomic Energy and Alternative Energies Commission), has held a series of training and traineeship programmes or sessions for representatives of Polish scientific milieu, so-called educators. As part of the related contract, several dozen delegates travelled to use the training opportunities in France.
- Between 2009 and 2013, a dozen-or-so higher (tertiary) education institutions have launched faculties, majors or areas of study connected with nuclear power engineering. A few universities and colleges have opened postgraduate studies in this field.
- 2012 saw the preparation and publication of learning titles in nuclear power engineering:
  - a brochure entitled *Poznaj atom* ['Get to know the Atom'] and educational bookmarks;
  - an educational movie *Poznaj atom* ['Get to know the Atom'];
  - instructional materials for secondary-school teachers of natural subjects, entitled *Podstawy energetyki jądrowej* ['The Basics of Nuclear Power];
  - a multimedia education kit *Energetyka jądrowa* ['Nuclear Power], offering e-learning training for secondary and upper-secondary school students.
- In the first half of 2013, pilot-tested course material was published in countrywide knowledge portals for teachers (SCHOLARIS and the NCFSVCE {KOWEZiU}-run portal[11]).

4. Informative and educational actions:

Beginning with 2009, a series of informative and educational actions have been implemented with a view to enhance public knowledge on nuclear power. Public opinion polls each time reported a low level of knowledge in the society, which in turn caused that support for, or resistance against, nuclear power were based upon feelings, rather than a reliable factual foundation.

Therefore, the Ministry of Economy inaugurated, as from 29th March 2012, an information campaign entitled *Poznaj atom. Porozmawiajmy o Polsce z energią* ['Get to know the Atom. Let's talk about Poland with energy'], aiming at providing the Poles with current reliable information on nuclear power and technologies. The campaign included a number of actions making use of traditional (the press, radio, publications) as well as modern communication tools (social media, social debates); a website was launched (www.poznajatom.pl), along with the campaign's profiles on community portals (Facebook, Twitter); advertising campaigning was carried out in the media; direct public enquiry was held with regional civil servants of the West-Pomeranian and Pomeranian Provinces [in Polish, *województwo zachodniopomorskie/pomorskie*]; a number of educational publications were issued, including newspapers' thematic supplements; a study visit of local-government and media representatives to Finland was organised; moreover, there were numerous debates, seminars, lectures and meetings concerning the implementation of PNPP.

[11] The abbreviation stand for the National Centre for Supporting Vocational and Continuing Education.

In 2013, owing to the State's budgetary situation and a limited financial resource available for promotional campaigning within Poland, the campaign in question was limited and based on the Ministry's own human and financial resources. Relations were continued with all the interested groups of recipients, through actions consisting in organisation of, and participation in, numerous social debates, educational actions, or publications. In turn, the campaign's Facebook profile has become quite an active and popular forum for discussing nuclear power matters.

Also the investor pursues his informative and educational actions, mainly on a local level.

The NAEA also carries out its information activities, as required by the law.

Knowledge on nuclear power is proactively popularised by the National Centre for Nuclear Research, the Institute of Nuclear Chemistry and Technology (INCT) as well as by certain universities or colleges.

5. Ensured supply of nuclear fuel:

In 2010, a study entitled *An evaluation of potential occurrence of uranium mineralisation in Poland, based on the outcome of geological-exploratory works* was compiled, which confirmed that uranium deposits occur in Poland.

6. Research facilities:

- The National Centre for Nuclear Research [NCBJ] was formed by merger of two institutes. One of the units set up within the NCBJ is a Nuclear Power Engineering Department, whose responsibilities extend to actions related to implementation of PNPP.
- The INCT and the Institute of Nuclear Physics, Polish Academy of Sciences (IFJ PAN) have joined activities to implement PNPP.
- ME has taken over from NAEA the tasks related to assignment of subsidies for nuclear safety and radiological protection (NSBP) whose main beneficiaries are nuclear power research organisations.
- On request of ME, the National Centre for Research and Development (NCBiR) has activated a strategic research project on 'Technologies supporting the development of safe nuclear power. The project will make it possible to interrelate the research pursued by Polish scientific teams with the research performed elsewhere, and to prepare scientific and technical personnel for Polish nuclear industry. Its implementation will also contribute to the implementation of actions related to spent nuclear fuel and radioactive waste.
- NCBJ is involved in the Allegro project aimed at building a new-generation reactor in cooperation with Poland's Visegrad Group partners (Czech Rep., Slovakia and Hungary). Allegro is one of the three basic projects being realized within CE's ESNII scheme and aimed at developing IV-generation reactors. NCBJ joined the programme on 25th June 2012. NCBJ's experts will be working on construction of a helium-cooled fast reactor. The technological concepts under development are aimed at more effective use of nuclear fuel and reduction of the amounts of radioactive waste.

7. Management of radioactive waste and spent nuclear fuel:

- A Team has been established for compilation of a *National plan for the management of radioactive waste and spent nuclear fuel* (NPMRWSNF), a scheme that has been joined by representatives of the offices and institutions dealing with radioactive waste and spent nuclear fuel management.

- Work has been initiated to identify the site for a new low- and medium-level radioactive waste storage facility. The consortium, led by the Polish Geological Institute (PGI), commenced the actual work, backed with the specific funding raised for the purpose by the National Fund for Environmental Protection and Water Management (NFEPWM [Polish abbr., NFOŚiGW]).
- Analyses indispensable for the compilation of the NPMRWSNF have been carried out.
- Recommendations regarding the management of radioactive waste and spent nuclear fuel were prepared and approved by the Minister of Economy in August 2012 to form the basis for the preparation of NPMRWSNF.
- A working group has been set up for supporting the concept of deep geological radioactive waste storage, by way of the construction of a Polish Underground Research Laboratory (PURL), joined by ME, PGI, and other interested institutions. The Group seeks, among other things, to support scientific research on storage of spent nuclear fuel and high activity radioactive waste to be used in the future for identification of the site and for construction of a deep geological radioactive waste disposal facility for spent nuclear fuel and high-activity radioactive waste.

8. Siting analyses for NPP:

In 2010, a document entitled *A professional evaluation (expert opinion) regarding the criteria for siting of nuclear power plants and an initial evaluation of the agreed sites* was prepared, on commission of ME. It confirmed the potential possibilities of siting NPPs in Poland. The document was forwarded to PGE which, being the investor, is responsible for the selection of the final site(s) for the NPP(s), Since then, PGE has been working on this problem.

9. International cooperation:

Poland pursues a broad international cooperation in the area of peaceful uses of nuclear energy, with special focus on nuclear power and technology issues, both within the competent international organisations and initiatives (incl. IAEA, NEA, IFNEC, GTRI, EURATOM) and with individual countries.

<u>Actions conducted in cooperation with IAEA:</u>

- Poland, through NAEA, actively contributes to the Regulatory Cooperation Forum (RCF) which ensures coordinated cooperation among nuclear regulators, including those of the countries where nuclear power is being launched and those having a developed nuclear power system.
- Polish experts take an active part in the work of a total of five committees and a commission involved in establishing safety and security standards for peaceful uses of nuclear energy.
- One of the essential instruments in the cooperation with the IAEA supporting the preparation for implementation of NPPP is the Technical Cooperation (TC) Programme. By means of international (European) as well as national, Poland-oriented projects, the TC Programme reinforces the preparation of Poland for launching nuclear power programme and for assurance of nuclear safety (national technical cooperation projects have been implemented since 2012, focused on getting ME and NAEA prepared for implementation of NPPP – the total value of these projects exceeds EUR 100,000 per annum).

- Moreover, as part of scientific-and-technical cooperation and technical assistance, Poland has been receiving an annual support in supplies of specialized apparatuses, appliances and equipment, foreign traineeship and scholarship offer, and expert visits. The year 2012 alone saw five technical aid projects under delivery in Poland, including a project called *Supporting the development of nuclear infrastructure for nuclear power purposes*.
- Two IAEA missions to Poland were held in 2013: an INIR and an IRRS mission. The outcomes of both will prove helpful in efficient and optimum preparation to implementation of nuclear power in Poland.

Actions implemented as part of cooperation with NEA:

- Poland has been a member of the NEA since November 2010.
- Poland takes an active part in the work of a total of seven NEA committees and working groups, taking advantage of the experience and expertise of the organisation and its member states.
- Actions are underway to enable Poland's accession to the NEA Data Bank, to enable the country to make use of the achievements of NEA member states, through scientific institutions involved in research on use of nuclear energy, including nuclear power and technologies.

Actions implemented as part of IFNEC:

- Poland participates in the work of IFNEC working groups.
- A meeting of IFNEC's Executive Committee was held in 2011 in Warsaw.

Actions delivered as part of GTRI:

Based upon the international agreements with the USA and the Russian Federation, spent nuclear fuel from Polish research reactors has been removed from Poland to Russia.

Actions delivered as part of EURATOM:

- Through NAEA and ME, Poland participates in EURATOM's ongoing legislative work[12] and takes part, on an ongoing basis, in other events, such as e.g. stress tests after the Fukushima meltdown accident.
- Through NAEA and ME, Poland pursues cooperation within the ENSREG forum.
- Polish research institutes, scientific institutes of the Polish Academy of Sciences and tertiary-level schools have joined the Euratom Framework Programme for research and training actions. The Programme came as a complementation to 7th Euratom Framework Programme for technological research and development. Polish participation in this scheme is characterised by a high (so-called) success coefficient.

On the bilateral level, Poland has entered into several agreements for cooperation in peaceful use of nuclear energy (with the USA, Japan, South Korea). NAEA has moreover signed cooperation agreements with the US and French nuclear regulators.

[12] See item 1.1.2. – Legislative framework (above).

CHAPTER 2. THE OBJECTIVES AND THE SCHEDULE OF THE POLISH NUCLEAR POWER PROGRAMME

2.1. THE FOUNDATIONS OF PNPP

In view of implementing nuclear power, an exercise of so high a priority for the country's economic and social development, and of ensuring energy security for Poland, it is indispensable to enact a programme for development of this particular area, which would satisfy the requirements of the Act on Development Policy Rules.[13] **Preparation and submission to the Council of Ministers of this PNPP fulfils the obligation imposed on the Minister of Economy under Article 108.a, item 1 of the Polish Atomic Law.**[14]

Moreover, the obligation to compile a PNPP ensues from the following normative acts and Government documents:

1. **Resolution no. 4/2009 of the Council of Ministers of 13th January 2009 on the actions taken for the development of nuclear power industry.**[15]
   §1:
   The Council of Ministers deems it indispensable to prepare and implement a Programme for Polish nuclear power industry.

2. **Ordinance of the Council of Ministers of 12th May 2009 on the appointment of a Government Plenipotentiary for Polish Nuclear Power.**[16]
   § 2, clause 2:
   The responsibilities of the Plenipotentiary shall include, in particular, to compile and submit to the Council of Ministers a draft Polish Nuclear Power Programme.

3. ***Energy Policy of Poland Until 2030.***
   Chapter 4.2.
   Actions to diversify the electricity generation structure through the launch of nuclear power:

   - institutional foundations to be developed for preparation and implementation of Poland's nuclear power programme.
   - a draft nuclear power programme for Poland to be compiled [...] and, subsequently , submitted to the Council of Ministers for approval.

4. (Medium-term) ***National Development Strategy 2020. Active society, competitive economy, efficient state.***[17]
   By means of the above document, the Council of Ministers has assumed the following position with respect to implementation of nuclear power:

[13] Act of 6th December 2006 'on the rules of development policy' (i.e. Journal of Laws [hereinafter, JL] 2009, no. 84, item 712, as amended).
[14] Act of 29th November 2000 – 'The Atomic Law' (JL 2012, item 264, as amended).
[15] Resolution no. 4/2009 of the Council of Ministers of13th January 2009 'on the actions to be taken for development of nuclear power industry (unpubl.).
[16] JL 2009, no. 72, item 622.
[17] As approved by Resolution no. 157 of the Council of Ministers of 25th September 2012 'on the approval of the *National Development Strategy 2020* (*Monitor Polski* [hereinafter, *MP*] – Official Journal of the Republic of Poland, item 882).

p. 91:
"The appropriate strategic choice is to build nuclear power stations; with adequate protection of radioactive waste, this source of energy is deemed the purest. Compared to energy production based on fossil fuels, nuclear power is characterised by a significantly lower energy generation cost and, in addition, by exiguous emissions of CO_2 and dusts. In spite of considerable investment outlays, nuclear energy is profitable in the longer run, due to the electricity generation costs, high capacity factor and a long period of operational use of power plant, which can be run for approximately fifty years."

Poland 2030. The Third Wave of Modernity. Long-term National Development Strategy.[18]

Again, the Council of Ministers presents its stance on implementation of nuclear power:
p. 112:
"The nuclear power programme under implementation is one of the best solutions, combining ensured long-term safety and stability of supplies of electricity and delivery of climatic and environmental objectives. [...] It is a source of energy that offers additional technological potential contributing to reduced energy generation costs. Although the investment process is long-lasting and costly, the later long-term operation, at relatively low operating expenses, presently renders nuclear power the lowest-cost attainable source."
p. 113:
"Nuclear power will contribute to ensuring energy security, and to transition toward 'green' economy."

This present PNPP constitutes a 'development programme' as provided for by Article 15, clause 4, item 2 of the Development Policy Rules Act.

2.2. TERM OF PNPP

The validity of PNPP as a long-term programme has been envisioned for the period of 2014 to 2024; likewise, the Programme's costs/expenses have been estimated for this period. This notwithstanding , the actions to be taken until the year 2030 have been covered. Construction of the first unit of the first nuclear power plant will commence during the period covered herein, and will expectedly be completed by 2024.

According to the Polish Atomic Law, [19] PNPP is to be compiled every four years, which will allow to regularly verify its assumptions and implementation cost data. As mentioned in the Introduction, actions related to preparing Poland for development of nuclear energy, as described in the 2010 draft PNPP, have been consistently delivered as from adoption by the Council of Ministers of Resolution no. 4/2009, on 13th January 2009.

[18] As assumed by Resolution no. 16 of the Council of Ministers of 5th February 2013 'on adoption of a long-term *National Development Strategy. Poland 2030. The Third Wave of Modernity* (*MP*, item 121).
[19] Atomic Law, Art. 108c, clause 2.

2.3. DIAGNOSIS OF THE SITUATION IN THE PROGRAMMING PERIOD

IAEA documents tell us that it needs ten to fifteen years of preparatory work to launch nuclear power, including the construction of the first power station. This timeframe is dependent on the country's developmental level.

As for Poland, in view of nuclear power implementation, it is necessary that infrastructure be built as indispensable for development and functioning of such projects and industry (i.e. legal, organizational and institutional infrastructure, research facilities, human resources training system).

An exhaustive diagnosis for the specific issues of special relevance for development of nuclear power industry is shown elsewhere herein, especially in Chapter 3 (Nuclear power in the context of long-term energy policy) and Chapter 4 (Analysis of the costs/expenses and economic reasonability of development of nuclear power). This concept of PNPP is owed to its complex and pioneering character.

2.4. SWOT

The strong and weak points in Polish economy as well as the opportunities and threats related to the development of nuclear power in Poland are described below.

Strengths:

- Poland has an advantageous geographical situation.
- Poland features a well-developed education system, incl. tertiary/university-level education.
- With the country's permanent long-term increase in demand for electricity, the local de-capitalised manufacturing base calls for being replaced.
- Poland offers a large market, with a prospect of constant increase in demand (considerable population, households growing richer as a steady trend), close access to the new East-Central European EU Member States and to the largest EU markets (esp., Germany).
- The country has advantageous macroeconomic conditions - with a stable economy, economic growth achieved in the recent years, low inflation rate, and stable banking system.
- The cost of labour is relatively low; in spite of its steady increase trend in the recent years, the cost of labour is still significantly lower than that of high-developed economy countries.
- Poland offers resources of qualified workforce, with a comparatively high qualifications of personnel needed for construction of nuclear power plants.
- Poland is a politically stable country.
- There is an operational nuclear inspection/regulatory system and a radiation monitoring system in place.
- There is an efficient radiation waste handling system in place.
- There is a research reactor in operation, and a related staff of experts.

- Poland participates in and/or contributes to all the international organisations of crucial relevance to the development of nuclear power.
- Potential technology suppliers have expressed considerable interest in the development of nuclear power locally.
- Poland has a compliant legal system.
- The investors' potential and capacities are a definite advantage.

Weaknesses:

- Unsatisfactory qualified staffing resources for operation of a nuclear power plant.
- Unequally developed transport infrastructure, of insufficient condition and parameters.
- Weak transport and traffic infrastructure countrywide (road and railroad networks, airports).
- Underdeveloped, and unevenly developed, power network/grid.
- Not-quite-efficient cooperation between the scientific sector and the economic sphere.
- Administrative limitations or restrictions (e.g. lengthy procedures, proceedings).
- Adverse forecasts for the country's demographic developments, which in a longer run will cause a shrinkage of human resources potentially available within Poland.
- High investment costs/expenses.

Opportunities:

- Poland faces an opportunity to see an economic revival in the regions, and a boosted industry countrywide.
- Scientific capabilities and research facilities are expected to develop.
- Economy to increase its innovative power.
- New, attractive jobs to be created.
- Reduction of import of hard coal and natural gas.
- Construction of stable and, in a long time horizon, economically profitable and cost-effective electricity generation sources.
- Limiting emissions of pollutants affecting the environment and/or detrimental to human health, incl.: NO_x, SO_2, CO (i.e. carbon monoxide, also called 'poison gas'), dusts, heavy metals (mercury, cadmium, arsenic, lead), tar substances and aromatic hydrocarbons (benzo[alpha]pyrene) and greenhouse gases (CO_2, NH_4).
- Diversified electricity generation structure.
- Development of relevant areas of higher/tertiary instruction, in view of establishing a strong staffing for the functioning of nuclear power facilities.
- Poland's investment attractiveness to grow owing to ensured stable supplies and prices of electricity.

Threats:

- PNPP may (partly) fail if underfinanced.
- With insufficient human resources/staffing in place, PNPP may come to a failure.
- Potential loss of political support for development of nuclear power in Poland.
- Difficulties in providing funding for construction of NPP(s) by the investor(s).
- Unsatisfactory social acceptance for development of nuclear power, with local communities' consent for construction of NPP, spent fuel storage facility and radioactive cemetery.
- Possible delays in construction of NPP, with the resulting increase in the costs of the project.
- A relatively short delivery time for the tasks and exercises to be completed.
- Hypothetical occurrence of a major nuclear breakdown anywhere in the world, with its adverse impact on social acceptance.

2.5. MAJOR OBJECTIVE AND DETAILED OBJECTIVES

The **major objective** of this PNPP is to implement nuclear power in Poland, thus contributing to provision of adequate quantities of electricity at prices acceptable to the economy and the society, with sustained satisfaction of environmental requirements.

This objective is to be implemented through a series of actions, as described below.

The major purpose will be served by the following **detailed objectives**:

1. Develop, establish, and update the legal framework for the development and functioning of nuclear power.
2. Ensure the highest achievable safety/security for NPP(s).
3. Introduce a rational and efficient system for handling radioactive waste and spent nuclear fuel, including construction of a new low- and medium-level radioactive waste storage facility.
4. Development of institutional background for nuclear power.
5. Enhance and sustain social support for the development of nuclear power – for instance, through enhanced social knowledge in this area.
6. Reinforce the national emergency service for radiation events with respect to the functioning of nuclear power, incl. through reinforcement of the national radiation monitoring system.
7. Provision of qualified staffing for the development and functioning of nuclear power.
8. Development of powerful and efficient research facilities for nuclear power.
9. Enhance the innovation of the technological standard of Polish industry.
10. Provide the conditions for reliable supplies of fuel to NPP(s).
11. The National Power System (NPS) to be prepared for the development of nuclear power.
12. Provide stable economic and financial conditions for the development of nuclear power.

Objective 1: To be achieved through compilation, adoption, and updating of appropriate legal regulations and, subsequently, ongoing control of the efficiency of their functioning.

Objective 2: To be achieved through professional activity of the investor, in line with the current requirements, under the supervisions of the Chairman of NAEA.

Objective 3: To be achieved through implementation of a system devised to handle radioactive waste and spent nuclear fuel (with special focus on funding) and systematic assessment of effectiveness and efficiency of its operation, as well as through identifying the site for and construction of a new low- and medium-level radioactive waste storage facility , based on social approval.

Objective 4: To be achieved through creation, or reinforcement, of institutions responsible for implementation and coordination of actions related to PNPP and its subsequently updated versions.

Objective 5: To be achieved through systematic information and education actions in the area of nuclear power and the consequently ensured high social acceptance for the delivery of PNPP.

Objective 6: To be achieved through comprehensive analyses of the present state-of-play (on the national and provincial, i.e. voivodeship, level) and, thereafter, preparation and implementation of the indispensable procedural and functional solutions, with appropriate upgrading of the relevant services, competent authorities and bodies.

Objective 7: To be achieved through developing a system of instruction and training in the area of nuclear power (*Plan for the development of human resources for the needs of nuclear power*), taking into account the needs of involved institutions and the possibilities of satisfying them at home and abroad.

Objective 8: To be achieved through creation, development and efficient functioning of consolidated research facilities for nuclear power.

Objective 9: To be achieved through provision of conditions for Polish enterprises to participate in the development of nuclear power.

Objective 10: To be achieved through entering into international agreements/understandings to provide conditions for stable long-term supplies of nuclear fuel, and through systematic evaluation of the possibilities and stability of fuel supplies from both domestic and external sources.

Objective 11: To be achieved through inclusion of the development and functioning of nuclear power in the National Transmission System development plans and, subsequently, through consistent accomplishment of these aspects, by constructing a network infrastructure indispensable for start-up and operation of NPP(s).

Objective 12: To be achieved through versatile and comprehensive economic and financial analyses in order to create foreseeable conditions for delivery of the investment projects, with adoption of appropriate relevant decisions.

2.6. RELATED STRATEGIC DOCUMENTS

Preparatory actions related to introduction of nuclear power in Poland are delivered in line with the domestic legislation while fully respecting the international and European laws and regulations, as well as in line with the IAEA recommendations.

This PNPP is compliant with the ***Medium-term National Development Strategy*** for Poland, which provides that implementation of nuclear power is the appropriate strategic option. The PNPP implements the Strategy’s Objective II.6 – ‘Energy security and the environment’, in particular, Objective II.6.3 – 'Increased diversification of supplies of fuels and energy' through introduction of nuclear power in the Polish electric power mix; due to the no-emission nature of nuclear power, Objective II.6.4 – 'Improved condition of the environment' is taken into account as well. The implementation of the PNPP will also help attain the other Strategy goals, such as II.2 – 'Increased capacity of the economy', and II.3 – 'Increased innovation of the economy'. The Programme's compliance with the national medium-term development strategy has been confirmed by the Minister of Infrastructure and Development in his opinion.[20]

Moreover, the Programme takes into consideration the objectives of the ***Energy Security and the Environment*** strategy (under preparation) whose draft has been adopted by the Ministry of Economy and recommended for approval by the Council of Ministers. The PNPP objectives are meant to help deliver Operational Objective no. 2 – 'Safe and competitive supplies provided to the national economy ', and Operational Objective no. 3 – 'Improved condition of the environment'.

PNPP is also compliant with the ***Long-term National Development Strategy***[21], which provides that "the nuclear power programme under implementation is one of the best solutions, which combines provision of long-term safety, security and stability of supplies of electricity as well as implementation of the climatic and environmental objectives. [...] It is a source of energy that offers additional technological possibilities contributing to reduced energy generation costs. Albeit the investment process as such is time- and cost-consuming, the following long-term operation, at comparatively low operating expenses, effectively renders nuclear power the lowest-cost source achievable nowadays."

The objectives defined in PNPP are moreover in compliance with ***Energy Policy of Poland Until 2030***, and achieve Objective no. 4 thereof – 'Diversification of electricity generation structure through introduction of nuclear power'.

Furthermore, PNPP is an element of the means and knowhow needed to ensure the prospects for economic development through increased potential of Polish power industry as described in the report ***Poland 2030. Development Challenges***.

The Programme takes into account the objectives of ***Europe 2020*** strategy adopted by the European Council on 17th June 2010 to benefit employment and intelligent, sustainable economic growth advantageous to social inclusion.

With respect to Poland, EC has identified in the said strategy document five key challenges of which three will be addressed because of the implementation of PNPP. These include:

- Improved innovative capacity of enterprises connected with implementation of innovative investments, economic diversification, and reorientation toward knowledge-absorbing production and services, through reinforced relations between tertiary (higher) education, research sector, and industry.
- Remedy the insufficient general level of investment outlays, including expenditure on transport and power infrastructure.
- Continued improvement of the functioning of the labour market, particularly if focused on improved employment rate.

[20] Opinion of the Minister of Infrastructure and Development on compliance of draft Development Programme with the National Development Strategy 2020 – Active Society, Competitive Economy, Efficient State, issued 19th December 2013.
[21] Adopted by the Council of Ministers on 5th February 2013.

The objectives of PNPP are also convergent with those of the ***Horizontal Concept of Industrial Policy in Poland***[22], which identifies the actions supporting, in the most efficient fashion, a long-term increase and development of Polish industry. These actions are to consist in enhanced competitiveness of industrial enterprises, thus leading to, among others:

- enhanced competitiveness of domestic products, particularly through increased innovation;
- increased productivity;
- increased employment.

The actions planned in PNPP moreover prove to be complementary to the actions taken into account in the draft ***National Reform Programme for the implementation of Europe 2020 strategy***[23] (as far as the areas Building Prosperity and Dynamic Development are concerned) whilst also fulfilling the recommendations of the ***Renewed Lisbon Strategy***, as revised and updated. The main axis of the latter is employment and economic growth, and respect for the rules of the strategy of durable and sustainable development, with increased mobilisation of all the respective domestic and Community resources.

The Lisbon Action Plan for Economic Growth and Employment encompasses actions taken in three major areas:

- Europe as a more attractive place for investment and work;
- knowledge and innovation for economic growth;
- more jobs and better employment to be created.

PNPP directly refers to all the above areas. It will particularly contribute to the delivery of the following *Renewed Lisbon Strategy* goals:

- Increased investment and use of new technologies, especially information and communication technologies;
- contribution to development of a strong European industrial base;
- creation of more jobs and better employment

PNPP is also part of the ***Renewed EU Sustainable Development Strategy***. One of the Strategy's major objectives is economic prosperity, which is to be attained through propagation of resilient, innovative and competitive knowledge-based economy – an economy that makes a reasonable use of environmental resources, ensures high standard of living, employment to all the citizens, and quality jobs.

2.7. MONITORING AND EVALUATION OF ACHIEVING THE MAJOR OBJECTIVE AND THE DETAILED OBJECTIVES

2.7.1. MONITORING SYSTEM

The monitoring of PNPP implementation refers to the implementation of all the objectives hereof; the Ministry of Economy's Nuclear Energy Department is in charge of this monitoring exercise. In

[22] Adopted by the Council of Ministers on 30th July 2007.
[23] Adopted by the Council of Ministers on 26th April 2011; updated 25th April 2012.

case any deviation from the intended results has occurred, the reasons behind any such deviation will be analysed, and appropriate corrective measures taken.

The outcome of the monitoring exercise and the PNPP progress status will be specified in the reports of the Minister of Economy, submitted to the Chairman of the Council of Ministers in line with the respective provisions of the Polish Atomic Law.[24]

Under Article 108c, clause 2 of the Polish Atomic Law, PNPP is prepared every four years, its subsequent versions to take into account the results of the work executed in the related period.

2.7.2. IMPLEMENTATION RATES

In order to quantify the PNPP objectives, and to enable the monitoring of its implementation, a set of implementation rates has been prepared with respect to the quantifiable objectives.[25]

Table. 2.1. PNPP Objectives implementation indicators:

Description of the indicators	Base value 2010	2020 value	2024 value	2030 value
Installed capacity in NPP(s) (MW_e)	0	--	1,000 minimum	3,000 minimum (6,000 as a 2035 target)
Obj. 2: Ensure top achievable safety/security for NPP(s) (number of radiological emergencies at NPP).	--	--	0	0 (target)
Obj. 3: Implement efficient system for handling radioactive waste and spent nuclear fuel	0	80%	100%	100% (target)
Obj. 5: Acquire and sustain public support for nuclear power countrywide	50%	55%	58%	60% (target)
Obj. 6: Reinforce domestic system of responding to radiological emergencies, incl. reinforce national radiation monitoring system	0	80%	100% (target)	100% (target)
Obj. 7: Prepare *Plan for development of HR for the needs of nuclear power*	0	1 (target)	1 (target)	1 (target)
Obj. 9: Polish enterprises to participate in construction of NPP in Poland (% of project value)	0%	10%	30%	60% (target)

[24] Every 24 months, by 30th June of a given year – as per Article 108e, clause 1 of the Atomic Law.
[25] For NPPP Objectives nos. 1,2, 4, 8, 10, 11, 12, the measure will be the continuous implementation of the objectives.

2.8. EVALUATION

The evaluation will serve to improve the quality and efficiency of implementation of PNPP. The following types of evaluation have been envisioned:

- ongoing evaluation, as the Programme is delivered;
- evaluations related to monitoring of Programme implementation, undertaken, in particular, in case the monitoring has identified a material deviation from the forecast implementation status of PNPP objectives, or in case there have occurred any reasons indicating the need for significant modifications thereof, or amendments thereto;
- strategic evaluations, devised to assess the Programme in the context of domestic politics and strategies;
- evaluations related to PNPP updates;
- ex-post evaluation, applied when the Programme is completed.

Evaluation research is to be done by independent external entities, the outcome to be sent to the interested departments and institutions as well as made publicly available. The first evaluation study was completed after PNPP was prepared; the following ones are expected with its subsequent updates.

As required by the Act on Development Policy Rules, 2011 saw compilation of an PNPP evaluation report, entitled *Analysis and assessment of efficiency and effectiveness of the Polish Nuclear Power Programme*[26].

2.9. PNPP'S IMPACT ON REGIONAL DEVELOPMENT

The implementation of PNPP will have a positive bearing on the regional development. This is of special relevance for the region where the NPP project will be finally located. New jobs will be offered at the NPP itself as well as in its surroundings. Based on the available analyses of foreign research centres and information received from NPP operators, it is found that at least two additional jobs within the region will be generated by each single job in the NPP under operation. However, local jobs emerge already at the stage of NPP construction – through direct recruitment of the local residents for the work at the construction site and for servicing the construction workers. The number of such jobs available depends on a number of factors, including the coordination between the local governments and the investor. For the projects currently under way elsewhere in the world, the number of such (direct) jobs is between several hundred and a few thousand. Added to such direct jobs should be indirect jobs to appear in the surroundings of each nuclear facility and fuel cycle establishment.

The condition of local infrastructure will be significantly improved, and the tax proceeds are expected to increase. These drivers will imply development of the regions where the NPPs are to be situated.

[26] Conclusions from the draft PNPP evaluation report – Appendix no. 4.

The implementation of the PNPP will also have a positive influence on the region where the radioactive waste repository is to be constructed.

2.10. SCHEDULE AND ACTIONS

The PNPP schedule encompasses the stages described as follows:

Stage 1, 01.01.2014–31.12.2016:

- Determine the location and conclude the contract for supply of the selected technology for the first NPP.

Stage 2, 01.01.2017–31.12.2018:

- Prepare the engineering and construction design and specifications; obtain the decisions and opinions as required by the law.

Stage 3, 01.01.2019–31.12.2024:

- Building permit and construction of the first unit in the first NPP; construction of subsequent units/NPP(s) to commence, the first unit to start up.

Stage 4, 01.01.2025–31.12.2030:

- Continued and commenced construction of subsequent units/NPP(s). Construction of the first NPP completed (completed construction of the second NPP is envisioned for 2035).

Table 2.2. List of actions:

Number and description of action	Purpose	Responsible parties/entities	Delivery timeframe
Action 1: Legal framework for construction and functioning of nuclear power in Poland	Prepare, adopt/enact and implement legal acts whose implementation or amendment is indispensable to enable construction and functioning of nuclear power and its associated infrastructure. Functioning of such regulations to be systematically monitored and appraised. Any indispensable modifications/amendments to be made on ongoing basis.	Minister in charge of economy; Chairman of NAEA (for the framework related to NSRP, physical protection and safeguards of nuclear material); Minister in charge of the State Treasury	This continual action is to be delivered until NPP is commissioned and subsequently during its operation.
Action 2: Analyses, professional evaluation/expert opinions necessary for delivery and update of PNPP	Carry out analyses and professional evaluation, prepare expert opinions as necessary for delivery and update of PNPP.	Minister in charge of economy	This continual action is to be delivered throughout PNPP term.
Action 3: Analyses, studies related to site of low- and medium-level radioactive waste storage facility; design and construction of such facility	Determine the site, prepare the design, and construction of a new low- and medium-level radioactive waste storage facility.	Minister in charge of economy; Radioactive Waste Disposal Facility (RWDE [ZUOP])	Final date: 31st December 2024
Action 4: *National plan for the management of radioactive waste and spent fuel* (NPMRWSNF)	Prepare and launch a technologically and economically reasonable, socially acceptable radioactive waste and spent nuclear fuel management system, as one of the key elements in the functioning of nuclear power.	Minister in charge of economy	This continual action is to be delivered throughout the implementation of PNPP.
Action 5: Instruction, training of labour force for nuclear power institutions and enterprises	Prepare labour force and personnel for purposes of Polish nuclear power, incl. preparation and development of infrastructure and operation of NPP.	Minister in charge of science and higher education; Minister in charge of education; Minister in charge of economy; Minister in charge of labour; Chairman of NAEA (for NAEA labour force); RWDE; Investor; Other institutions offering personnel support for nuclear power purposes	This continual action is to be delivered throughout the implementation of PNPP.

Action 6: Information and education actions	Provide the society with credible and reliable information on nuclear power and enhance the society's knowledge in this respect through education actions.	Minister in charge of economy; Minister in charge of education; Investor; Chairman of NAEA (for NSRP only); RWDE; Research institutes	This continual action is to be delivered throughout the implementation of PNPP.
Action 7: Research facilities	Creation of adequate research facilities for the needs of nuclear power, as indispensable for multi-aspect and comprehensive use by Poland of the opportunities and potential related to the implementation of nuclear power.	Minister in charge of economy, Minister in charge of science	This continual action is to be delivered throughout the implementation of PNPP.
Action 8: Polish industry to participate in PNPP	This action is aimed at ensuring the largest possible share of Polish industry in supplies of appliances and delivery of services for the nuclear power sector.	Minister in charge of economy; Polish Agency for Enterprise Development	This continual action is to be delivered throughout the implementation of PNPP.
Action 9: Supplies of nuclear fuel provided from domestic and external sources	Acquisition of information and data concerning uranium resources in the territory of Poland, their exploitation potential, and the most advantageous option of supplying Polish nuclear power with uranium and fuel cycle services.	Minister in charge of economy; Minister in charge of the environment	This continual action is to be delivered throughout the implementation of PNPP.
Action 10: Nuclear regulatory/inspection authority	Ensure the functioning of an independent, modern and professional nuclear regulatory authority , which, as a public trust organisation, will prove capable to meet the challenges implied by the development of nuclear power in Poland.	Chairman of NAEA, supervised by Minister in charge of the environment	This continual action is to be delivered throughout the implementation of PNPP.

STAGE 1 [1st January 2014 to 31st December 2016]

<u>TASKS OF GOVERNMENT ADMINISTRATION:</u>

A) NUCLEAR REGULATORY AUTHORITY

NAEA to be prepared to act as nuclear regulatory authority for nuclear power: Increase of the staff and funds for the functioning and development of technical resources and facilities. Issuance of organisational and technical recommendations. Training of own personnel. Participation in actions defined in B.1. below.

B) OTHER OFFICES

1. **Legal framework for construction and functioning of nuclear power:** Legal framework to be updated and developed.
   Responsibility of: Minister in charge of economy; Chairman of NAEA; Technical Supervision Office (UDT); Minister in charge of health (for health examination of nuclear power personnel).
2. **Analyses and expert evaluations/opinions indispensable for control of implementation and updates of PNPP:** Analyses and expert evaluations/opinions to be prepared.
   Responsibility of: Minister in charge of economy.
3. **Analyses and studies related to siting of low- and medium-level radioactive waste storage facility; design and construction of such facility: choice of the siting** for the facility.
   Responsibility of: Minister in charge of economy, RWDE.
4. **NPMRWSNF:** The National Plan to be approved by the Council of Ministers; implementation to start.
   Responsibility of: Minister in charge of economy; RWDE.
5. **Instruction and training of labour force for nuclear power institutions and enterprises:** Training of educators for the needs of Polish university-level schools – to continue; training for the needs of nuclear power institutions – to commence. Compile a *Plan for the development of human resources for the needs of nuclear power*. Offices to be prepared for issuance of appropriate decisions and opinions.
   Responsibility of: Minister in charge of science and higher education; Minister in charge of education; Minister in charge of economy; Minister in charge of labour; Chairman of NAEA (with respect to NAEA personnel); RWDE; UDT; other inspection/control institutions in Poland; institutions related to environmental protection and industrial development; institutions in charge of safety and security, physical protection and emergency planning; radiological emergency response system; radiation monitoring system.
6. **Information and education actions:** Ministry of Economy's actions to continue, with the need for certain actions to be delivered by specialised external entities. Preparation and subsequent delivery of information, educational and consulting actions with respect to site of radioactive waste storage facility.
   Responsibility of: Minister in charge of economy; Minister in charge of education; Chairman of NAEA (for NSRP issues only); RWDE; research institutes.
7. **Research facilities:** Scientific and technological infrastructure of the research facilities to further upgrade/improve.
   Responsibility of: Minister in charge of economy; Minister in charge of science; research institutes.

8. **Polish industry to participate in the delivery of PNPP:** Prepare an inventory of the national industrial potential – specifically, of entrepreneurs that could start preparing for applying for delivery of orders whose quality standard is conformant with nuclear industry requirements. Information and training actions to be carried out for participation of Polish industry in PNPP; updates to be made on the Polish industry's potential to participate in supplies for nuclear power. Actions to be taken in cooperation with the Investor.
   Responsibility of: Minister in charge of economy; Polish Agency for Enterprise Development.
9. **Conditions provided for supply of uranium from domestic and external sources:** Assessment of the possibilities to use Polish uranium resources in the future; search for new technologies and possibilities of its use. Identification of the potential fuel suppliers for Polish NPPs, in cooperation with the Investor and in line with his needs, in order to determine the possibility for the Investor to provide the future fuel supplies.
   Responsibility of: Minister in charge of economy, Minister in charge of the environment.

TASKS OF INVESTOR:

1. Complete the siting and environmental research.
2. Carry out the environmental impact assessment (EIA).
3. Select the optimum site location.
4. Acquire the rights to the land; obtain from the competent Province Governor (Voivode) a decision determining the site location.
5. Carry out an examination of the site area in view of preparation of the design; prepare the facilities (actions to start).
6. Choose the nuclear technology.
7. Obtain a general opinion of NAEA Chairman, under Article 39b of Polish Atomic Law.
8. Prepare an initial safety/security report.
9. Administrative procedure to commence in view of obtaining the building permit, incl. a permit from the nuclear regulation/inspection authority.
10. Carry out variation power network analyses and collaboration with PSE.
11. Sign the major contracts.
12. Further develop the competencies and personnel resources as necessary for the Investor and the future NPP operator.
13. Information, educational and consulting actions to be carried out (mainly in the prospective NPP sites).

STAGE 2 [1st January 2017 to 31st December 2018]

TASKS OF GOVERNMENT ADMINISTRATION:

A) NUCLEAR REGULATORY AUTHORITY

Permit for construction of NPP to be issued on request of the Investor. Issue organisational and technical recommendations. Train the institution's own personnel. Participate in the actions defined in B.1. below.

B) OTHER OFFICES

1. **Legal framework for construction and functioning of nuclear power:** Evaluate the functioning of the legal solutions; make the necessary corrections, if need be.
   Responsibility of: Minister in charge of economy; Chairman of NAEA; UDT.
2. **Analyses and expert evaluations/opinions indispensable for control of implementation and updates of PNPP**: Analyse the updated versions of expert evaluations/opinions.
   Responsibility of: Minister in charge of economy.
3. **Analyses and studies related to siting of low- and medium-level radioactive waste storage facility; design and construction of such facility:** Carry out and complete the necessary agreements and approvals; prepare the facility design.
   Responsibility of: Minister in charge of economy; RWDE.
4. **NPMRWSNF:** Inspect the implementation and make the necessary update, if need be.
   Responsibility of: Minister in charge of economy.
5. **Instruction and training of labour force for nuclear power institutions and enterprises:** Continue/follow up the relevant actions. The *Plan for the development of human resources for the needs of nuclear power* to be launched and implemented.
   Responsibility of: Minister in charge of science and higher education; Minister in charge of education; Minister in charge of economy; Minister in charge of labour; Chairman of NAEA (with respect to NAEA personnel), RWDE; UDT; other inspection/control institutions in Poland; institutions related to environmental protection and industrial development; institutions in charge of safety and security, physical protection and emergency planning; radiological emergency response system; radiation monitoring system.
6. **Information and education actions:** ME to continue its actions, taking into account the need for some of the actions to be performed by specialised third parties. Continue the information, educational and consulting actions with respect to siting of radioactive waste storage facility.
   Responsibility of: Minister in charge of economy; Minister in charge of education; Chairman of NAEA (for NSRP issues only); RWDE; research institutes.
7. **Research and scientific base:** Scientific and technological infrastructure of the research facilities to be further upgraded/improved; the research and scientific base to be included in nuclear power projects as they are implemented.
   Responsibility of: Minister in charge of economy; Polish Agency for Enterprise Development.
   Responsibility of: Minister in charge of economy; Minister in charge of science; research institutes.

8. **Polish industry to participate in the delivery of PNPP:** In collaboration with the Investor, analyse Polish industries' participation in the Programme; support actions related to Polish industry joining the supplies for international nuclear power.
   Responsibility of: Minister in charge of economy; Polish Agency for Enterprise Development.
9. **Conditions provided for supply of uranium from domestic and external sources:** Update the data obtained with respect to the possibilities of provision of fuel supplies for Polish NPPs.
   Responsibility of: Minister in charge of economy; Minister in charge of environment.

TASKS OF INVESTOR:

1. Area and land examination in view of preparing the design; prepare the facilities and supply base.
2. Design work.
3. Obtain a complete set of decisions and opinions, incl. NAEA Chairman's permit for the construction of the facility and the building permit.
4. Obtain the decision in principle from the Minister of Economy.
5. Finalise the connection contract with PSE.
6. Further develop the competencies and personnel resources as necessary for the Investor and the future NPP operator.
7. Information, educational and consulting actions to be carried out (mainly in the prospective NPP sites).

STAGE 3 [1st January 2019 to 31st December 2024]

TASKS OF GOVERNMENT ADMINISTRATION:

A) NUCLEAR REGULATORY AUTHORITY

Inspect the construction of NPP for nuclear safety and security. Start-up and operation permits issued on request of the Investor. Nuclear safety/security surveillance exercised for construction of the first and the subsequent nuclear units. Organisational and technical recommendations to be issued. Training of the institution's own personnel. Participation in actions defined in B.1. below. Supervision of actions described below in B.4.

Verify the readiness of the response system in case of radiological emergencies/events at NPP, through appropriate exercises carried out in collaboration with the other institutions. Verify the readiness of the national radiation monitoring system.

B) OTHER OFFICES

1. **Legal framework for construction and functioning of nuclear power:** Evaluate the functioning of the legal solutions; make the necessary corrections, if need be.
   Responsibility of: Minister in charge of economy; Chairman of NAEA; UDT.
2. **Analyses and expert evaluations/opinions indispensable for control of implementation and updates of PNPP**: Relevant analyses and evaluations to be carried out.
   Responsibility of: Minister in charge of economy.
3. **Analyses and studies related to siting of low- and medium-level radioactive waste storage facility; design and construction of such facility.**
   Responsibility of: Minister in charge of economy, RWDE.
4. **NPMRWSNF:** Inspect the implementation and make periodical update.
   Responsibility of: Minister in charge of economy.
5. **Instruction and training of labour force for nuclear power institutions and enterprises**: Continue/follow up the relevant actions. Implementation of the *Plan for the development of human resources for the needs of nuclear power* to continue.
   Responsibility of: Minister in charge of science and higher education; Minister in charge of education; Minister in charge of economy; Minister in charge of labour; Chairman of NAEA (with respect to NAEA personnel), RWDE; UDT; other inspection/control institutions in Poland; institutions related to environmental protection and industrial development; institutions in charge of safety and security, physical protection and emergency planning; radiological emergency response system; radiation monitoring system.
6. **Information and education actions:** Actions to continue, with support from the Investor.
   Responsibility of: Minister in charge of economy; Minister in charge of education; Chairman of NAEA (for NSRP issues only); RWDE; research institutes.
7. **Research facilities:** Scientific and technological infrastructure of the research facilities to further upgrade/improve; the facilities to join nuclear power projects as they are implemented.
   Responsibility of: Minister in charge of economy; Minister in charge of science; research institutes.

8. **Polish industry to participate in the delivery of PNPP:** Monitor Polish industries' participation in the Programme; in cooperation with the Investor, support actions related to Polish industry joining the supplies for international nuclear power.
   Responsibility of: Minister in charge of economy; Polish Agency for Enterprise Development.
10. **Conditions provided for supply of uranium from domestic and external sources:** Update the data obtained with respect to the possibilities of provision of fuel supplies for Polish NPPs and access to other fuel-cycle services.
   Responsibility of: Minister in charge of economy; Minister in charge of environment.

TASKS OF INVESTOR:

1. Close the project financing.
2. Construct the NPP.
3. Obtain permit for start-up.
4. Start-up.
5. Permit for operation.
6. Construction of subsequent units commenced.
7. Further develop the competencies and personnel resources as necessary for the Investor and the future NPP operator.
8. Information, educational and consulting actions to be carried out (mainly in the prospective NPP sites).

STAGE 4 [1st January 2025 to 31st December 2030]

<u>**TASKS OF GOVERNMENT ADMINISTRATION:**</u>

A) NUCLEAR REGULATORY AUTHORITY

Oversee the operation of the existing units and the construction of subsequent ones. Issue/update organisational and technical recommendations. Training of the institution's own personnel. Participation in actions defined in B.1. below.

B) OTHER OFFICES

1. **Legal framework for construction and functioning of nuclear power:** Evaluate the functioning of the legal solutions; make the necessary corrections, if need be.
   Responsibility of: Minister in charge of economy; Chairman of NAEA; UDT.
2. **Analyses and expert evaluations/opinions indispensable for control of implementation and updates of PNPP**: Relevant analyses to be carried out**.**
   Responsibility of: Minister in charge of economy.
3. **NPMRWSNF:** Inspect the Plan's implementation. Seek an optimum site for a spent fuel storage facility and collect funds for construction of same. Analyse the possibilities of using fuel-cycle services inside and outside Poland.
   Responsibility of: Minister in charge of economy.
4. **Instruction and training of labour force for nuclear power institutions and enterprises**: Continue/follow up the relevant actions
   Responsibility of: Minister in charge of science and higher education; Minister in charge of education; Minister in charge of economy; Minister in charge of labour; Chairman of NAEA (with respect to NAEA personnel), RWDE; UDT; other inspection/control institutions in Poland; institutions related to environmental protection and industrial development; institutions in charge of safety and security, physical protection and emergency planning; radiological emergency response system; radiation monitoring system.
5. **Information and education actions:** Actions to continue, with support from the Investor.
   Responsibility of: Minister in charge of economy; Minister in charge of education; Chairman of NAEA (for NSRP issues only); RWDE; research institutes.
6. **Research facilities:** Continually join the actions fostering Polish nuclear power.
   Responsibility of: Minister in charge of economy; Minister in charge of science; research institutes.
7. **Polish industry to participate in the delivery of PNPP:** Analyse the possibilities and support the actions related to expanding Polish industries' share in supplies for international nuclear power.
   Responsibility of: Minister in charge of economy.
8. **Conditions provided for supply of nuclear fuel from domestic and external sources:** Update the data obtained with respect to the possibilities of provision of fuel supplies for Polish NPPs
   Responsibility of: Minister in charge of economy; minister Responsibility of: Minister in charge of environment.

<u>TASKS OF INVESTOR:</u>

1. Construction of subsequent units/NPPs[27].
2. Continued development of competencies and human resources as indispensable for the Investor and NPP operator.
3. Information, educational and consulting actions to be carried out (mainly in the prospective NPP sites).

[27] For a schedule of construction of the first NPP as proposed by the Investor, refer to Appendix no. 1.

CHAPTER 3. NUCLEAR POWER IN THE CONTEXT OF LONG-TERM ENERGY POLICY

3.1. THE ROLE OF NUCLEAR POWER IN EUROPEAN ENERGY POLICY

As provided by Article 194, clause 2 of the Treaty on the Functioning of the European Union ‚[28], EU Member States have a free choice of their energy sources. Moreover, according to Article 1 and Article 2.c of the Treaty Establishing the European Atomic Energy Community (the EURATOM Treaty)[29], the purpose behind the EURATOM is to establish and grow nuclear industries and develop nuclear energy within the Community.[30]

According to *An Energy Policy for Europe*[31], the primary challenges the EU is facing are to improve security of energy supply and enhance competitiveness of EU economies, whilst observing the sustainable development principle. The Policy's priority areas include: diminishing adverse impact of power sector on the environment; limiting the EU's susceptibility on influence of external factors, ensuing from its dependency on imports of hydrocarbon fuels; supporting increase in new jobs and economic growth; and, provision of the consumers with stable energy supplies at affordable prices.

Chapter 3.8 of the Policy in question emphasises the role and values of nuclear power as one of the means of gaining energy safety and limiting carbon dioxide emissions in Europe. This has also been reflected in an European Parliament's Resolution on Conventional Energy Sources and Energy Technology.[32] The latter document emphasises the importance of nuclear power for stabilisation of electricity prices due to the low share of fuel cost in the total cost of electricity production and the role of nuclear power in meeting the environmental protection obligations as a source of energy with zero emission of carbon and other substances into the atmosphere.

The strategic *Energy Road Map 2050* (*ERM 2050*)[33] points to nuclear power as an essential element of EU's energy mix:

- In most scenarios proposed by *ERM 2050,* nuclear power is instrumental in implementation of the assumed EU objectives.
- All the proposed scenarios feature nuclear power (at 2.5% to 19.23% of share in electricity production), whereas the 'strong development of renewable sources' and 'low share of nuclear power' options assume its lowest proportion in percentage terms.
- *ERM 2050* emphasises the Member States' right to decide, each for themselves, as far as use of nuclear technologies is concerned.

[28] The Treaty on the Functioning of the European Union, done at Rome, 25th March 1957, (JL 2004, no. 90, item 864; as amended).
[29] As done at Rome, 25th March 1957, consolidated version, OJ EU C 84, 30.03.2010, p. 1.
[30] The corresponding provisions are to be found in motif 3 of the Preamble to the Euratom Treaty.
[31] CE Communication of 10th January 2007 – An *Energy Policy for Europe*, COM (2007) 001.
[32] Resolution of the European Parliament of 24th October 2007 on Conventional Energy Sources and Energy Technology (2007/2091(INI)).
[33] CE Communication of 15th December 2011 – *Energy Road Map 2050,* COM(2011) 885.

- *ERM 2050* stresses that for countries using nuclear power, this technology will be the main driver to reduce CO_2 emissions. A considerable proportion of the nuclear option in the energy basket ensures the low total cost of electricity overall.

In the report *EU Energy, Transport and GHG Emissions: Trends to 2050*[34], the European Commission forecasts the development of European power industry for the following four decades, as a result of implementation of the European climate policy. One finding is that by the year 2050 nuclear power stations will have become one of the major sources of electricity in the EU, with a 21% share in energy generation, and the major zero-emission source beside the renewable ones. It is envisioned that Poland will see the launch of NPPs of joint installed capacity of 9,600 MW, which will become a significant source of energy – along with the still-prevalent coal-fired power plants and the renewables. Although quite conservative technical and economic assumptions, including investment cost, have been made for NPP, the Report forecasts that new NPPs will be constructed, or, at least, the operation of the presently functioning ones will be extended, for almost all the countries possessing such facilities as of today (save for Germany, Belgium and Slovenia).

The potential for use of nuclear sources in electric-engineering industry is reflected in *Energy Policy of Poland Until 2025 (PEP 2025)*[35]. The tasks envisioned in this respect, as specified in an Appendix to *PEP 2025* – 'Schedule of executive tasks to be delivered by 2008', have not been executed.

The structure of entities at the time, especially the organisationally fragmented electricity manufacturing sector, was not of advantage to meeting so crucial investment challenges. Of substantial importance for the investment potential occurred to be the consolidation of the electric power sector, completed in 2007, in line with the *Programme for the Electric Power Engineering Sector*.[36]

The Polish energy sector has been for a few years facing serious challenges. Poland's economic development, connected with the necessity to cover an increasing demand for energy; the ageing power-generation assets in Polish electric power engineering system; inadequate development level of the fuels and energy manufacturing, transmission and transportation infrastructure; considerable dependence on external supplies of natural gas and an almost complete dependence upon external supplies of crude oil; and, moreover, the environmental obligations – all render it necessary to take actions that would prevent deterioration of the situation of fuel and energy consumers. The increasing hard coal exploration costs and the difficulties in acquisition of new deposits of lignite, combined with the prospect of progressive restriction of availability of this particular fuel for the electric power, form an essential premise for seeking diversification opportunities in the fuel base for electricity generation, and for launching new carriers of energy to ensure long-lasting and reliable supplies of electricity, which would also be stable in pricing terms. Nuclear power definitely meets all these conditions.

In parallel, the world economy has been in the recent years affected by a series of adverse phenomena. Remarkable fluctuations in the prices of fuels, increasing demand for energy on the part of developing countries, severe failures or breakdowns of power systems, and increasing environmental contamination and pollution call for a revisited approach toward energy policy. As part of its ecological obligations, the EU has set quantitative targets for the year 2020 – the so-called

[34] *EU Energy, Transport and GHG Emissions: Trends to 2050. Reference Scenario 2013*, European Commission, 2013.
[35] Notice of the Minister of Economy and Labour of 1st July 2005 'on Poland's energy policy to 2025' (*MP* no. 42, item 562).
[36] *A programme for the electric-engineering industry*, adopted by the Council of Ministers on 28th March 2006.

3x20.[37]. December 2008 saw adoption by the EU of a climate and energy package, which proposes concrete legal instruments to reach these targets. Through actions initiated on the national level, the domestic energy policy is joining the implementation of the energy policy targets defined at the EU level.

Being an EU Member State, Poland has been taking an active part in the development of a common energy policy and in implementing its main targets within the specific domestic conditions, taking into account sustained competitiveness of the country's domestic economy, protected interests of the consumers, energy resources held, and the technological determinants of generation, transmission, and distribution of electricity.

[37] GHG emissions to be reduced by 20% as versus 1990; energy consumption to be reduced by 20% as compared to the 2020 forecast for the EU; increased proportion of renewable sources of energy – to 20% of total EU consumption (target for Poland: 15% in final consumption), incl. up to 10% in transportation sector.

3.2. DECISIONS OF CRUCIAL RELEVANCE TO DEVELOPMENT OF NUCLEAR POWER

The crucial decisions of Polish Government administration include the following:

1. The Council of Ministers adopted a *Resolution on the actions taken for the development of nuclear power*, according to which at least two nuclear power plants ought to be constructed in Poland, of which the first should commence its operations by 2030. The Resolution was adopted based on the following premises:
    - the need to diversify energy generation sources and launch new investment projects in view of replacing the de-capitalised baseload power plants;
    - the need to reduce environmentally hazardous emissions of CO_2, NO_x, SO_2, dusts, and heavy metals, through employment of nuclear technologies in the power industry;
    - potential to reduce the imports of coal and natural gas;
    - the costs of NPP-based electricity generation to become stable and predictable in a long time horizon, against lower unit cost of generation, as compared to other power technologies;
    - stable electricity generation costs and certainty that the capital invested yields a return, given the NPP operation period of a minimum of sixty years, as assumed at present;
    - a potential to build long-term reserves of nuclear fuel;
    - safe supplies of nuclear fuel, based on the option to select the nuclear fuel or uranium supplier(s) and the fuel cycle services providers from various regions of the world and politically stable countries;
    - full responsibility of nuclear operators for safe handling of spent nuclear fuel and radioactive waste;
    - third-party costs to be internalised[38];
    - the resources of organic fossil fuels to be preserved for use of future generations - including the resources of coal as a valuable raw material for the chemical and pharmaceutical industries;
    - potential for economic revival of the regions and reinvigoration of domestic industry;
    - development of research and scientific base for nuclear power;
    - nuclear power-related study programmes/majors to develop within higher schools and upper-secondary schools;
    - the national economy's innovative capability to increase;
    - increasing social interest in the economic, social, and environmental effects related to the implementation of nuclear power.

2. By means of a Council-of-Ministers regulation[39], the Government Plenipotentiary for Polish Nuclear Power' was established, at the rank of Undersecretary of State at the Ministry of Economy. The Plenipotentiary's tasks extend to development and implementation of nuclear power, including the tasks set forth by the national energy

[38] With respect to carbon emission allowances, health/environmental costs, etc.
[39] Ordinance of the Council of Ministers of 12th May 2009 'on the appointment of the Government Plenipotentiary for Polish Nuclear Power' (JL no. 72, item 622).

policy, within the meaning of Article 14 of the Polish Energy Law[40]. These responsibilities include, among other things, compilation and submittal to the Council of Ministers of a draft PNPP.

3. The actions related to nuclear power have been described in the *Framework action plan for nuclear power*[41].

4. One of the primary priorities of Polish energy policy indicated in *PEP 2030* is to diversify the electricity generation structure through the launch of nuclear power.

The priorities indicated by *PEP 2030* are heavily interdependent. Improvement in energy efficiency limits increasing demands for fuels and energy, thus contributing to enhanced energy safety and security, resulting from reduced dependence on imports; moreover, it fosters a limited impact of power industry on the environment through reduced emissions. Similar effects are brought about by the development of consumption of renewable energy sources, including the use of bio-fuels, taking advantage of pure coal technologies and development of nuclear power.

The decision to introduce nuclear power in Poland is based on the necessity to ensure supplies of appropriate quantities of electricity at reasonable prices, whilst observing the environmental protection rules. Protection of the climate, together with the climate and energy package adopted by the EU, requires that energy generation and production be switched into low or zero carbon emission technologies.

Given the present-day situation, taking advantage of any and all available technologies, with parallel increase of energy safety and security and decreased emissions of pollutants and contaminants, with observance of economic effectiveness, have become of special significance.

The decisions made to date with respect to the development of nuclear power in Poland have also been informed by the clear indications of investment revival in the nuclear sector – not only in Asia and America but also in Europe. The ambitious goal of reconciling economic growth and improvement of the quality of life, whilst taking into account the ecological determinants, have made EU countries seek for solutions ensuring safe and secure supplies of electricity, including through diversified fuel base of the power system.

As per the *Programme of executive actions for the years 2009 to 2012*[42], the main goal in the nuclear power area was to prepare an adequate legal and organisational infrastructure that would ensure the prospective investors the conditions appropriate for construction and start-up of NPPs relying on safe technologies, with the underlying high culture of nuclear safety and social support across the implementation stages, i.e.: choice of site, design, construction, start-up, and decommissioning of the NPP. These objectives will only be deliverable if the investor has stable conditions ensured to carry out the project – particularly as regards the possibility of reinforcing its own market position, which in turn ensures stability of funding for the project and ability to compete with other power enterprises, with the prospect of a further integration of the regional electricity marketplace.

The detailed objectives in this field have included:

- Harmonisation of the legal system, in view of efficient transaction of the process of development of nuclear power in Poland;

[40] The Polish Energy Law Act of 10th April 1997 (i.e. JL 2012, item 1059, as amended).
[41] As adopted by the Council of Ministers on 11th August 2009.
[42] Appendix to *PEP 2030*.

- Provision of human resources for nuclear power;
- Public Information and education for nuclear power;
- Selection of the siting for the first NPPs;
- Selection of the siting for, and construction of, a low- and medium-level radioactive waste storage facility;
- Provision of research facilities for PNPP based upon the existing research institutes;
- Preparation of nuclear fuel cycle solutions ensuring for the country safe and sustainable access to nuclear fuel, taking account of the option to recycle spent fuel and to enable high-level radioactive waste storage.

CHAPTER 4. ANALYSIS OF THE COSTS AND THE ECONOMIC RATIONALE BEHIND THE DEVELOPMENT OF NUCLEAR POWER

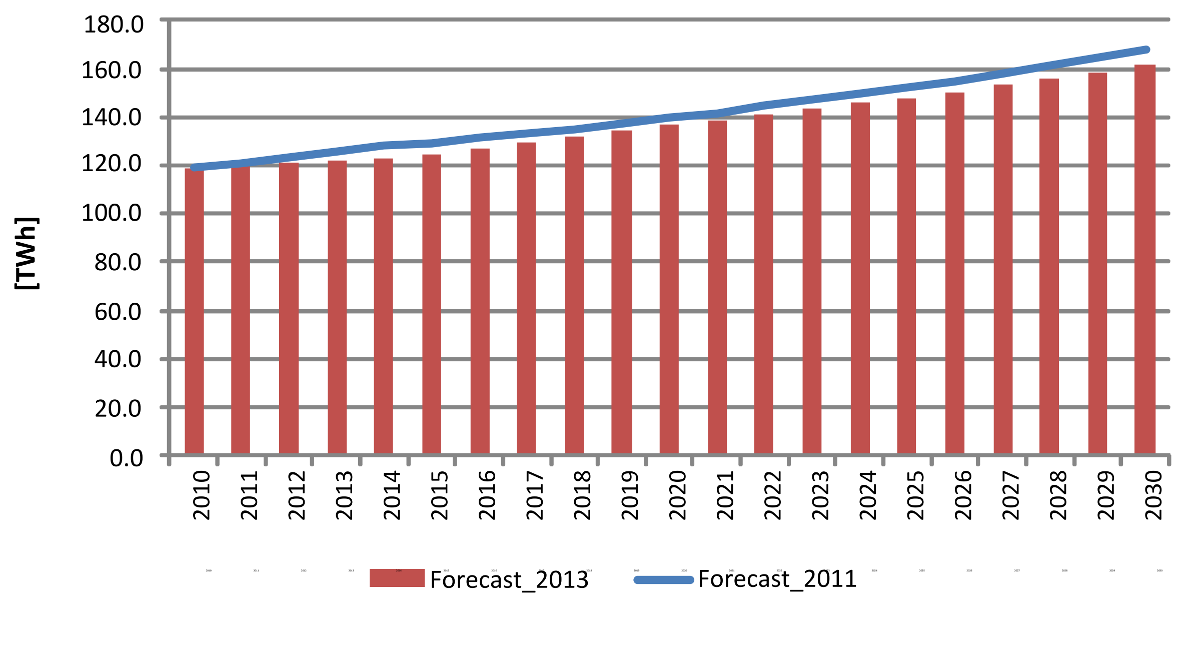
4.1. FORECAST OF INCREASED DEMAND FOR ELECTRICITY

The changing economic situation viewed in a broader international context and, in particular, the trends observable in the energy market, have made it necessary to verify the previous forecasts (of 2009–2011) with respect to fuels and energy, which have been used in, inter alia, the assumptions for *PEP 2030*.

In compiling the most recent and updated forecast of the demand for fuels and energy until 2030[43], prepared by the Energy Market Agency (*Agencja Rynku Energii S.A.*, ARE) on commission of ME, the most recent available projections of macroeconomic and demographic indices and technical assumptions have been taken into account – along with other drivers, such as pricing of carbon emission allowances affecting the demand for electricity and district heat as well as the future generation structure.

In the period under analysis, the demand for final electricity is expected to increase by approx. 36%, i.e. from 119.1 TWh as of 2010 into 161.5 TWh by 2030, which stands for an average annual increase of 1.5%. An increased demand has been, and will continue to be, true for all the sectors, with trade and services sector (a 46% increase), households (33%) and industry (28%) coming to the fore. The ratios included in the updated forecast have slightly reduced the forecast values compared to *Forecast_2011*[44] (Fig. 4.1).

Fig. 4.1. Comparison of the forecasts of final demand for electricity: *Forecast_2013* vs. *Forecast_2011*.



Source: *An updated forecast of demand for fuels and energy until 2030*, ARE S.A., June 2013.

[43] *Updated forecast of the demand for fuels and energy to 2030*, ARE, June 2013.
[44] *Updated forecast of the demand for fuels and energy to 2030*, ARE, September 2011.

The above data concerning increased demand for electricity have been confirmed by the up-to-date evaluations of PSE regarding the demand for **peak** power **load**. There are two scenarios of average-annual increase in demand for the said power, i.e.:

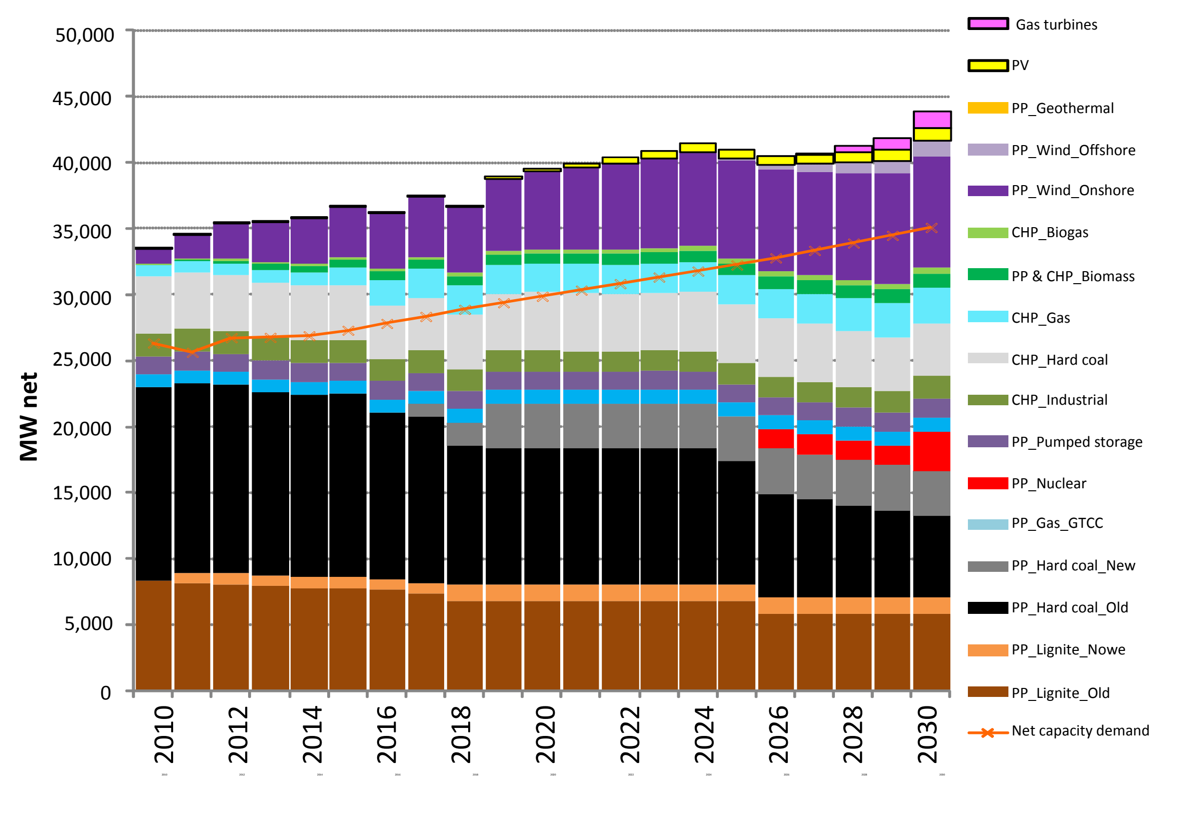
- by 1.5% - to 2028;
- by 1.1% - to 2030, with a 0.85% increase to 2020.

What the above-specified data also tell us is that, owing to increased electricity demand and forecasted shutdowns of generation units, the Transmission System Operator (TSO) will find it difficult to get the system balance, even if the expected increment in power related to the plans to build new generation units is taken into consideration. These problems are expected to be significantly suppressed by the planned construction of NPPs.

To provide such a volume of electricity production at reasonable cost and with observance of environmental considerations will imply the need to build new zero-emission and low-emission sources based on various power technologies, including high-efficiency coal-fired, nuclear, gas, and renewable sources.

In the scenario assuming construction of new fossil-fuel (hard and brown coal-fired) and gas-fired power stations, the role of power stations fired with coal and the growing proportion of the renewables in the electricity generation mix is expected to be until 2030 as pictured in Fig. 4.2. It is assumed that the determined sources are the new units located in: Stalowa-Wola (2015 – CHPP; gas; 436 $MWel_{net}$); Włocławek (2016 – CHPP; gas, 450 $MWel_{net}$); Turów (2018 – PP; lignite; 440 MW_{net}); Kozienice (2017 – PP; hard coal; 925 MW_{net}); Opole (2018 and 2019 – PP; hard coal; 2*830 MW); and Jaworzno (2019 – PP, hard coal; 830 MW). In terms of the scenario in question, the net generating capacity of the generation sources is seen growing to approx. 44.5 GW, up from 33.5 GW as of 2010 (roughly, a 33% increase). The role of baseload power plants fired with coal-derived fuels is significantly decreasing, whilst the contribution of renewables (esp., land wind farms) and combined heat-and-power plants propelled with natural gas is on an upward trend.

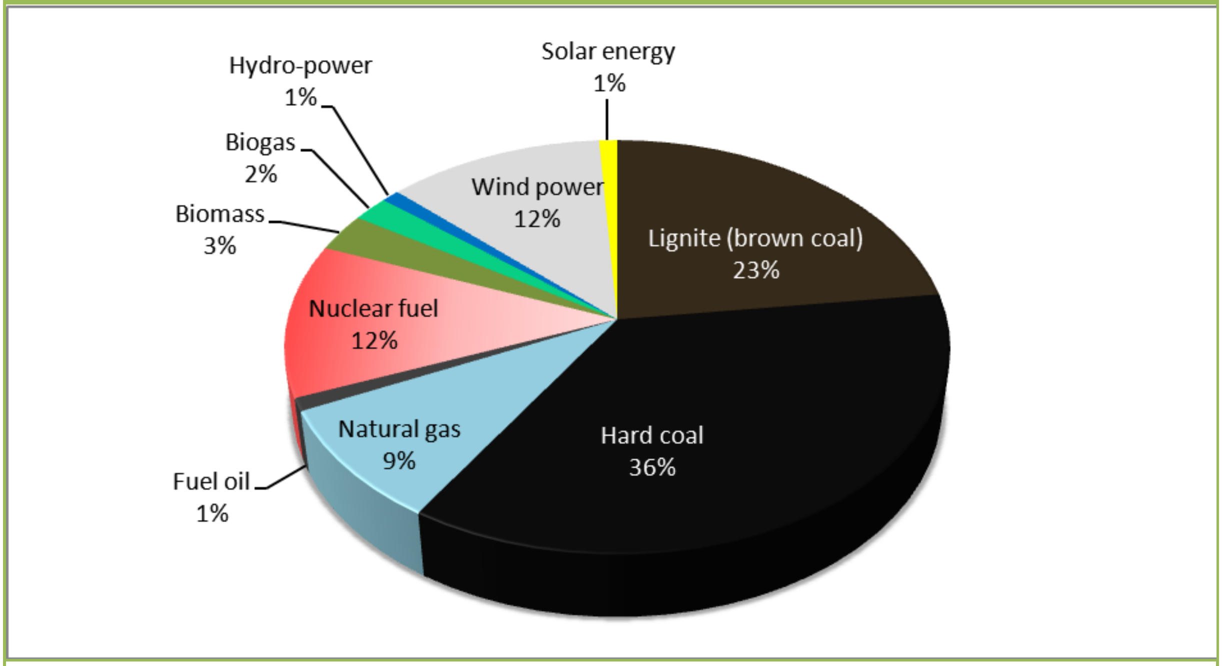
Fig. 4.2. Net generating capacity for electricity generation sources, by technology. Based on a scenario with conservative assumptions for nuclear power, including new investment projects, esp. new coal capacities.



Source: ***An updated forecast of demand for fuels and energy until 2030*****, ARE S.A., June 2013.**

The above-described changes concerning the structure of installed capacities will also affect the fuel mix in production of electricity. With conservative assumptions made for nuclear power, the electricity generation fuel mix will be as in Fig. 4.3.

Fig. 4.3. Forecast electricity generation fuel mix in 2030. Based on a scenario including new investment projects, esp. new coal capacities.



Source: ***Forecast of the structure of generating capacities to 2030, with specified technical and economic parameters for the nuclear power plant*****, ARE S.A., June 2013.**

The change in the fuel mix is also connected with decommissioning of worn-out coal-fired units that are replaced with new units combusting hard coal (approx. 3,400 MW till 2030), characterized by high efficiency, low SO_2 and NO_X emissions; and, with two NPPs of the capacities of approx. 3,000 MW each, with the first unit of the first station to be started up in 2025 and the other units, by 2035 (2*3,000 MW = 6,000 MW).

As the *Forecast_2013 (ARE analysis of June 2013)* has assumed conservative conditions for nuclear power, the structure of capacity and electricity production of the lowest generation cost within the up-to-2030 timeline has been determined on additional order of ME, taking into account the technical and economic parameters attained in the market for newly-built electricity generation sources (according to EC and MAE analyses). The changes are shown in Table 4.1.

Table 4.1. Comparison of modified input parameters for newly-built electricity generation sources:

	New analysis	*Forecast_2013*
Discount rate (for all generation sources)	6%	8%
NPP capacity factor	0.90	0.85
NPP operation lifetime (years)	60	40

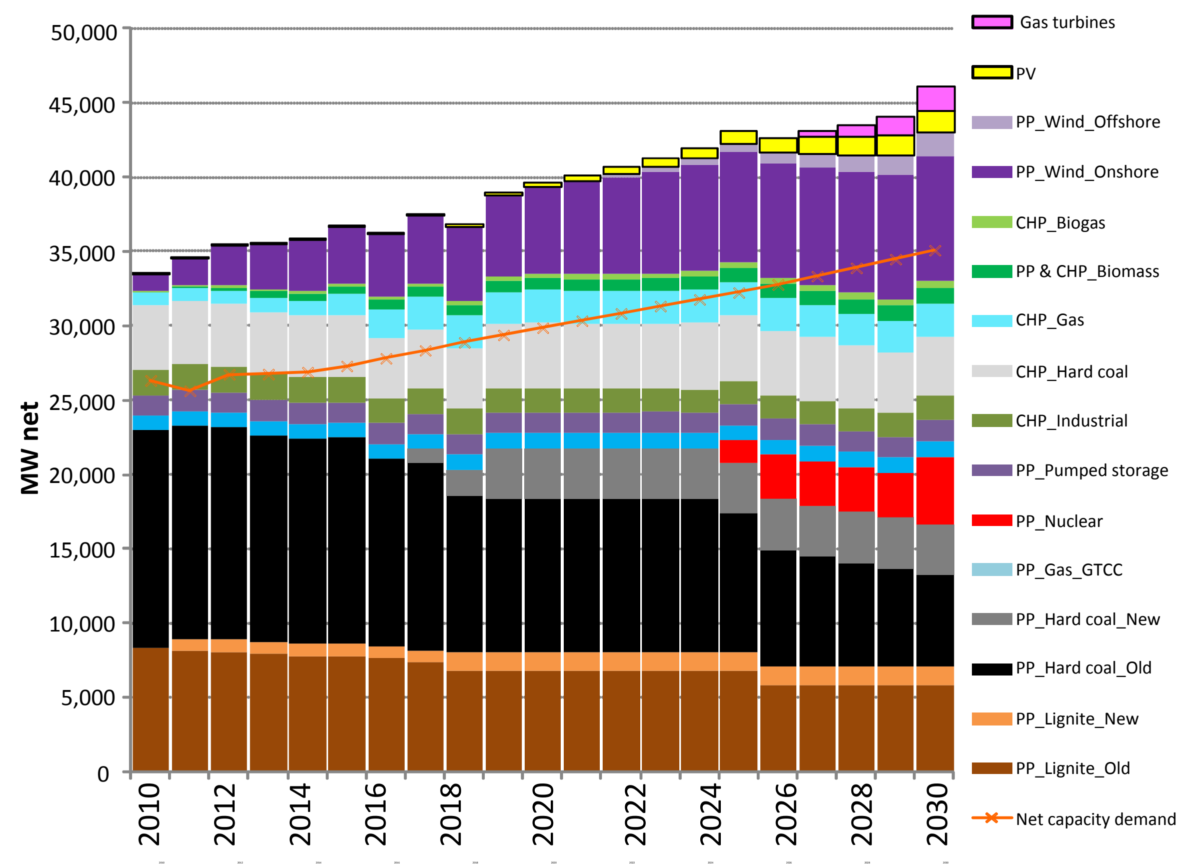
The earlier ARE assumptions were partly based on technical and economic specification of second-generation reactors, mainly with respect to the assumed load factor and operation lifetime of the unit. In turn, the designing assumptions of third-generation reactors, which are to be constructed in Poland, envision the load factor of no less than 90% (with availability in excess of 92%). Even the presently operated generation II reactors exceed this figure remarkably in a number of countries. For instance, in Finland, the old post-Soviet VVER-440/W-213 reactors (a reactor of the same type was intended for the Żarnowiec NPP under construction in the 1980s) at Loviisa NPP attained in the recent years the load factor of 95%; the BWR units at Olkiluoto NPP perform at less than 97%. In Germany, the newest PWR units (Emsland and Isar NPPs) make up to 94%. A number of NPPs in the United States perform as high as in excess of 100% (a few years' trend averaging over 90%).

Operation lifetime is the other indicator that called for being corrected. The forty years period assumed in the earlier version of the forecast was based on generation II reactors presently in operation, which work much longer anyway (presently, their operation is being extended, in many countries, from 40 to 50 or 60 years; further extension of the operation time is still possible, as long as the NPPs continue to comply with the safety/security requirements). All the generation III reactors are, by definition, designed to work for sixty years, with the option for twenty more years, if not more, of extension.

Discount rate is yet another factor that has been modified. It was necessary to make this modification as a definite majority of investments in new electricity generation sources internationally are brought into effect based on relatively cheap capital. The governments of numerous countries endeavour to provide energy or power investment projects (nuclear and conventional alike) with predictability and stability conditions in terms of the regulatory, political, market-related, etc. environment. This directly translates into reduced investment risk, and thus, reduced capital acquisition cost. Construction of the first NPP is the key in terms of energy safety and security, and in terms of preventing the economy from suffering high costs of energy; hence, it calls for the State to proactively collaborate with the investors. Creation and maintenance of adequate conditions for the investment project to be accomplished is expected to directly translate into the cost of capital acquired from the domestic as well as foreign sources. Similarly, the changes foreseen in the energy marketplace will be favourable in terms of profitability of new power units.

Comparing the outcome of the aforesaid analysis against that of *Forecast_2013*, one concludes that the crucial difference between the two lies in the pace at which NPPs are expected to develop (see Fig. 4.3.1). *Forecast_2013* has two nuclear units appearing by 2030 (one around 2026 and the other, in 2030), with the aggregate capacity of 3,000 MW, while the new analysis (scenario) would expect the first nuclear unit to appear a year earlier – around 2025, with the following one commissioned in ca. 2026 and the third one, by 2030. Altogether, there is approx. 4,500 MW of nuclear capacity to be installed by 2030, as per the present scenario. It is worth mentioning that the subsequent unit(s) are expected to appear in 2031.

Fig. 4.3.1. Net generating capacity for electricity generation sources, by technology – with parameters defined for newly-built generation sources.

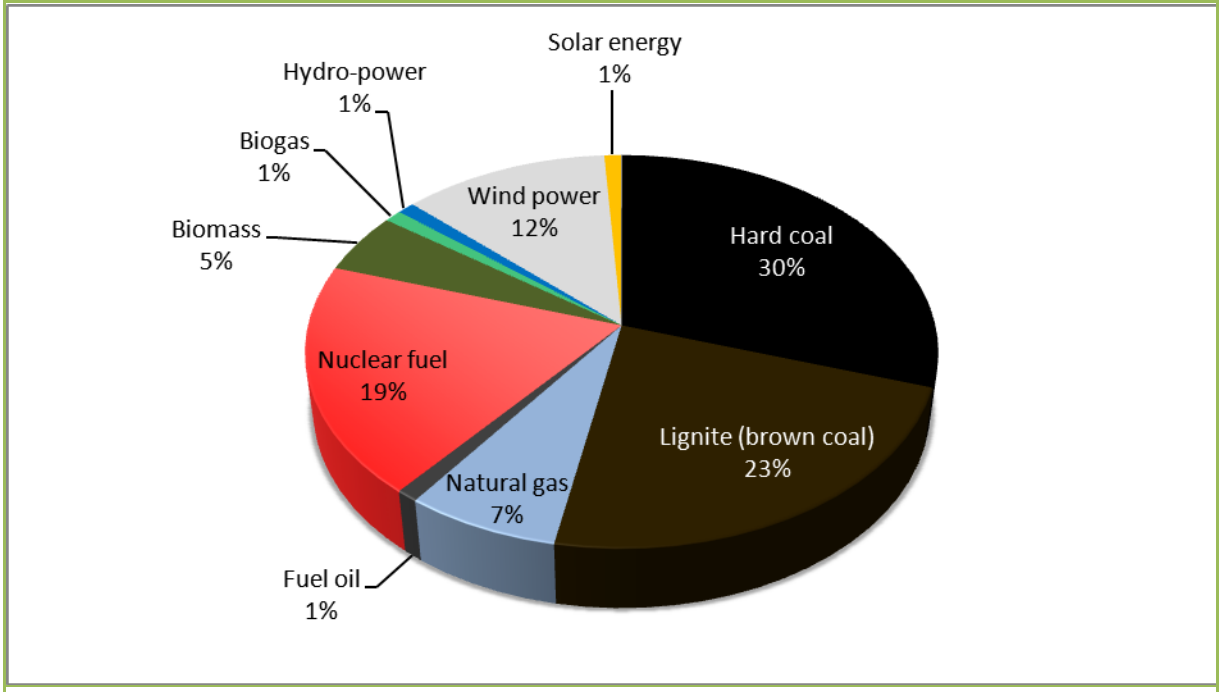


Source: ***Forecast of the structure of generating capacities to 2030, with technical and economic parameters specified for the nuclear power plant*****, ARE S.A., September 2013.**

The faster development of nuclear power, as described above, will also affect the fuel structure in production of electricity. The nuclear technology would become an essential element in the generating-source mix as from 2025, with a 7% share in the net domestic electricity generation. By 2026, approx. 23 TWh (i.e. more than 13% of Poland's electricity generation) will have been based on nuclear power stations, whereas the NPP production in 2030 will be at 35 TWh (a 19% share in domestic electricity output).

In the year 2030, electricity production by fuel, based on various sources, is expected to be as pictured in Fig. 4.3.2.

Fig. 4.3.2. Forecast electricity generation fuel mix in 2030 – with parameters defined for newly-built generation sources.



Source: ***Forecast of the structure of generating capacities to 2030, with technical and economic parameters specified for the nuclear power plant*, ARE S.A., September 2013.**

Within the period considered, at least 12,000 MW of conventional generating units will have been decommissioned (approx. 6,000 MW to 2020 and another 6,000 MW to 2030). The change in the technical and economic parameters for nuclear power will not affect the decommissioning process.

4.2. NUCLEAR POWER IN THE CONTEXT OF CLIMATE POLICY

The future structure of electricity generation in Poland will be heavily dependent on the climate policy being carried out, especially with regards to the functioning of the EU's carbon emission allowance trading system (EU ETS) and the emission restrictions related to the entry into force of the EU Directives: IPPC[45] (as from 2016) and IED[46] (as from 2020).

Presently, Poland's commercial power industry is responsible, in its entirety, for emitting approx. 150 million tonnes of carbon dioxide annually.[47] The existing electricity generation sources, including those whose construction commenced before 2008, are covered by the gradually expanding obligation to purchase the carbon emission allowances auctioned between 2013 and 2020, whereas 100% of the necessary allowances will have to be bought through auction in 2020. To the new electricity sources, whose construction started after 2008, the obligation to purchase CO_2 emission allowances, as from 2013, is complete. It should be noted that until 2012 inclusive, Polish commercial power stations had covered approx. 90% of the demand for carbon emission rights out of the free-of-charge pool granted by the EU, whereas since 2013 the proportion has been around 70%, with a

[45] Directive 2008/1/EC of 15 January 2008 concerning integrated pollution prevention and control (OJ L 24, 29.1.2008, p. 8).
[46] Directive 2010/75/EU of 24 November 2010 on industrial emissions (integrated pollution prevention and control) (OJ EU L 334, 17.12.2010, p. 17).
[47] *Emitor 2010*, ARE S.A., Warsaw 2011; *Emitor 2011*, ARE S.A., Warsaw 2012; *Emitor 2012*, ARE S.A., Warsaw 2013; the average for the years 2010–2012.

dropping trend, to arrive at 0% in 2020. The missing remainder of allowances will have to be purchased from the open market.

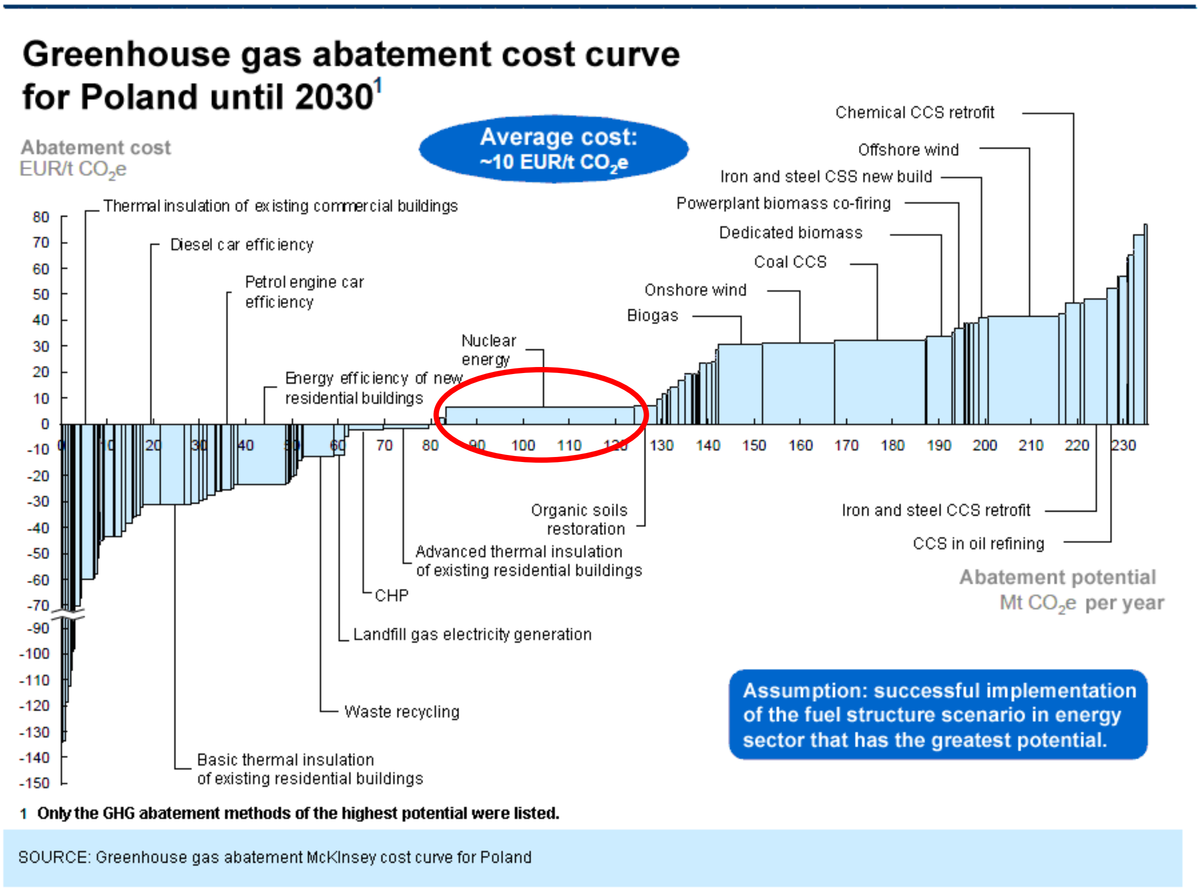
Owing to the expected increase in the cost of emission allowance prices, up to EUR 25 and EUR 30 per 1 tonne in 2025 and 2030, respectively, in the context of the need to ensure cost effectiveness of power generation, with the resultant competitiveness of Polish economy, production of electricity based on zero-emission sources, such as nuclear power plants, becomes legitimate. What shape will the EU climate/energy policy assume after 2020, has not been determined yet. Poland's postulate is to render the relevant decision dependent upon a global climatic agreement, which is expected to be concluded in 2015. While the adoption of the EU strategy for combating the climate warming seems certain, in any case, the analyses contained herein assume that the strategy will continue past 2020. Regardless, however, of the processes taking place on the global and EU levels, a transformation of Polish economy toward low emissions is a must. The shrinking resources, and their rising prices, cause that only those countries which will be capable of adapting to the new developmental challenges, will remain competitive. Therefore, Polish electrical-engineering and power industry will be in need of zero-emission sources of generation – one of these being nuclear power plants.

With respect to SO_2, NO_x and dust emissions, it is assumed that the amended IPCC directive will be implemented from 2016 onwards, instructing the Member States to introduce very rigorous admissible ceilings of exhaust gases with respect to facilities with considerable pollutants emissions. As far as power sector is concerned, these include facilities in excess of 50 MW capacity, which means that these regulations will pertain to all the Polish power plants and most municipal district heat-and-power plants. The regulations in question impose the need to make considerable investment in environment protection installations or systems, which to a remarkable extent penalises the coal and gas sources of electricity generation.

4.2.1. ANALYSIS OF THE GREENHOUSE GAS EMISSION REDUCTION POTENTIAL

On commission of ME, McKinsey&Company prepared in 2009 a report titled *An evaluation of the potential to reduce emissions of greenhouse gases in Poland to 2030*.

Fig. 4.4. GHG emission reduction cost curve for Poland, till 2030.



Source: McKinsey & Company, 2009.

The curve illustrating the cost of reduced carbon emissions to 2030, as proposed in the report for a mix of fuels that ensures the theoretically maximum possible reduction in the emissions, reflects a bi-directionality of actions taken in view of reducing GHG emissions. In the diagram left-hand side section (Fig. 4.4.), actions are indicated that allow for reduced consumption of electricity, this being the lowest-cost method to reduce the emissions. Yet, the electricity saving potential is practically limited; in order to ensure economic development and adequate living standard to the citizens, it is necessary to ensure production of electricity at an appropriate level. As for generation, the most cost-effective carbon emission reduction method is to take advantage of nuclear power sources.

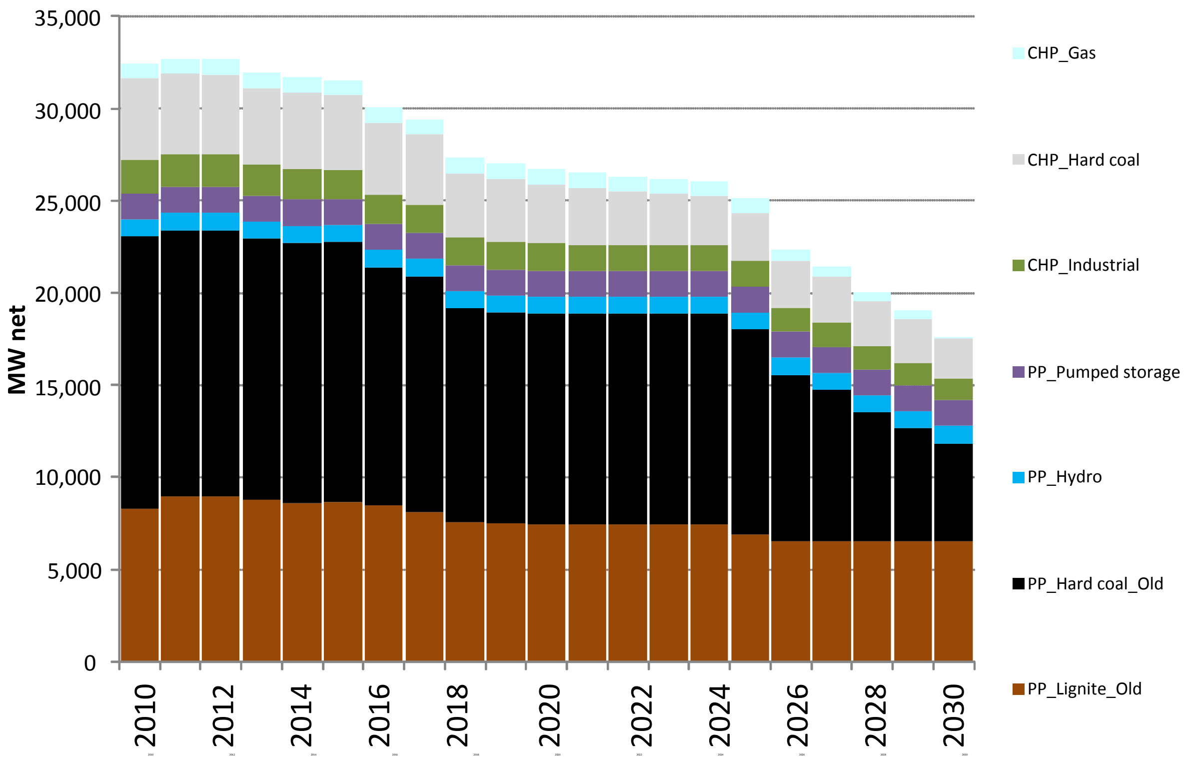
Each of the columns shows the reduction method under analysis:

- The column's width shows the tonnage (in million tonnes) of CO_2, reducible with use of the method;
- The column's height shows the cost of each of the reduction methods, as converted to Euro/tonne of emitted carbon quantity reduced.

4.2.2. PLANNED SHUTDOWNS OF GENERATING CAPACITIES

Moreover, it is assumed that after 2016 the sector will be gradually adopting to the IED requirements. What the Directive does, among other things, is exacerbate the requirements regarding emissions of the SO_2, NO_x compounds for installations fired with gas fuel; this translates into considerably higher costs or expenses because of the need to apply the post-combustion CCS technology.

Fig. 4.5. Changes in the generating capacity of utility/commercial power plants and 'industrial' power stations, including losses (decommissioned/withdrawn for upgrading) and capacity growths due to upgrades.



Source: ***An updated forecast of demand for fuels and energy until 2030*****, ARE S.A., June 2013.**

Figure 4.5 shows the aggregate effect of planned decommissioning and upgrades of generating units in Poland's utility (commercial) and 'industrial' power, the latter referring to power stations generating electricity for the needs of their associated industrial establishments. The schedule specified below enables to determine the forecasted deficits in capacities and the necessary investments in new generating capacities in order to ensure coverage of the increasing demand for electricity and the required capacity reserve within the system. The schedule is taken into account in model calculations. The results of the analysis indicate that at least 12,000 MW of generating capacity will have been decommissioned by the year 2030, which is approx. 6,000 MW to 2030 and the remaining 6,000 MW, to 2030.

The planned decommissioning of generating capacities mainly ensue from their technical wear-and-tear and failure to comply with the EU requirements with respect to exhaust gas parameters.

The assumed connection to the network of the first NPP around 2025 will partly allow for satisfying the potential deficit of generating capacities.

According to the ARE forecast of June 2013 (the scenario taking new investments into account, especially new coal capacities), certain crucial changes are expected in the fuel mix for generation of electricity, mainly based on the climate policy under implementation and actions performed in view of limiting adverse impact of power industry on the environment. In specific:

- A decrease is expected in the share of coal in the electricity production mix, namely from approx. 89% in 2010 to approx. 59% in 2030.
- The proportion of electricity generated in NPPs will be around 12% in 2030.
- The share of renewable energy sources will significantly increase in the electricity manufacturing structure, with approx. 19% of Poland's electricity production to be based on these sources by 2030.
- The renewable energy sources-based electricity production ensures that the target of 15% share of renewables-based energy in the gross final energy demand by 2020 will be met, in line with Directive 2009/28/EC on the promotion of the use of energy from renewable sources[48].
- The role of natural gas will increase, with the proportion in the electricity generation mix of approx. 9% by 2030.
- Although coal-derived fuels will continue to be dominant in the power sector, the growing diversification in the fuel mix will enable to remarkably decrease the emissions of CO_2 and of pollutants such as SO_2, NO_X and dusts – owing to the development of renewables, nuclear power, high-efficient cogeneration and the CCS technology.

4.3. FORECAST OF TECHNOLOGICAL AND FUEL STRUCTURE IN PRODUCTION OF ELECTRICITY

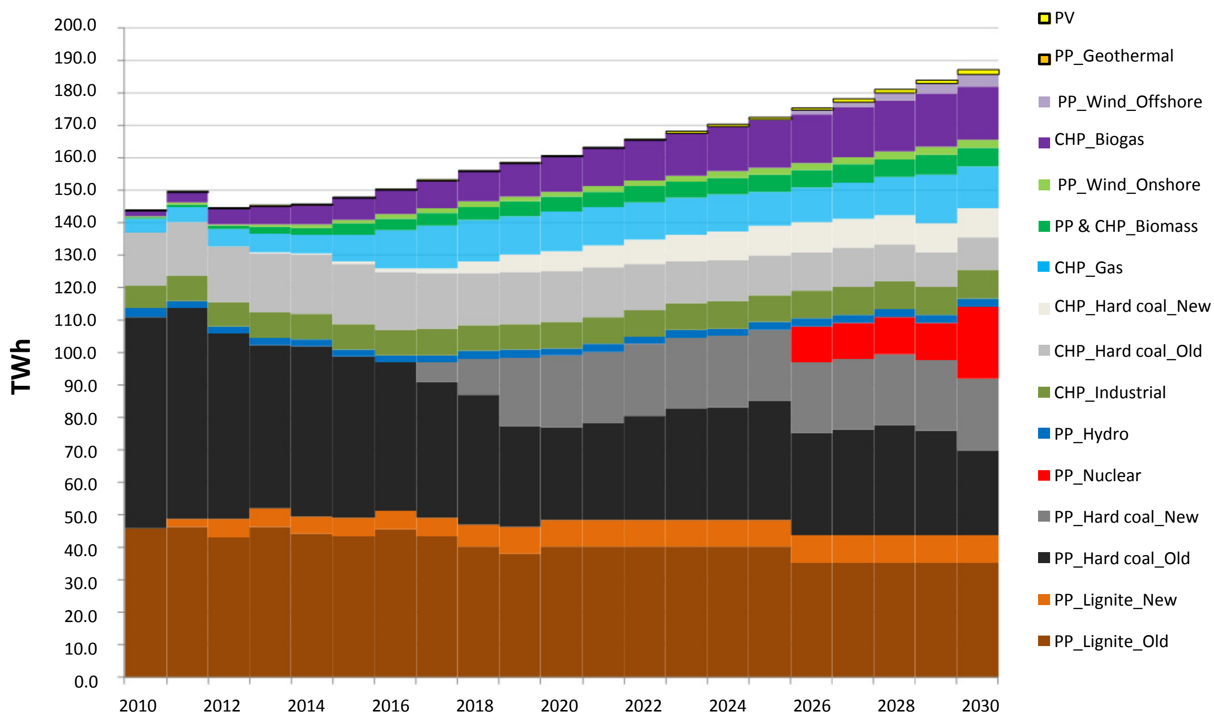
As indicated by the forecast of the structure of future generating capacities, satisfaction of the domestic demand for final electricity will call for significant increase in the net production of electricity: from 119.1 TWh as of 2010 to approx. 161.4 TWh in 2030 – an increase by, roughly, 36%.

The energy production structure will see a significant decrease of the share of baseload power plants fired with coal-derived fuels: the 2010 figure of 89% to go down to approx. 59% by 2030. In turn, renewables-based generation will increase, attaining a share of approx. 19% in the domestic electricity production, in net terms, by the year 2030.

For the new NPPs, an approximate share of 6.5% is expected in production of electricity for the year 2025; by 2030, the proportion will grow to some 12%, thus contributing to stabilised prices of energy. A projection of electricity generation by source and type of fuel is shown in Fig. 4.6.

[48] Directive 2009/28/EC of the European Parliament and the Council on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC (OJ L 140, 05.06.2009, p. 16).

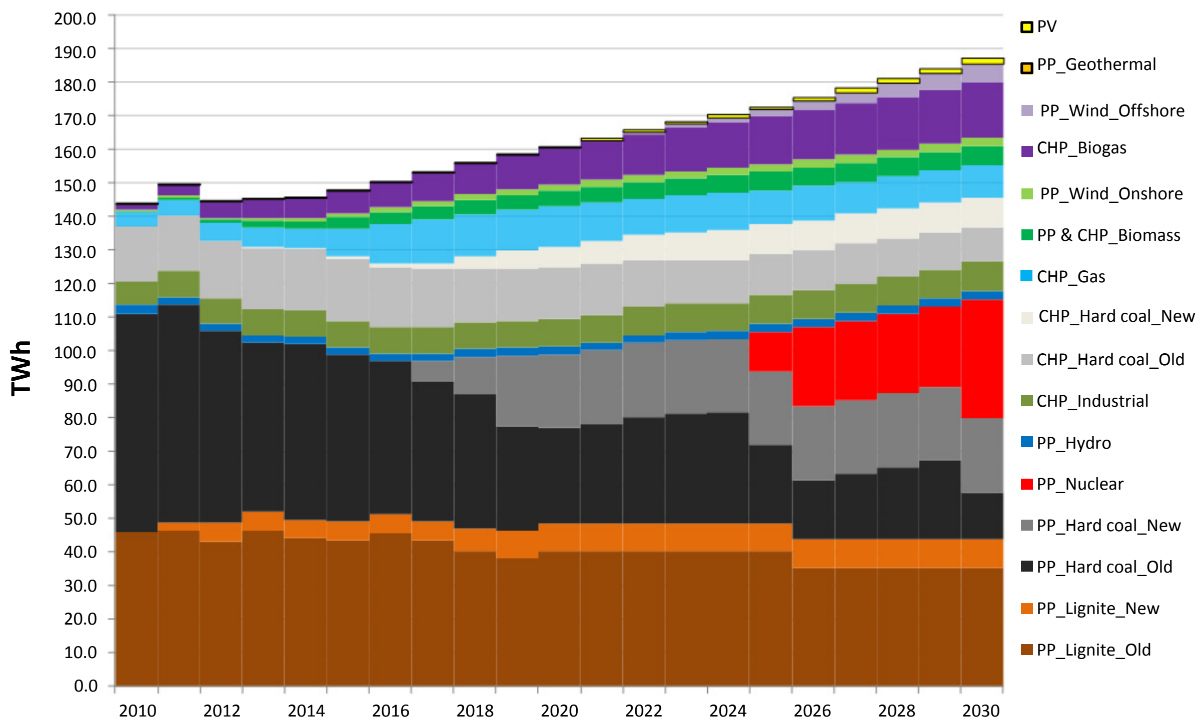
Fig. 4.6. Forecast production of electricity for Poland, to 2030 (in net terms).
Based on a scenario taking into account new investments, esp. in new coal capacities.



Source: ***An updated forecast of demand for fuels and energy until 2030*, ARE S.A., June 2013.**

As per an analysis prepared by ARE in September 2013 (with the market parameters for nuclear power), nuclear power has a 7% share in the net domestic electricity generation as of 2025; the share is to grow by 19% to 2030 (35 TWh). A projection of electricity production by type of source and fuel is shown in Fig. 4.6.1.

Fig. 4.6.1 Forecasted production of electricity for Poland, to 2030 (in net terms) – with parameters defined for newly-built generation sources.



Source: ***Forecast of the structure of generating capacities to 2030, with technical and economic parameters specified for the nuclear power plant*****, ARE S.A., September 2013.**

4.4. ECONOMIC JUSTIFICATION FOR THE IMPLEMENTATION OF NUCLEAR POWER

An ARE *Updated comparative analysis of the electricity generation costs for nuclear, coal-fired and gas-fired power stations and renewable sources of energy*, prepared in April 2013 on commission of ME, points to the implementation of nuclear power in Poland within the coming decades, until 2050, as an economically justifiable venture.

The said analysis deals with the costs of generation of electricity in power plants operating based on various technologies, and envisioned for commissioning in Poland until 2050; the expenditure in question is to be borne by the national economy and the society. The analysis's outcome is a substantial factor in the shaping of Poland's energy policy, particularly when it comes to determining the most desirable investment directions in the electric power generation sector.

4.4.1. TECHNOLOGIES UNDER CONSIDERATION

The analysis compares electricity generation technologies envisioned for commissioning in the years 2025, 2035, and 2050. Assessment of the averaged cost of electricity generation has been carried out for a typical set of technologies in the domestic conditions, which also appear in analyses prepared by internationally renowned institutions and research centres. The analysis being referred to has been based on the operational experiences with the existing and projected facilities and the forecasts presented in the most up-to-date literature.

The cost competitiveness of electricity generation technologies has been considered across the uses of installed capacity. Similarly as in the analysis updated as mentioned, no peak-load source technologies have been taken into account, their generation costs being dependent on the structure of basic sources – as in e.g. pumped storage plants, and heavily dependent on the local conditions – as with run-of-river plants. Also, combined heat-and-power plants were excluded from the comparison study, as the cost of electricity cogenerated with heat is depended on the local demand for heat and external conditions of district-heat regulated prices.

The comparative analysis has, in turn, considered wind power stations (onshore and offshore) and photovoltaic installations. However, it should be stressed that their role in the power system is different than that of large conventional generation units, and these sources are not to be approached as fully alternative.[49] Hence, a different approach has been applied with respect to these sources, the generation costs being shown in a different arrangement than those for traditional sources.

The analysis of generation costs did not take into account the issues related to subsidising any technology whatsoever.

For the year 2025, apart from the electricity generation technologies commercially available today, the analysis in question covers certain technologies being intensely developed today and expected by the said time to have been advanced to a level enabling their commercial use. This is particularly true for *carbon capture and storage systems, cogenerated with* CO_2 storage facilities. It is expected that such installations, which are being tested nowadays at laboratory scale, may soon be launched for industrial use and thus they have been included in the comparative analysis for the period. The technology has been taken into account for the same reason. An identical composition of technologies has been assumed for the sources whose start-up is envisioned around 2035. In turn, since any expectations regarding new technologies in such a distant time horizon intrinsically imply considerable uncertainty, the comparative analysis for the year 2050 has only taken into consideration (beside those made available earlier) the technologies being developed but still at their early development stage. Within the timeframe being considered, substantial development of nuclear technologies is envisioned, with the assumption that NPPs equipped with generation IV reactors will be operated. Hence, as regards the year 2050, the same set of technologies has been considered as for 2025 and 2035, respectively, taking into account technological development that would lead to achieving by these units higher generation efficiencies in the future – with the essentially different cost parameters. In addition, generation IV reactors are considered the plants which will serve as the links closing the fuel cycle, thus increasing the nuclear fuel resources for thermal reactors.

The following technologies have been compared in the analysis:

- condensing power plants, fired with pulverised hard coal (**PC**) combusted in pulverised-fuel boilers, with flue-gas desulphurisation ($DeSO_2$) and denitration ($DeNO_x$) installations;
- power plants with pulverised hard coal boilers and carbon capture-and-storage installations (**PC +CCS**);
- condensing power plants, fired with pulverised lignite (**PL**) combusted in pulverised-fuel boilers, with $DeSO_2$ and $DeNO_x$ installations;

[49] For instance, it is impossible to compare these sources with conventional sources across the range of the capacity factor.

- power plants with pulverised lignite boilers and carbon capture-and-storage installations (**PL +CCS**);
- NPPs with generation III (light) water reactors (**LWR**);
- NPPs with generation IV reactors;
- gas-fired power plants – integrated hard-coal gasification combined cycle (**IGCC_C** – coal);
- power plants with integrated hard-coal gasification combined cycle and carbon capture-and-storage installations (**IGCC_C + CCS**);
- gas turbine combined cycle power stations (**GTCC**);
- gas turbines (**GT**),
- biomass power plants (**BM**),
- onshore wind power stations (‘**wind onshore**’);
- offshore wind power stations (‘**wind offshore**’);
- photovoltaic power stations (**PV**).

4.4.2. INVESTMENT OUTLAYS FOR INDIVIDUAL ELECTRICITY GENERATION SOURCES

With a view to determining the economic premises for energy policy with regards to the choice of the directions of development of electricity generation sources, the analysis has made use of a methodology[50] applicable in determining the costs of electricity generation from the standpoints of national economy and society. From an economic point of view, in discussing and comparing electricity generation technologies, the two different investment efficiency ratios prove to be crucial: (i) investment outlays indispensable for construction of a power plant/station, expressed in [EUR/MW]; and, (ii) the costs of electricity generation, expressed in [EUR/MWh]. Investment outlays encompass overnight investment costs (OVN) and the cost of capital, third-party and own, as incurred by the investor in the course of the construction project and referred to as interest during construction (IDC).

For comparisons of competitiveness, electricity generation costs are used as broken down into fixed costs, variable costs, and constituents thereof.

For the sake of competitiveness comparison, energy generation costs are used as broken down into fixed costs, variable costs, and cost constituents. Investment outlays are reflected in the costs through depreciation(/amortisation) of assets and cost of capital.

In the available publications, the current investment outlays (OVN) on construction of the sources of energy under consideration is characterised by a considerable spread, due to differential conditions of project implementation. For the needs of the analysis in question, referential amounts of investment outlays have been estimated for the facilities envisioned for commissioning in the years 2025, 2035, and 2050 (Table 4.7). The outlays are inclusive of the power enterprises’ own expenditures, not taken into account separately with respect to the purpose of the analysis.

[50] IAEA, *Expansion Planning for Electrical Generating Systems. A Guidebook*, Vienna 1984.

Table 4.7. Reference unit OVN for the sources under consideration [EUR thousand'2012/MW].

Type of source	2025	2035	2050
PC	1,550	1,550	1,550
PC+CCS	2,600	2,500	2,400
PL	1,700	1,700	1,700
PL+CCS	2,750	2,650	2,550
Nuclear LWR	4,000	3,850	3,650
Nuclear IV GEN	--	--	4,150
GT	400	4,00	400
GTCC	850	850	850
IGCC_C	2,250	2,100	2,100
IGCC_C+CCS	3,100	2,900	2,700
BM	2,400	1,950	1,800
Wind onshore	1,350	1,300	1,250
Wind offshore	2,550	2,350	2,200
PV	1,350	1,200	1,100

Source: *Updated comparative analysis of the electricity generation costs for nuclear, coal-fired and gas-fired power stations and renewable sources of energy*, ARE S.A., April 2013.

For the purpose of these calculations, periods typically referred to in scientific reference literature have been followed, save for NPPs (for which the quoted lifetime is a minimum of sixty years) [51]. The analysis has conservatively assumed, for a change, a forty years' useful life, which may translate into the totality of the analytic outcome for this particular technology in a less advantageous manner.

Both the OVN and the total investment outlays for the periods under discussion prove the highest for nuclear, whilst it should be kept in mind that nuclear-power investments and projects imply an incomparably longer temporal horizon of the plant's operation: more than sixty years for generation III/III+ reactors operating at low variable cost due to low cost of fuel.

4.4.3. AVERAGED UNIT FIXED COST

This particular category encompasses investment outlays (OVN, taking account of IDC) as well as fixed costs of operation and maintenance (O&M), inclusive of decommissioning costs. It is assumed that the average unit fixed cost is taken into account in the form of annual write-downs made to a decommissioning fund which is defined on a ratio basis, in terms of decommissioning outlays after completion of the facility's operation. The cost of decommissioning of an NPP is much higher than the corresponding cost for conventional power plants; however, owing to the discount effect, the amount of such write-downs does not form a substantial costs item, even with capital-intensive nuclear sources.

[51] For generation III reactors.

Table 4.8. Reference fixed costs of operation and maintenance [EUR thousand/MW-year].

Type of source	2025	2035	2050
PC	36	36	36
PC+CCS	62	58	52
PL	40	40	40
PL+CCS	66	60	56
Nuclear LWR	90	90	90
Nuclear IV GEN			80
GT	10	10	10
GTCC	18	18	18
IGCC_C	58	56	54
IGCC_C+CCS	64	62	60
BM	70	70	70
Wind onshore	40	40	40
Wind offshore	95	85	80
PV	20	20	20

Source: *Updated comparative analysis of the electricity generation costs for nuclear, coal-fired and gas-fired power stations and renewable sources of energy*, ARE S.A., April 2013.

4.4.4. AVERAGED UNIT VARIABLE COST

This category extends to personnel costs, cost of (raw) materials and fuels, the facility own needs (auxiliaries), and those related to use of the environment. [52] Fees for carbon emissions have been separately taken into account, as this is a substantial element of energy generation cost in terms of comparative analysis. With its considerable impact on the operating expenses of power stations fired with hydrocarbon fuels, prices of fuels are of key significance for selection of the electricity generation technology. One of the main advantages of nuclear power technology is a relatively low cost of fuel, as compared to the technologies making use of coal or gas.

The price of nuclear fuel is EUR 0.4–0.7 per 1 GJ[53]. This analysis has assumed that the nuclear fuel price was equal EUR 0,8/GJ in 2010, with a 0.5% average annual growth rate for the years 2011 to 2050.

[52] For NPPs, this category encompasses write-offs for a fund to be used in a future for financing neutralisation and storage of radioactive waste.

[53] G. Harris, P. Heptonstall, R. Gross, D. Handley, *Cost estimates for nuclear power in the UK*, Imperial College Centre for Energy Policy and Technology-ICEPT, London, 2012; G. Rothwell, *New U.S. Nuclear Generation: 2010–2030*, Stanford Institute for Economic Policy Research, Stanford, 2010; Y. Du, J.E. Parsons, *Update on the Cost of Nuclear Power*, MIT Center for Energy and Environmental Policy Research, 2009; R. Tarjanne, A. Kivisto, *Comparison of electricity generation cost*, Lappeenranta University of Technology, Lappeenranta, 2008.

Table 4.9. Variable cost of operation and maintenance, according to reference literature [EUR/MWh].

Type of source	2025	2035	2050
PC	2.4	2.4	2.4
PC+CCS	3.2	3.2	3.2
PL	2.4	2.4	2.4
PL+CCS	3.2	3.2	3.2
Nuclear LWR	0.8	0.8	0.8
Nuclear IV GEN			0.8
GT	2.8	2.8	2.8
GTCC	1.8	1.8	1.8
IGCC_C	3.6	3.6	3.6
IGCC_C+CCS	4.2	4.2	4.2
BM	5.0	5.0	5.0
Wind on-shore	0.0	0.0	0.0
Wind off-shore	0.0	0.0	0.0
PV	0.0	0.0	0.0

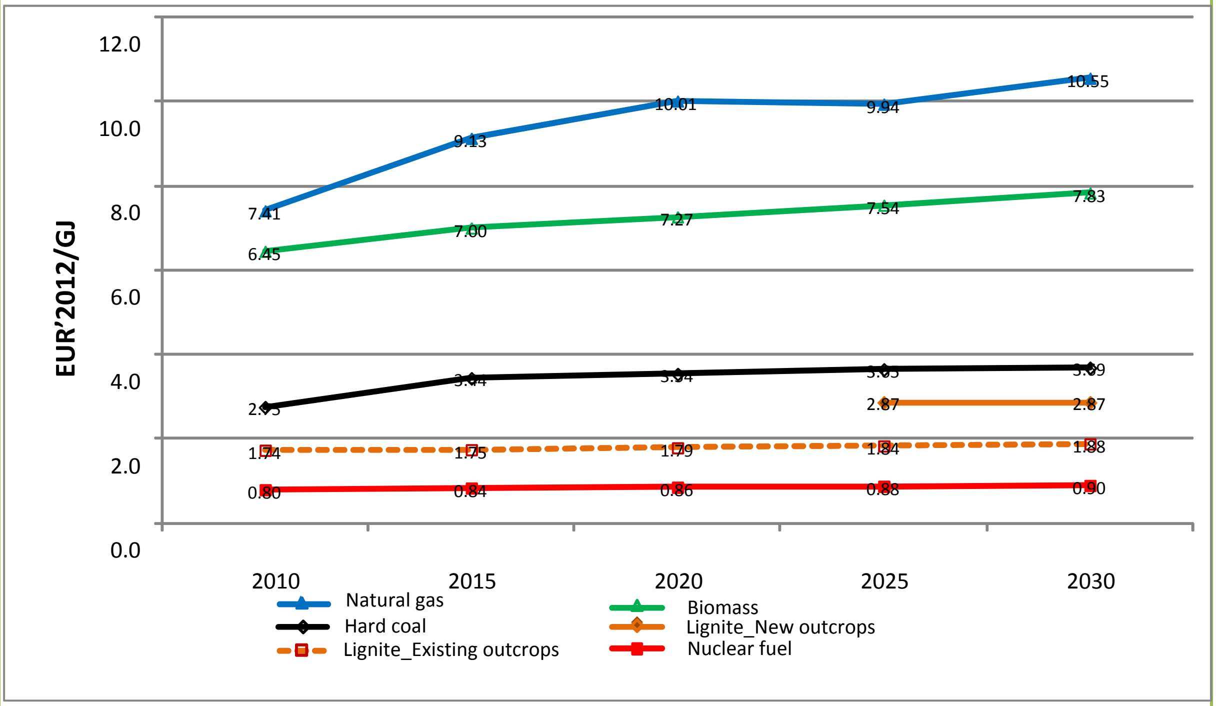
Source: *Updated comparative analysis of the electricity generation costs for nuclear, coal-fired and gas-fired power stations and renewable sources of energy*, ARE S.A., April 2013.

Fuel price projections

In the international market, the nuclear fuel is commonly accessible, which holds true for uranium ore as well as for the capacity of processing into uranium hexafluoride and the establishments' capacity of enriching and producing fuel elements for reactors. It has therefore been assumed that nuclear fuel resources would not inhibit the pace at which nuclear power industry is expected to be developing, given its forecasting and operation-related prospects, with a 0.5% annual average increase expected for the period 2010 to 2030.

The pricing projections for Poland, as prepared based thereupon and assumed for the purpose hereof, are shown in Fig. 4.10.

Fig. 4.10. Forecast fuel prices.



Source: ***Updated comparative analysis of the electricity generation costs for nuclear, coal-fired and gas-fired power stations and renewable sources of energy*, ARE S.A., April 2013.**

4.4.5. VARIABLE COSTS RELATED TO CARBON EMISSION FEES

The prices of allowances for CO_2 emissions have been assumed for the years 2025 and 2035 based upon the OECD/MAE projection[54]. A slight increase in the allowance cost is assumed as from 2035, which is to result from a development of low-emission coal technologies, zero-emission renewable sources and nuclear power (Table 4.12). Owing to considerable uncertainty as far as the future prices of carbon emission allowances are concerned, the sensitivity analysis has considered options of remarkable upward/downward deviation in the value of such allowances as versus the reference scenario.

Table 4.12. Cost of carbon emission allowances

Projected pricing of carbon emission allowances as at the year of commissioning[€/tCO_2].			
2020	**2025**	**2035**	**2050**
15	25	35	40

Source: *Updated comparative analysis of the electricity generation costs for nuclear, coal-fired and gas-fired power stations and renewable sources of energy*, ARE S.A., April 2013.

Having regard to the fact that the third settlement period under the EU ETS 2013–2020 is presently in force, which in spite of the derogations afforded to Poland implies gradual elimination of free-of-charge allocation of emission allowances, the power and energy sector will over the subsequent years have to be purchasing increasing numbers of emission allowances, at rising prices. Thus, the cost of energy generation will be increasing, which, in turn, is intended to promote zero-emission and low-emission technologies.

[54] *Word Energy Outlook 2012*, OECD/IEA, Paris, 2012.

4.4.6. AVERAGED TOTAL COST OF GENERATION OF 1 MWH OF ELECTRICITY, BY GENERATION SOURCE

The analytical results for the year 2025 (Table 4.13) show that already at the capacity factor (CF) equalling 0.8, nuclear power is characterised by the lowest cost of electricity generation – i.e. EUR 86.3 per 1 MWh. This trend is to be seen reinforced in the subsequent periods - by 2035 and 2050, respectively – thus corroborating the technology's long-term efficiency. This is all the more crucial if one takes into account that the present reactor generations operate at capacity factors of at least 90%. For example, the French company AREVA offering a III-generation EPR declares its availability at the order of 92%.

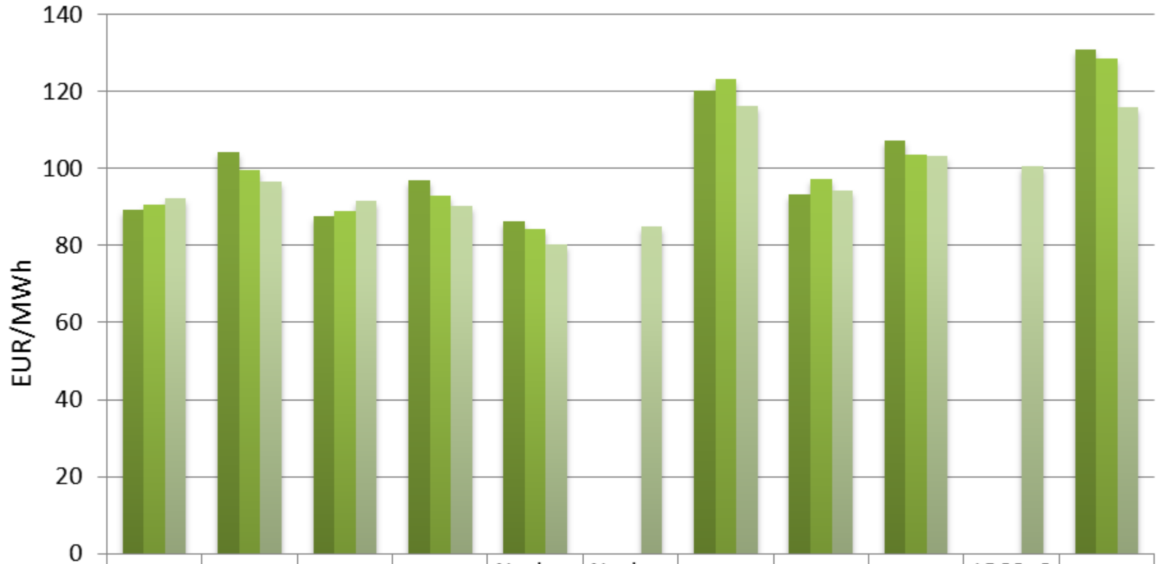
Tab. 4.13. Unit generation cost [EUR/MWh]: a 2025 estimation.

Generating unit	Source capacity factor (CF)					
	0	**0.2**	**0.4**	**0.6**	**0.8**	**1**
PC	x	175.8	118.1	98.9	89.3	83.5
PC+CCS	x	250.2	152.9	120.5	104.3	94.6
PL	x	182.7	119.3	98.2	87.6	81.3
PL+CCS	x	251.5	148.6	114.2	97.1	86.8
Nuclear LWR	x	314.9	162.5	111.7	86.3	71.1
GT	x	141.5	127.4	122.7	120.3	118.9
GTCC	x	139.0	108.5	98.3	93.2	90.2
IGCC_C	x	235.5	149.9	121.4	107.2	98.6
BM	x	267.4	176.5	146.1	131.0	121.9

Source: *Updated comparative analysis of the electricity generation costs for nuclear, coal-fired and gas-fired power stations and renewable sources of energy*, ARE S.A., April 2013.

In order to more completely picture the unit generation cost by technology and with the timeframes assumed (i.e. by 2025/2035/2050), a single CF value was assumed, as a standard – i.e. 0.8 (Fig. 4.11). The obtained data confirmed similar levels of unit costs per the individual timeframes, without a definite trend being indicated – with a similar scale of cost decrease being observable for CCS-equipped technologies and for nuclear power.

Fig. 4.11. Averaged unit energy generation costs for sources envisioned for commissioning in 2025, 2035 and 2050, resp. – at CF 0.8 [EUR/MWh].



	PC	PC+CCS	PL	PL+CCS	Nuclear LWR	Nuclear IV	GT	GTCC	IGCC_C	IGCC_C +CCS	BM
2025	89,3	104,3	87,6	97,1	86,3		120,3	93,2	107,2		131
2035	90,7	99,7	89,1	92,8	84,2		123,2	97,3	103,7		128,7
2050	92,4	96,6	91,7	90,3	80,3	85	116,3	94,3	103,4	100,5	116

Source: ***Updated comparative analysis of the electricity generation costs for nuclear, coal-fired and gas-fired power stations and renewable sources of energy*, ARE S.A., April 2013.**

4.4.7. COMPETITIVENESS OF SOURCES FOR TYPICAL WORKING CONDITIONS WITHIN THE SYSTEM

Under the real working conditions of generation sources, the degree at which capacity is used for individual technologies appears much differentiated, which stems from their role in the electric power system. This translates into the real cost of generation, as characteristic to a given type of source. Hence, a comparison has been carried out between generation costs obtained for the reference conditions wherein all thermal power plants operate at the same capacity factor of 80%. Subsequently, CF values typical to individual technologies have been compared: for NPPs (85%), coal-fired CCS power plants (80%), coal-fired power plants (without CCS) (70%), and gas-fired power stations (55%). The breakdowns have also taken into account wind power stations, assuming a 25% CF for onshore stations, 40% for offshore wind farms, and 11% in case of photovoltaic stations.

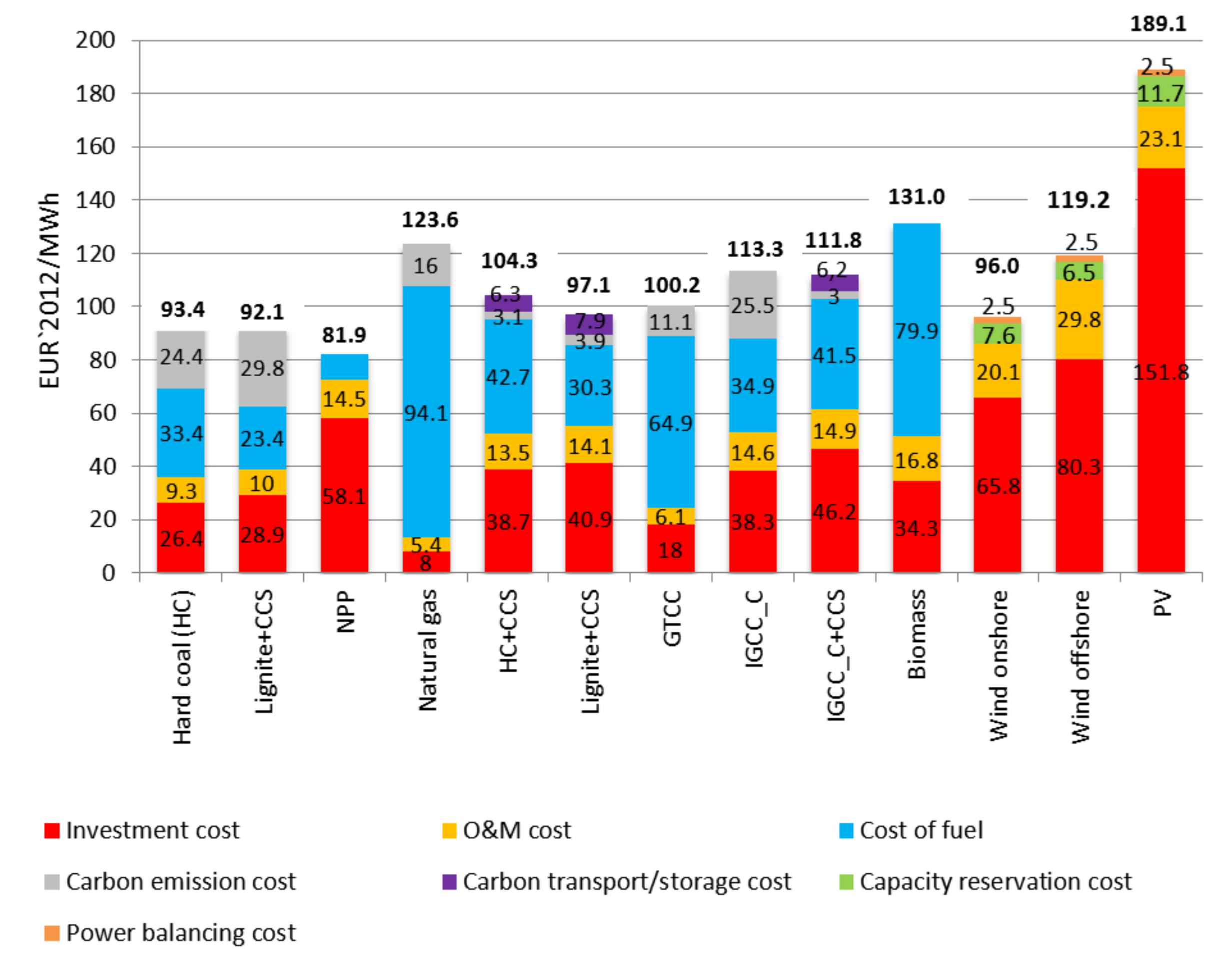
For the reference conditions, cost of energy generation with sources envisioned for commissioning around 2025 indicate a competitive edge on the part of NPPs (which appears even greater when it comes to diverse availability coefficients – EUR 79/ MWh), which is heavily dependent upon the assumed pricing of carbon emission allowances. With coal-fired sources not equipped with CCS, the generation costs are – inclusive of the carbon expenditure – slightly higher than those for NPPs.

Offshore wind power stations are characterised by one of the highest generation costs – this being the case in spite of relatively advantageous assumptions made for the technology's parameters. Due to a high proportion of the cost of fuel, biomass-fired stations are the second most expensive electricity generation source, following PV technologies.

With the working conditions of thermal power plants at diversified load coefficients (Fig. 4.12.), NPPs become increasingly competitive compared to their coal-fired counterparts. In parallel, the competitiveness of gas-and-steam power plants falls down, for which the generation cost exceeds the corresponding cost with CCS-equipped units fired with lignite, and even with onshore wind farms.

Due to high cost of energy generation, photovoltaic power stations, biomass-fired stations as well as offshore wind farms remain uncompetitive.

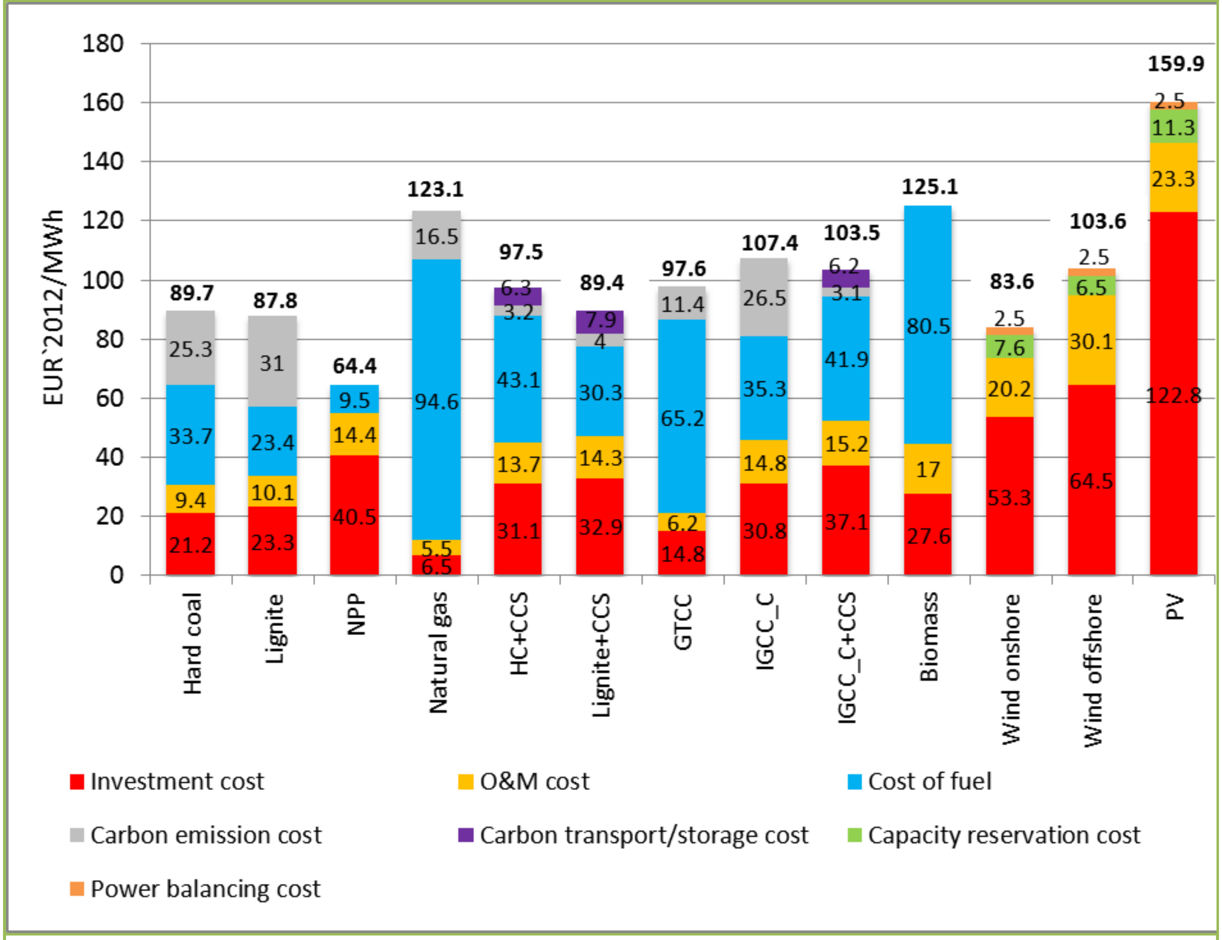
Fig. 4.12. Averaged unit energy generation costs for sources envisioned for commissioning in 2025.



Source: ***Updated comparative analysis of the electricity generation costs for nuclear, coal-fired and gas-fired power stations and renewable sources of energy*****, ARE S.A., April 2013.**

A comparative analysis has also been made for costs of electricity generation with use of diverse sources, with the assumption of the new technical-and-economic parameters for newly-built generating sources, as specified in Table 4.1. The results have shown that, given the parameters in question, nuclear is the lowest-cost option amongst the technologies under analysis (cf. Fig. 4.12.1).

Fig. 4.12.1. Averaged unit energy generation costs for sources envisioned for commissioning in 2025, with parameters for newly-built generation sources.



Source: ***Forecast of the structure of generating capacities to 2030, with technical and economic parameters specified for the nuclear power plant*, ARE S.A., September 2013.**

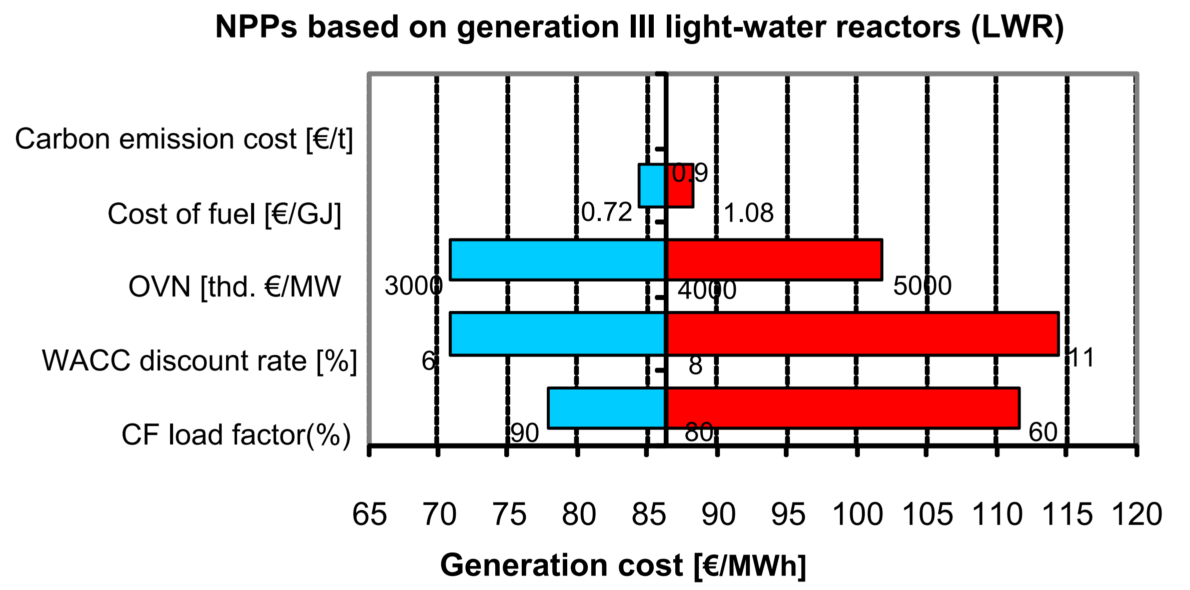
The outcomes of the analyses carried out for the sources to be commissioned around the year 2035 are not different, in terms of quality, compared to those for 2025, as shown above. NPPs based on the established and well-tested LWR technology remain the source with the lowest generation cost. As regards cost of generation, the subsequent types are lignite-fired and coal-fired power plants/stations, lignite-fired CCS-equipped power plants/stations, and onshore wind farms. Gas-and-steam plants perform at a relatively fair level; taking their high operating flexibility into account, these particular sources may be really competitive to coal-fired units. With a diverse load coefficient, the mutual competitiveness of individual technologies remains basically unchanged. Among power plants to be commissioned around 2050, NPPs equipped with reactors of the III and IV generation would offer the lowest generation costs (it being remarked that forecasts concerning the expenditure related to generation IV NPPs are encumbered with considerable uncertainty). Generation IV NPPs will probably produce energy at a cost slightly higher than their generation III peers, this being due to higher investment outlays related to the striving for further improvement of safety and security. The high competitiveness of nuclear technologies stems primarily from the foreseen moderate increase in the costs of fossil fuels and CO_2 emission allowances.

Amongst the conventional sources, the lowest cost of generation is in the case with lignite-fired power plants equipped with CCS.

4.4.8. IS ELECTRICITY GENERATION COST SENSITIVE TO CHANGES IN BASIC ANALYTICAL PARAMETERS?

The estimated costs of electricity generation for individual technologies are burdened with uncertainty owing to the difficult-to-predict future changes in the parameters of decisive influence on such costs. The prices of fuels, the prices of carbon emission allowances, the structure and conditions of investment project funding all make their substantial impact on the generation costs. For some technologies, considerable discrepancies in assessment of investment outlays are the case. With these circumstances in mind, sensitivity analyses have been carried out in order to show the potential influence of the primary input parameters on the averaged cost of generation in the specified technologies (levelized cost of energy, LCOE)[55] (Fig. 4.13.).

Fig. 4.13. Integrated cost sensitivity for NPP.



Source: ***Updated comparative analysis of the electricity generation costs for nuclear, coal-fired and gas-fired power stations and renewable sources of energy*, ARE S.A., April 2013.**

An integrated analysis of cost sensitivity for NPP attests to a complete neutrality of a nuclear project relative to CO_2 emission cost [in EUR/t] and to a very weak correlation with the cost of fuel [in EUR/GJ]. The discount rate, the load factor, and the initial cost of investment are key to the cost-effectiveness of production of 1 MWh of energy.

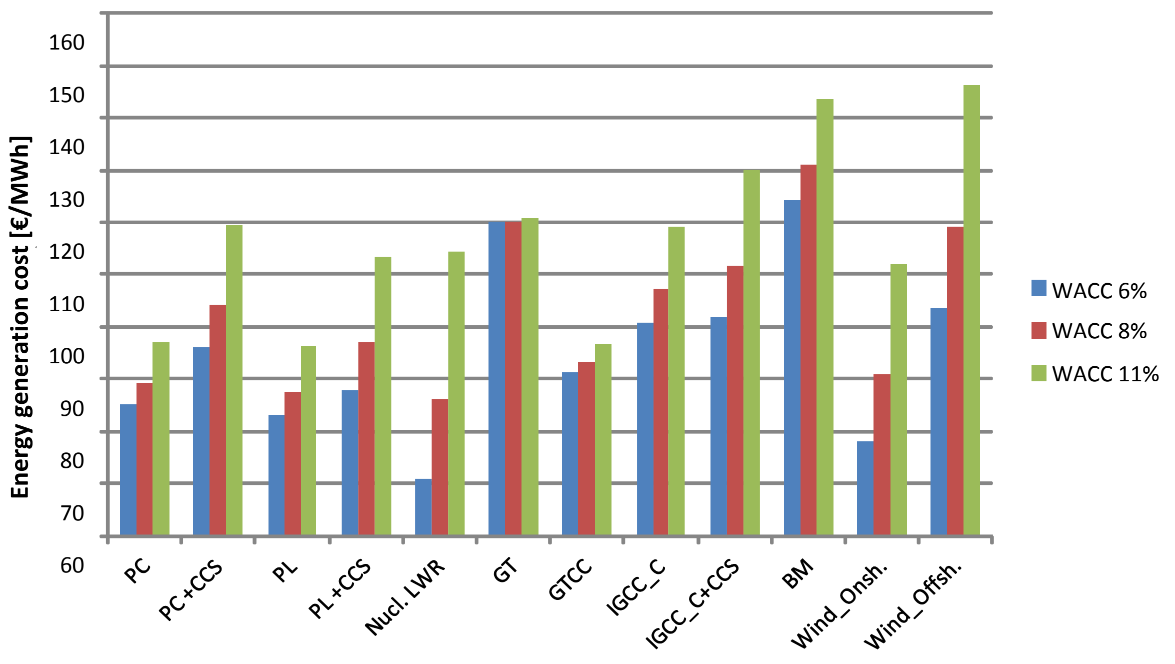
4.4.9. ELECTRICITY GENERATION COST ANALYSIS: SENSITIVITY BY TECHNOLOGY, AT VARIOUS DISCOUNT RATES, AS FOR 2025

What the discount rate influences the most heavily is profitability of nuclear technologies. At a low discount rate of 6%, nuclear technologies are definitely the most competitive source of generation, which is true already at the carbon cost of around EUR 20 per 1 tonne. With the rate of 8% and the assumed average price of carbon emission allowances above EUR 30/t, NPPs become competitive

[55] See *ARE analysis*, Chapter 6.

against the coal-based sources. With the same cost of carbon and the weighted average cost of capital (WACC) assumed at 11%, the cost of energy generation through NPP is higher than for coal-fired power stations with no CCS and gas-and-steam plants, whilst being comparable to that with installations furnished with CCS. It has to be borne in mind, though, that the calculations for CCS-equipped units are much more uncertain than those for the other sources, and that they do not consider the technical or logistical possibilities of carbon storage (see Fig. 4.14).

Fig. 4.14. Electricity generation cost, by technology, at various discount rates, 2025.



Source: *Updated comparative analysis of the electricity generation costs for nuclear, coal-fired and gas-fired power stations and renewable sources of energy*, ARE S.A., April 2013.

Given the present-day realities prevailing in international financial markets, the interest rates of venture capital with which the WACC discount rate, as used in this analysis, is correlated, perform clearly lower. For instance, the present profitability of ten-year bonds for the individual EU countries, the United States, and Japan is between 0.86% and 4.37%[56], whereas the profitability of long-term corporate debentures used by large multinational private entities to support their own projects, oscillates between 5% to 8%. These figures are close to the historical long-term interest rates for debt instruments as recorded for macro-economically stable countries. It can be found, with much probability, that, save for hypothetical hyperinflation occurrences lasting over a ten-year period, the probability of excess of 10% WACC discount rate is extremely low. Taking these conditions into account, NPP appears to be the lowest-cost source of electricity generation in terms of a reasonably foreseeable long-term economic and financial perspective.

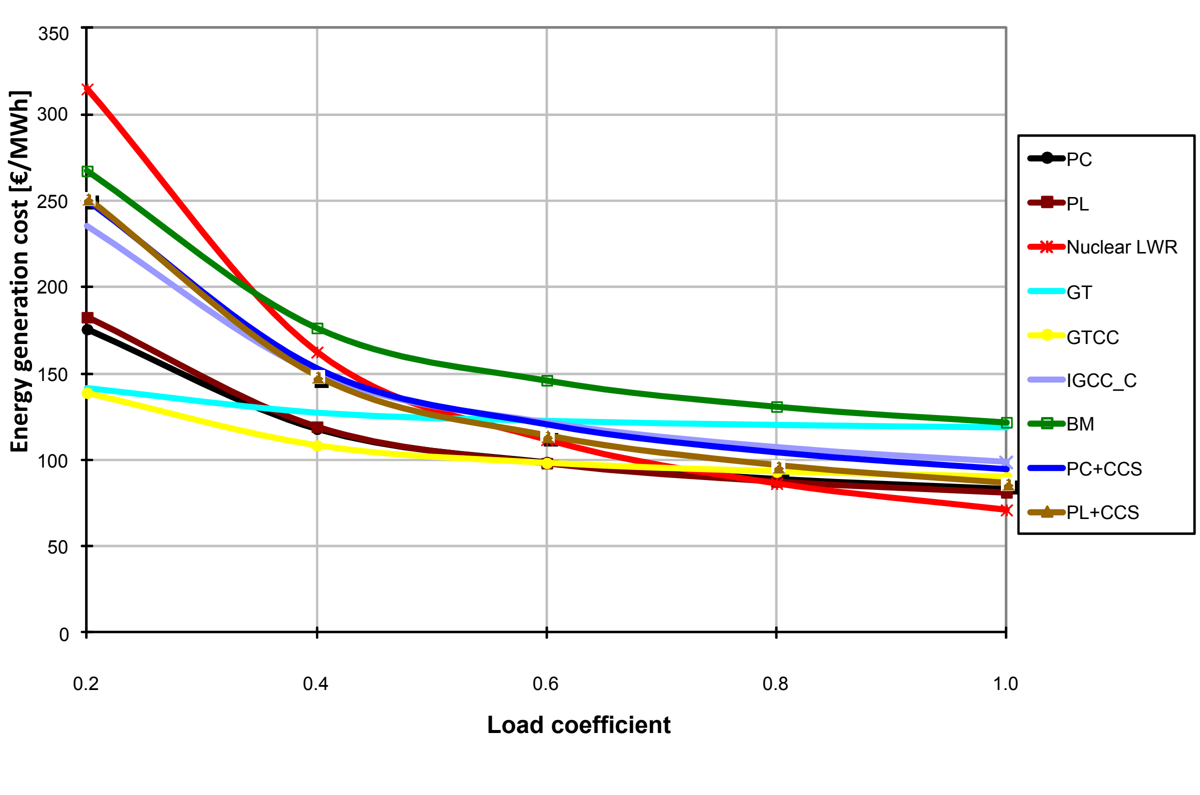
4.4.10. ELECTRICITY GENERATION COST ANALYSIS: SENSITIVITY BY TECHNOLOGY, AT VARIOUS LOAD COEFFICIENTS

The curves depicting the competitiveness of the sources envisioned to be used around 2025, the date Poland's first nuclear unit is scheduled for commissioning (Fig. 4.18.), demonstrate the competitiveness of NPP in operating conditions correspondent with the average load rate in excess of 0.8 (i.e. approx. 7,000 hrs), with the average discounted carbon emission allowance price of

[56] Cf. the relevant EUROSTAT data, at: www.ec.eutostat.europa.eu.

approx. EUR 33/t for the unit's entire useful life. The averaged generation cost for an LWR-equipped NPP, at the load coefficient of 0.9 (approx. 8,000 hrs), as typical for this particular technology, is around EUR 80 per 1 MWh.

4.15. Averaged unit cost of generation [€/MWh] for the sources to be commissioned ca. 2025.



Source: ***Updated comparative analysis of the electricity generation costs for nuclear, coal-fired and gas-fired power stations and renewable sources of energy*, ARE S.A., April 2013.**

The competitiveness curves for the sources envisaged for use around the year 2035 are indicative of an increasing trend, along with the increase in the prices of fossil fuels and of carbon emission allowances, for NPP, as related to the other units considered in the analysis.

4.5. SUMMARY

In analysing power-sector investment projects – particularly, for the nuclear sector, which is characterised by an extremely long period of unit operation – what needs especially to be borne in mind is a long-term perspective. The project delivery period in itself, spanning five to six years, might encompass a full reversal in the economic cycle, whilst a nuclear unit operation period may coincide with up to several such cycles.

The *Comparative analysis of the electricity generation costs for nuclear, coal-fired and gas-fired power stations and renewable sources of energy* confirms that NPPs commissioned around 2025 will prove to be competitive against the other, be it the lowest-cost, classical sources operating at the system's base load, with carbon emission allowance exceeding EUR 20/t (as of 2012). Nuclear sources will be growing even more competitive in the following years, due to the expected increase in the prices of organic fuels and of CO_2 emission allowances.

Resulting from the expected decrease in investment outlays, as the construction technology is mastered with time, the differences in the cost of electricity generation – in particular, between fossil fuel-based technologies and renewables-based technologies, will be seen decreasing. All the same, there are considerable differences in the LCOE for individual technologies, spanning from EUR 86/MWh (for NPP) to EUR 189/MWh (for PV), as of 2025, or even, for same technologies, EUR 80/MWh to EUR 150/MWh, as of 2050 (all in 2012 terms).

Given the assumed technical and economic parameters for newly-built NPPs, the competitiveness of nuclear power is found significantly growing; hence, NPPs are expected to be a significant source of electricity production in Poland.

Taking into account the obligation imposed on Poland to meet the carbon emission reduction requirements, as coupled with a limited potential to make use of renewable sources of energy, and low probability that CCS systems will be applied commercially, owing to high cost and technical difficulties involved, **the launch of nuclear power as part of the country's power mix appears to be completely legitimate economically as well as technologically. In the face of delivery of the greenhouse gas emission reduction targets assumed by Poland, NPPs is the lowest-cost option that ensures, moreover, the highest stability of supplies and costs among the technologies potentially applicable in the Polish realities.**[57]

Nevertheless, it has to be stated that unit cost of electricity generation, regardless of the method and/or correctness of the assumptions being made, can only to a limited extent be helpful in determining an optimal direction of investing in new sources of generation. Such cost is, namely, net of the comprehensive operating conditions of a power system, particularly, the structure of sources that would ensure an optimum-cost coverage of the 24-hour energy consumption curve. Neither does the cost in question include the systemic limitations ensuing from the fuel mix of the NEPS sources, the necessity to maintain the indispensable operating power reserve, or the need to ensure the development of renewables and cogeneration as set forth in the energy policy, etc. Therefore, in making the investment decision, the investor will have to carry out the relevant corporate analyses.

On making comparative analyses for individual energy generation technologies, in the context of implementation of the national energy policy, the issue of high third-party system expenses, especially on the grid level, ought to be taken into account. As per a recent NEA/OECD analysis[58], for renewable sources, characterised by variable power output, the system costs taken into account on the transmission grid level increase the total cost of energy supply by up to a third, depending on the country, technology, and degree of renewable sources' penetration.

[57] *Updated comparative analysis of the electricity generation costs for nuclear, coal-fired and gas-fired power stations and renewable sources of energy*, Agencja Rynku Energii S.A., Warszawa 2013.
[58] *Nuclear Energy and Renewables: System Effects In Low-carbon Electricity Systems*, NEA/OECD, 2012.

CHAPTER 5. ORGANISATION OF TASKS FOR IMPLEMENTATION OF THE POLISH NUCLEAR POWER PROGRAMME

5.1. ASSUMPTIONS BEHIND THE FUNCTIONING OF NUCLEAR POWER

The specificity of nuclear power, an element so far absent in Polish energy structure, calls, during its implementation stage and the first period of its functioning, for an individualised organisational and legislative approach, one that takes into consideration the strategic character of this sector for the country's economy, among other things. This specific status is based on, inter alia:

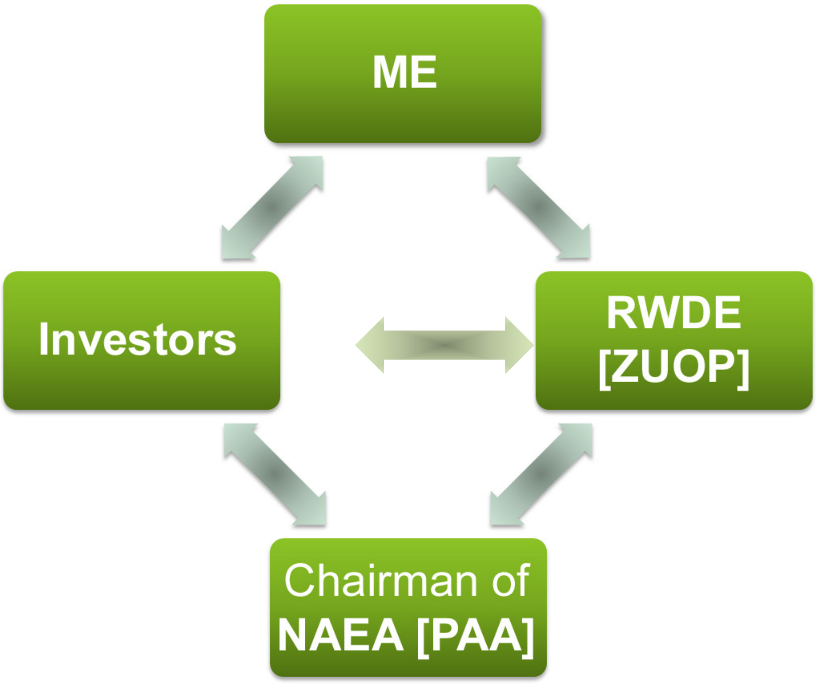
- the importance of nuclear power for the country's economic safety and self-sufficiency in energy;
- the State's share in ensuring nuclear safety and radiological protection (NSRP) across the country's territory and at all the stages, incl.: siting analyses and choice of the site, design, construction, operation, and decommissioning of NPF, manufacture of appliances, and the acquisition, use and storage of nuclear materials. This is achievable through provision of the indispensable efficient mechanisms to control, supervise, and enforce the obligations of the investor(s) and operator(s) of the NPP and other NPFs, who are responsible for ensuring NSRP in the first place;
- the State's subsidiary responsibility for any possible damages resulting from nuclear breakdowns or failures;
- social response to nuclear power and the necessity to win and maintain social acceptance for the use of nuclear energy for the country's social and economic purposes;
- the effects of the development of nuclear power on the national economy as a whole, and on the region where the project is situated – including the possibilities of stimulating the economic development and to develop science, academic institutions and knowledge operators, and transfers of new technologies;
- the particular importance attached to addressing, in a long time horizon, the management of radioactive waste and spent nuclear fuel and the decommissioning of NPPs once their operation has come to an end.

Implementation of the indispensable legal solutions and appointment or establishment of the relevant institutions, including national government bodies dedicated to nuclear power, ought not to limit the sector's competitive character to any larger extent than would be justifiable by the interest of the State and NSRP issues. Similarly to most national economy sectors, the nuclear power sector ought to function on a competitive basis, as this is the solution that ensures it high economic efficiency. In the long run, along with the country's increased nuclear safety, economic efficiency forms a substantial premise for any investment project in energy. With a competitive nuclear power sector, the role of the State is to develop an appropriate and stable legal environment that would enable the investors to construct NPPs and to operate them safely and effectively. This action also includes the establishment of competent institutions equipped with the necessary tools and human resources and capable of implementing the assumed legal solutions.

An element of essential importance is to determine the rules and the scale of participation of the NPP investor and, thereafter, operator, in creating the associated infrastructure, incurring the cost of construction of the spent nuclear fuel and radioactive waste storage facilities, and making payments due to the use of such installations. The NPP investor's involvement in such actions imposes on the State the obligation to create, in a longer run, stable conditions for conducting business operations.

5.2. MAJOR ENTITIES IN POLISH NUCLEAR POWER SECTOR

There are four main entities identifiable within the Polish nuclear power model:



1) **Minister in charge of economy:** The basic responsibility includes setting and coordinating the implementation of the nuclear power development strategy (the PNPP). Consistent with the State's power policy, the said strategy is subject to cyclical update and approval by the Council of Ministers. The PNPP projects will be elaborated by ME.
2) **Chairman of the National Atomic Energy Agency (NAEA** [PAA]**)** is the central, autonomous public administration body, acting as the **nuclear regulator**, which, assisted to this end by the Agency, exercises supervision in Poland, for the sake of NSRP, over the use of ionising radiation in the industry, medicine, and scientific research.[59] In the realm of nuclear power, the Chairman of NAEA fulfils the regulatory functions, in that he rations, oversees and controls the operation of NPP for safety and security.
3) **Radioactive Waste Disposal Enterprise (RWDE** [ZUOP]**)** is the institution devised to handle radioactive waste. A significant share of the costs related to management of radioactive waste produced by NPP, including spent nuclear fuel, will be covered by its operator.
4) **Nuclear power facility investors** and, once the operation of these facilities is commenced, **operators** have the experience and knowledge necessary for construction and operation of such facilities as well as the appropriate financial resources.

[59] Save for the uses of X-ray apparatuses in medical diagnostics, interventional radiology, surface radiotherapy and radiotherapy of neoplasmic afflictions, since oversight in these areas is exercised by Provincial Sanitary-Epidemiological Stations (or by the competent services reporting to the Minister of National Defence and Minister of the Interior).

Apart from these enumerated above, **Polish scientific units** (research institutes, scientific institutes of the Polish Academy of Sciences, and universities) will play an essential part.

No development of nuclear power will be enabled, nor will the creation and functioning of the aforesaid institutions become legitimate, unless the target regulatory solutions and the Government's involvement in the implementation of PNPP provide the conditions appropriate for creation of NPF investors. The solutions proposed by the State should take into account the NSRP requirements, the expectations with respect to improved power safety, competitiveness and development of economy, as well as business expectations of NPF investors, whilst restricting the risks for each of these areas, to the maximum extent possible.

5.2.1. MINISTER OF ECONOMY

The main responsibility of ME is to plan and coordinate the implementation of the State's strategy for development of nuclear power in Poland, mainly through:

- preparing plans and strategies for development and functioning of nuclear power in Poland;
- coordinating the implementation of the State's strategy in the development of nuclear power and preparing the assumptions for the strategy modifications or amendments;
- preparing and coordinating the implementation of the State's strategy with respect to the handling of radioactive waste and spent nuclear fuel, preparing the assumptions for the strategy modifications or amendments, including seeking the sites for storage of waste;
- preparing proposals for development of a legal system necessary for proper functioning of nuclear power in Poland;
- performing actions related to public information, education and popularisation, as well as scientific, technological and legal information in the field of nuclear power;
- supporting the completion of nuclear-power investment projects;
- actions aimed at providing competent human resources for nuclear power;
- cooperation with EU bodies, international organisations, lobbying organisations and European initiatives in the area of nuclear power;
- developing bilateral cooperation with other countries in various fields of nuclear power;
- supporting the contributions from Polish industry to the tasks done in favour of nuclear power, including through compilation of quality standards as required for inclusion of Polish enterprises in the chain of orders for (raw) materials and appliances for nuclear power – with the proviso of the regulatory requirements and observing the rules of competition and non-discrimination with respect to EU entrepreneurs;
- investigation of the market for uranium and nuclear fuel cycle services, and preparing recommendations in this respect;
- ensuring conditions for safe and efficient supplies of nuclear fuel, with assessment of the potential to use the uranium resources available within Poland;
- cooperation with Government administrative bodies and with subordinate or supervised institutes for scientific research in nuclear power, and supporting the contacts between Polish scientific and industrial units, on the one side, with the competent units of other countries and international organisations, on the other side, in the realm of nuclear power;

- creating conditions for development and use of nuclear technologies in industries, medicine, agriculture, and other areas;
- monitoring the nuclear power sector internationally and at home, incl. the nuclear technologies market.

The scope of tasks and responsibilities as specified above translates into a necessity to hire employees-in-charge, highly professional and with expertise – in the area of nuclear power as well as in the other fields – in order to ensure adequate standard of management and to deliver ME's organisational and managerial functions.

5.2.2. CHAIRMAN OF NATIONAL ATOMIC ENERGY AGENCY (NUCLEAR REGULATOR)

Being the central Government administration body in charge of NSRP, the NAEA Chairman acts as the **nuclear regulator**. The basic elements of the NSRP system (so-called regulatory infrastructure) include:

- the relevant legal system, consisting of laws and secondary legislation thereof, guidelines as well as technical and organisational recommendations;
- the appropriate supervisory office, which grants the entitlements (permits) for conduct of specified activities or operations, oversees and controls these activities/operations, acting pursuant to the binding legal regulations and within the limits set forth by the same;
- provision of sufficient technical resources/facilities and well-trained human resources in adequate numbers.

The regulatory body has to have the appropriate authorisations, rights and competencies in order to efficiently exercise its regulatory and supervisory functions, and has to be independent of the other governmental bodies responsible for promotion and development of activities subject to regulation or oversight. Similarly, the regulatory body must be independent from the users, permit holders, and designers and constructors of radiation sources employed in various types of professional activity. The regulatory body's scope of responsibilities has to be clearly separated from that of any other institution, so that representatives of this institution, which is the authority in the matters of safety and security, could remain independent in their judgements and decisions.

The activities of the NAEA Chairman are regulated by the Polish Atomic Law and its secondary legislation. The Chairman's responsibilities are moreover laid down by several other Acts or Laws.

As from 1st January 2002, NAEA Chairman has been overseen by the minister in charge of environment.

The relevant elements of the NSRP system, as delivered by the NAEA Chairman, include:

- Oversight of activities using nuclear materials and sources of ionising radiation, exercised through: granting permits for performance of such activities or for recording thereof; inspection of the conduct of such activity; control of the doses received by employees; supervising the training of nuclear regulatory inspectors, radiological protection inspectors (experts in NSRP functioning with units pursuing their operations based on permits granted), and of employees professionally exposed to ionising radiation; control of the trading in radioactive material; keeping the records of radioactive sources and their users, and central records of individual doses; for activities using nuclear materials: moreover, keeping detailed records and accounting of such materials, approving plans for their physical protection, and inspecting the technologies employed.

- Recognition of the country's radiation situation, through coordinating (and standardising) the work of field stations and posts measuring the radiation doses, content of radionuclides in selected elements of the natural environment and potable water, foodstuffs and fodders.

- Maintenance of a service prepared for recognising the country's radiation situation and responding in the event of radiation incidents: an informative and consulting role, with provision of expert support to authorities responsible for managing the action to eliminate the hazards and remove the effects of the incidents, and collaboration with other competent authorities and services operating within the national crisis response system.

- Performance of works aiming at fulfilment of Poland's obligations under the international treaties, conventions and agreements regarding NSRP.

With respect to nuclear facilities (including NPP) and radioactive waste storage facilities, the Chairman of NAEA grants permits, with respect to NSRP, for:

- construction,
- commissioning,
- operation, and
- decommissioning

of such storage facilities.

5.2.3. RADIOACTIVE WASTE DISPOSAL ENTERPRISE (RWDE)

RWDE is responsible for safe and rational management of radioactive waste, including any waste generated by nuclear power. RWDE will continue to operate the existing radioactive waste storage facility and is responsible for construction of a new storage facility for low- and medium-level radioactive waste and spent nuclear fuel. As from 1st January 2012, the competence for exercise of owner supervision of RWDE has been transferred from the Minister in charge of the State Treasury to the Minister in charge of economy. The financial responsibility for the management of waste produced by nuclear power will be placed on the NPF operator, who is obligated to collect the funds and finance the activities in this particular respect.

5.2.4. NUCLEAR POWER FACILITY INVESTORS/OPERATORS

Nuclear power facility investors and, once the operation of these facilities is commenced, operators will be entities having sufficient financial resources, suitably qualified human resources as well as the experience and knowledge indispensable for construction and operation of such facilities, and having a credible and reliable NPF design to offer.

NPF investors/operators will be charged with several responsibilities; in particular:

- ensure the safety of the nuclear facility;

- collect funds for preparation of storage of radioactive waste and spent nuclear fuel, and the storage thereof;

- collect funds for decommissioning of NPF;

- decommission the NPF after its operation has come to an end;
- satisfy the requirements with respect to civil responsibility for nuclear damages, under the Polish Atomic Law;
- prepare and periodically verify the emergency plans and procedures; prepare the company services for responding in case of emergency incident.

The construction design of the first NPP is unique, owing to the pioneering character of such investment project in Poland and the necessity to prepare the entire environment for the construction, commissioning, operation and, thereafter, decommissioning of the nuclear facilities, indispensable for efficient functioning of the nuclear sector in Poland. Thence, a series of additional tasks have been envisioned for the Government and the investor of the first NPP, along with certain arrangements with respect to their mutual relations.

The development of the regulatory, organisational, educational, research and other infrastructure will call for considerable financial outlays to be made. It is assumed, under the proposed model of Polish nuclear power, that the outlays will be incurred by the investor of the first NPPs on a shared basis with the public institutions. Due to this reason and in view of the strategic significance of nuclear power for the security of the State, it has been envisioned that the investor for the first NPPs, of the installed capacity of up to approx. 6,000 MW, will be a company with direct or indirect majority share of the State Treasury. This means that PGE Polska Grupa Energetyczna S.A. (PGE), Poland's largest power group, will be assigned as the project organiser for construction of the first NPPs in Poland. The operator's actions in the first NPPs will be conducted by a PGE subsidiary (or, PGE subsidiaries).

The NPP vendors and contractors will be selected in compliance with the competitiveness and transparency rules, in line with the relevant European and national standards, as well as with the clearly formulated requirements with respect to ensured supplies of appliances conformant to the NSRP requirements. To satisfy the latter requirement, the boundary requirement would be that only those vendors be invited for the bargaining who have the modern generation III/III+ nuclear technology on offer, and whose installations comply with the requirements set forth by the **European Utilities Requirements (EUR)** and the U.S.'s **Utility Requirements Document (URD).** Throughout the procedure for selection of the suppliers, from the preparation of the key requirements posed to the suppliers to the moment the selection is made, permanent cooperation between the Government administration representatives and the investor will be indispensable.

A token of confirmation that the investor has met the requirements described above and that the appropriate business model has been prepared and the adequate financial conditions chosen, will be the receipt by the investor of the crucial decision whereby the Government accepts the construction of a NPP in a defined ting, by the specified investor, with use of the specified technologies.

Throughout the operations of the NPP, the operator will be obligated to permanently collaborate with NAEA in view of ensuring complete safety of the installations and systems. Although NAEA is to oversee the operation of the power plant, the domestic and international regulations make the operator accountable for the plant's safety and security, in terms of absolute responsibility for damages resultant from possible accidents.

Once the operation of the NPP is completed, the operator will be obligated to obtain a permit for de commissioning of the facility and to carry out the exercise in line with the ensuing NAEA requirements.

Throughout the preparation for the construction and, subsequently, the construction, operation, and decommissioning of NPP, the investor/operator will be obliged to carry out informative and educational actions targeted at the local community inhabiting the commune within which the NPFs are located as well as the adjacent communes.

The investor is obligated to plan the actions to ensure adequate human resources for the purposes of operation of the NPP.

5.3. PARTICIPATION OF STATE AUTHORITIES AND BODIES

As recommended by the IAEA, the State administration's responsibility in the management of nuclear power development projects should be entrusted to an organisational unit established for this very purpose, called the Nuclear Energy Program Implementing Organisation (NEPIO). At the present-day stage of preparations for implementation of nuclear power in Poland, this part is played by the Government Plenipotentiary for Polish Nuclear Power, together with ME's Nuclear Energy Department. The Plenipotentiary's activities are supported by the actions taken by the interdepartmental Task Force for Polish Nuclear Power and by members of the Social Advisory Team affiliated to the Plenipotentiary's office.

The nuclear power development tasks will be delivered by:

- ME (Government Plenipotentiary for Polish Nuclear Power, Nuclear Energy Department);
- Chairman of NAEA;
- Chairman of the Energy Regulatory Authority [URE];
- Technical Supervision Office [UDT] and other Polish inspection/control institutions;
- environmental protection and industrial development institutions;
- institutions responsible for safety/security, physical protection and emergency planning, radiological emergency response system and radiation monitoring system;
- local Province Governor (Voivode);
- transportation infrastructure administrators.

The implementation of PNPP will moreover call for participation of a number of other Polish offices, such as: the Ministry of the Environment, the Ministry of Finance, the Ministry of Science and Higher Education, the Ministry of National Education. the Ministry of Interior, the Ministry of National Defence, the Ministry of Health, the Ministry of the State Treasury, the Ministry of Foreign Affairs, the Ministry of Infrastructure and Development, the Ministry of Labour and Social Policy, the Ministry of Administration and Digitalisation, the Internal Security Agency, the Intelligence Agency, the Government Centre for Security, the State Labour Inspectorate, the General Office of Building Control, and the Chief Sanitary Inspector.

All the institutions performing inspections and oversight in the investment process for NPPs in Poland will have to get prepared for inspecting or controlling these facilities. This implies the necessity to consider the appropriate funds within their budgets in view of hiring new experts in nuclear power or training and granting certificates to these institutions' existing personnel.

Consequently, the expenditure for PNPP-related tasks will have to be taken into account by the aforesaid offices and other organisations, within the appropriate sections of the Budget Act or these institutions' own financial schedules.

The responsibilities of ME and NAEA, the two major institutions as regards the implementation of PNPP, have been described above.[60] The roles of the other institutions are as follows:

Table 5.1. Institutional responsibilities in PNPP (excl. ME and NAEA).

Institution	The role it plays in PNPP
Chairman of URE	As with the other electricity and heat producers, the NPP operator will be obliged to obtain a licence for generation of electricity (and, possibly, thermal energy), issued by URE Chairman, under the Polish Energy Law.
UDT and other Polish inspection institutions	Perform technical supervision tasks, in their entirety, save for NSRP.
Province Governor (Voivode) administering the project siting area	The Voivode is competent for the following responsibilities: establishing perpetual usufruct of land and transfer of ownership of the buildings, other facilities or premises situated therein to the investor; issuing the decision permitting the preparatory works; issuing the building permit; requesting GDEP to reconcile the environmental conditions, together with a renewed environmental impact report; conducting public consultation for renewed environmental impact assessment. The local Voivode will issue a decision determining the NPP site , which will settle the final ting of the NPP.
Government administration	Directly or indirectly involved in the implementation of PNPP, in line with the competencies of the authorities or bodies concerned.
Polskie Sieci Elektroenergetyczne S.A.	Acts as the operator of the power transmission system.
Transport infrastructure administrators (esp., PKP Polskie Linie Kolejowe S.A.)	Provides the necessary transportation infrastructure to serve the construction project and the functioning of NPP.

5.4. LEGAL ENVIRONMENT

5.4.1. THE LEGAL FOUNDATION FOR PNPP

The Minister of Economy is obligated to develop a polish nuclear power programme under Article **108a, item 1 of the Polish Atomic Law**.

Implementation of nuclear power has also been envisaged in a series of Government documents:

1) **Resolution of the Council of Ministers no. 4/2009 of 13th January 2009 on the actions taken for development of nuclear power**: The Council of Ministers has thereby deemed it necessary that an NPPP be compiled and implemented. A Government Plenipotentiary for Polish Nuclear Power would be appointed as tasked with preparing a draft PNPP

[60] See Chapter 5 – *Design of tasks for implementation of the Polish Nuclear Power Programme*, pp. 68-70.

determining, in particular, the number, size, and potential sites for NPPs in Poland. The Resolution has moreover obliged the Minister in charge of the State Treasury to ensure cooperation with PGE Polska Grupa Energetyczna S.A. in the compilation of PNPP and to ensure this enterprise's leading role in the implementation thereof.

2) **Resolution of the Council of Ministers no. 202/2009 of 10th November 2009 on Poland's energy policy until 2030:** By means of this Resolution, *Energy Policy of Poland Until 2030*, the major strategic document in the area of energy production, has been adopted. Among the policy's crucial objectives is diversification of the generation structure in electrical power, including the launch of nuclear power. The implementation of nuclear power is to be detailed by this present PNPP.

3) **Ordinance of the Council of Ministers of 15th May 2009 on the appointment of Government Plenipotentiary for Polish Nuclear Power**: Appointment of the Government Plenipotentiary entrusted with preparation of an PNPP and submittal of the same to the Council of Ministers.

5.4.2. PROMOTING NUCLEAR POWER

The authority responsible for promotion and development of nuclear power in Poland is the Minister in charge of economy, whose role in this respect is determined by the legislative acts. As per the Government Administration Procedures Act[61], the Minister in charge of economy is responsible for use of nuclear energy, in its entirety, for the country's social and economic purposes. The responsibility of the Minister in charge of economy for the development of nuclear power, including preparation of strategy projects and coordination of their implementation, is set forth by the Polish Atomic Law. The Minister may perform these tasks via the Plenipotentiary, whose rank is that of Under Secretary of State in the ME.

Since it is necessary to create a legal framework enabling efficient completion of the investment project, a particular Law has been prepared and adopted for the investment and construction process. specifically, the Act of 29th June 2011 'on the preparation and Implementation of investments in nuclear power facilities and associated investments' has provided for a special, privileged investment path for NPP construction designs and projects.

5.4.3. NUCLEAR SAFETY AND RADIOLOGICAL PROTECTION

The nuclear safety/security system (extending to radiological protection, physical protection of nuclear facilities and materials, and preventing the proliferation of nuclear material) is anchored in the Polish Atomic Law and the secondary legislation adopted pursuant thereto. The Polish legislative system heavily builds upon the legal output of the international community. As it stands today, the Atomic Law has been shaped by the instruments of international and supranational law. Poland has ratified and implemented all the international agreements indispensable for ensuring the legal framework for use of nuclear energy; as member of EURATOM, Poland has also incorporated the European *acquis* in this respect. Alongside the treaties and conventions, Community directives and regulations, applicable within the Polish law are also certain unbinding provisions of numerous instruments – the so-called soft law – of which IAEA's Safety Standards recommendations are the major ones. The safety/security system is described in detail in Chapter 6 – Ensured conditions for safe use of nuclear power.

[61] I.e. JL 2013, item743, as amended.

5.5. INTEGRATED NUCLEAR INFRASTRUCTURE REVIEW (INIR)

Poland has submitted itself to a review exercise within the INIR mission executed by IAEA in the countries implementing nuclear power. There have been two INIR missions to Poland, including a preparatory mission carried out in April 2010 and the core mission in March 2013; the latter has confirmed that Poland is appropriately prepared for further actions to implement and develop nuclear power.

A total of nineteen PNPP areas have been subject to incisive analysis, including, for example, the regulatory framework, development of the human resources and research facilities, industrial involvement, and public procurement process. The key entities engaged in the delivery of PNPP: ME, the Ministry of the Environment, GDEP, the Internal Security Agency, the Nuclear regulatory authority, the Government Centre for Security, UDT, RWDE as well as the enterprises: Polskie Sieci Elektroenergetyczne S.A., PGE Energia Jądrowa S.A., and PGE EJ1 Sp. z o.o. – the investor of Poland's first NPP, have all lent themselves to the mission's evaluation.

Poland has been appreciated by the mission due to e.g. high cooperation standards as part of public consultation on the local, national, and international level, and in recognition of modern legal regulations having been implemented. IAEA has positively assessed the country's preparation for implementation of PNPP, in whole.

A final version of the mission's report is due to be published on the official websites of both IAEA and ME.

CHAPTER 6. ENSURING THE CONDITIONS FOR THE SAFE USE OF NUCLEAR POWER

6.1. COOPERATION FOR THE SAFE USE OF NUCLEAR POWER

The top priority of PNPP is to ensure NSRP with respect to the public and the NPF personnel, including physical protection of any nuclear facilities. Thiscalls for cooperation between all the stakeholders, including, in the first place: the Government Plenipotentiary for Polish Nuclear Power, NAEA –i.e the nuclear regulator, the investor(s) of the future NPFs, their operator(s), and suppliers of nuclear technologies. The cooperation will extend to all the issues related to provision of adequate standards of nuclear safety andsecurity of NPFs and nuclear materials.

Among the major elements of PNPP, with a bearing on the future safety/security level, are the legal regulations concerning NSRP requirements as set forth in the amended Polish Atomic Law and its secondary legislation, along with the existing and planned institutional infrastructure:

- IAEA, together with nuclear regulatory inspectors and all the control institutions involved in the oversight of the design, construction, commissioning, operation, and decommissioning of NPPs;
- ME (Minister in charge of economy, Government Plenipotentiary for Polish Nuclear Power, Nuclear Energy Department);
- RWDE.

6.2. NUCLEAR FACILITIES IN POLAND

There are the following nuclear facilities functioning at present in Poland:

1) Research reactor 'MARIA', with a technological pool, located at the NCBJ, Otwock-Świerk (near Warsaw);
2) Research reactor 'EWA' (decommissioned), located at the RWDE, Otwock-Świerk;
3) Two spent fuel storage installations, located at the RWDE, Otwock-Świerk.

As far as NSRP is concerned, the nuclear facilities are supervised by the NAEA, in terms of nuclear regulation and inspection functions. These functions include, inter alia, issuance of commissioning permits, once the previous ones have expired, or annexes amending such permits, based on safety/security evaluations made by nuclear regulatory inspectors, such evaluations being made on the basis of review and analysis of the documentation submitted by managers of organisational units operating the nuclear facilities, as well as on the basis of inspections/controls carried out. Such controls or inspections are made for compliance of the pursued operations with the safety and security report and the requirements laid down by the regulations and the terms-and-conditions specified by the permits. The nuclear regulator analyses the reports submitted by managers of organisational units operating the nuclear facilities and verifies these reports in the course of controls carried out at the nuclear facilities as well as through direct contacts between nuclear regulatory inspectors and the operating personnel.

There has been no isotopic enrichment facility, nuclear fuel manufacturing facility, nuclear fuel processing facility, or nuclear power plant in Poland to date. Pursuant to a resolution of the Council of Ministers, construction of an NPP was commenced in the 1980s in Żarnowiec, in the north of Poland. Eventually, the 'Żarnowiec Power Plant Under Construction' was put into liquidation in December 1990.

Owing to NPPs being operated not far from the borders of this country, collaboration with nuclear regulatory authorities of the adjacent countries, which is based upon intergovernmental agreements on early notification of nuclear accidents and NSRP cooperation, is of high importance. NAEA has entered into such agreements with all the countries neighbouring on the Republic of Poland and, moreover, with Austria, Denmark and Norway. In their evaluation of potential radiological emergencies, the parties to these agreements make use of the uniform criteria set forth by the International Nuclear Event Scale (INES).

Initiating the development of a nuclear energy programme, Poland is becoming an important partner to the global nuclear safety and security system. The status of this country as a reliable partner in the system enables it to benefit from participation in the relevant international cooperation programme, part of which is common effort for implementation of programmes in line with IAEA's basic safety principles and other IAEA safety guides (or their counterparts: U.S. or French standards).

6.3. DEVELOPMENT AND MAJOR ELEMENTS OF THE POLISH NUCLEAR SAFETY SYSTEM

Nuclear safety and security of nuclear facilities has been regulated by the Polish Atomic Law of 29th November 2000, in particular, by Section 4 – 'Nuclear facilities')Arts. 34 to 39k) thereof.

The Polish Atomic Law and the secondary legislation thereto have worded the fundamental regulations for the requirements of:

1. Radiological protection (extending to workers, the public, and patients).
2. Nuclear and radiation safety, including:
   - safety and security of nuclear facilities;
   - handling of nuclear materials and ionising radiation sources;
   - safety of radioactive waste and spent nuclear fuel;
   - safety of transport of radioactive materials and sources, spent nuclear fuel and radioactive waste;
   - assessment of radiation situation and emergency response.
3. Physical protection (extending to nuclear facilities and nuclear materials).
4. Non-proliferation of nuclear materials and technologies (safeguards).
5. Civil responsibility for nuclear damages.

The Republic of Poland is a party to the EURATOM Treaty. On the basis of this treaty several directives have been adopted and subsequently implemented in the Polish legal system.

Of particular importance for the safety of the activities involving the application of ionising radiation, and for the nuclear safety of nuclear facilities, is Council Directive 96/29/EURATOM[62], setting, inter alia, dose limits for organisational units pursuing activities implying exposure to ionising radiation, and for general public, the rules assuring that radiation exposure will be as low as reasonably achievable and providing for protection of the public against ionising radiation.

Under the Polish Atomic Law, the units within the area of which nuclear material, radioactive sources and appliances comprising the same, radioactive waste or spent nuclear fuel, may be located are liable to regulatory control and inspection – even if such a unit performs no action involving any of these, which would otherwise have required a permit or notification (Polish Atomic Law, Article 70a).

All the provisions concerning NSRP are contained in the Polish Atomic Law. In order to ensure efficient functioning of an independent, modern and professional nuclear and radiological regulator as a public trust organisation, it is indispensable that NAEA be prepared for acting as such authority for nuclear power.

Two IAEA missions have been invited to Poland on initiative of the Government Plenipotentiary for Polish Nuclear Power, in order to evaluate the preparation status and the courses of action taken in view of development of nuclear power in this country.

The purpose of the Integrated Regulatory Review Service (IRRS) mission is to evaluate the activities of the nuclear regulatory authority and to review the regulatory aspects concerning nuclear security and safety of facilities in operation (research reactors, waste storage facility) and to be constructed (NPP, spent fuel storage facility at the NPP site, radioactive waste storage facility). This exercise directly concerns NAEA. A group of IAEA experts preparing the mission visited Poland in November/December 2009; the review took place in April 2013. In the result of the IRRS mission, IAEA experts have checked, among other things, NAEA's preparation for implementation and development of nuclear power in Poland. The report compiled following the mission has indicated the institutions' activity areas that have been assessed positively and proposed a series of conclusions to be implemented by NAEA in order to ensure complete preparation for the delivery of the tasks related to development of the nuclear power programme.

The other IAEA/INIR mission is discussed in section 5.5.

Also, a concept of NAEA's functioning has been prepared, with NAEA being a nuclear regulatory authority, the needs of nuclear power being taken into account. The concept defines the indispensable legislative, organisational and functional changes, with a schedule determined to bring about these changes, and the persons responsible. Through the launch of a new nuclear-oriented organisational structure, the concept in question was implemented in autumn 2011.

6.4. AMENDMENT TO THE POLISH ATOMIC LAW

An amendment to the Polish Atomic Law, in force as from 1st July 2011, has altered and significantly extended the provisions regulating the matters relevant to nuclear facilities. It determines the basic NSRP requirements on siting, design, operation, and decommissioning of nuclear facilities, with the more detailed regulations being laid down in the secondary legislation. The Republic of Poland has

[62] Council Directive 96/29/EURATOM of 13 May 1996 laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionising radiation (i.e. OJ EC L 159/1, 29.06.1996, p. 291.

thereby met its obligation to determine the national legal framework for the national nuclear safety and security requirements for nuclear facilities (i.e. Article 4.1(a) of the Council Directive 2009/71/Euratom).

The amended Law also determines the issues of civil responsibility for nuclear damage, the procedure of preparation and updating the state’s strategy in the field of nuclear power, as well as the obligations of nuclear facility operators to raise public awareness on the operation of such facilities.

The safety priority rule

The amendment has been based on the principle of safety priority with respect to the operation of nuclear facility, ensuing from Article 6.4 and Article 5.3 of Council Directive 2009/71/Euratom).

The Polish Atomic Law has introduced the rule whereby the provision of NSRP, physical protection and nuclear safeguards is responsibility of the manager of the organisational unit permitted to perform activities involving radiation exposure and consisting in construction, commissioning, operation, or decommissioning of nuclear facility. This responsibility persists even though the permit for performing exposure-involving activities might have been withdrawn or expired, until the approval by the Chairman of NAEA a nuclear facility decommissioning report.

These regulations are found to be completely justified by the IAEA provisions: the *IAEA Safety Standards. Licensing Process for Nuclear Installations (Specific Safety Guide No. SSG-12)* states that the main responsibility for overall safety rests with the person or organisation responsible for the facility and activities causing radiological hazards, whereas observance of the rules and requirements imposed by the regulatory office does not release such person/organisation responsible for the facility and nuclear activity from the basic responsibility for the safety (cf. 2.17).

Regardless of the obligations of the organisational unit manager participating in the construction of nuclear facility, the requirements to be fulfilled by the other investment process participants have been extended by inclusion of the obligation to meet the requirements of nuclear safeguards, alongside the fulfilment of the NSRP and physical protection requirements.

Moreover, the amended Article 35, item 4 of the Polish Atomic Law has extended the provisions previously comprised in Article 35, item 3 thereof, by wording the principle that in the siting, design, construction, commissioning, and operation of nuclear facility – including its overhaul and upgrade– as well as in its decommissioning, such technical and organisational solutions should be applied as are indispensable for reducing the number of workers and the general public exposed to ionising radiation across the stages of functioning of the nuclear facility, the ionising radiation doses received by them being as low as possible, with the economic and social factors reasonably taken into consideration.

Awareness raising actions

Pursuant to Article 8 of Directive 2009/71/EURATOM, the Republic of Poland ought to ensure that the information regarding the regulation of nuclear safety, including the expertise of the nuclear regulatory authority, be made publicly available to the workers and the general public. Therefore, the principle was set in the Polish Atomic Law whereby everybody has the right to obtain, from the manager of the organisational unit performing the activities consisting in commissioning, operation or decommissioning of the nuclear facility, written information on the condition of the facility’s (installation’s) NSRP, influence on the health of humans and on the environment, and on the volume and isotopic composition of releases of radioactive substances from the nuclear facility into the environment. The organisational unit manager ought to post such information on the unit's official website every 12 months, at least. Moreover, the manager should forthwith notify the Chairman of NAEA, the local authorities of the commune within whose area the nuclear facility is situated, as well as those of the adjacent communes, of any unscheduled incidents occurring at the nuclear facility (installation), which may cause or have caused the occurrence of a threat, and post information on the unit's official website on any unscheduled threat-causing incidents having occurred at the nuclear facility (installation) within the last twelve (12) months. The manager of such unit should also notify the NAEA Chairman in any such case.

The obligation has been imposed on the NAEA Chairman to render available – in line with the rules defined in the regulations on disclosure of information on the environment and its protection, participation of the public in environmental protection and on environmental impact assessments – the information on the RSRP condition of the nuclear facilities/installations, their influence on the human health and the environment, and on the volume and isotopic composition of releases of radioactive substances from the nuclear facilities into the environment, as well as the information on the permits issued for such facilities, supervisory decisions made with respect to the same, and the results of annual evaluation of the safety and security of the nuclear facilities/installations. No information concerning physical protection, nuclear safeguards, and no proprietary information forming business or enterprise secrecy, within the meaning of the counteracting unfair competition regulations, is subject to disclosure whatsoever.

With the receipt of a request for permit for activities involving exposure to ionising radiation, consisting in construction of a nuclear facility (installation), the Chairman of NAEA is obligated to forthwith publish in the Public Information Bulletin (on the website of the NAEA Chairman as the publishing entity) the content of the request for such permit, together with an abridged safety report and the information concerning:

1) procedure initiated for issuance of a permit for construction of a nuclear facility;
2) the possibility to submit comments and requests;
3) the procedure and place for submitting comments and requests, remarking that they be submitted within twenty-one (21) days;
4) the date and place of the administrative hearing, open to the public, in case such hearing is due to be held.

The information referred to in items 1 to 4 is due to be published by the NAEA Chairman in the press whose circulation encompasses the commune being home to the site to which the request for permit pertains, as well as the adjacent communes.

The option has been admitted to propose comments and requests in writing, orally for the record, or with use of electronic communications, without the necessity to sign the same with a safe electronic signature.

The Chairman of NAEA is obligated to consider the comments and requests submitted. To this end, he may hold an administrative hearing, open to the public. As the grounds for the decision issued, irrespective of the requirements imposed by the Polish Code of Administrative Procedure, the Chairman will have to inform on the participation of the public in the procedure, and in what ways have the comments and requests submitted relative to the public participation been taken into account.

The obligation to ensure transparency in safety of nuclear facilities (installations) for the public, and public participation across the lifecycle of the nuclear facility, is raised by the *IAEA Safety Standards. Licensing Process for Nuclear Installations (Specific Safety Guide No. SSG-12)*. The document provides that the regulatory authority or holder of permit should ensure easy access to proper and comprehensive information regarding safety, the licensing procedure and the operations licensed. These pieces of information ought to be featured in an easily accessible place, such as the internet, mass media, and the like.

Siting

The Polish Atomic Law contains the principle whereby a nuclear facility is to be located in an area that allows for ensuring NSRP, physical protection while commissioning, operating, and decommissioning the facility (installation), and for execution of efficient emergency response procedure in the event that a radiological emergency occurs.

As per the Polish Atomic Law, the nuclear facility investor, who is to hold the permit in the later period, should by himself evaluate the area devised as a site of the nuclear facility, with use of the evaluation methods producing measurable results and well mapping the terrain's real conditions.

The outcome of the evaluation of the prospective site area, together with the results of the underlying investigation and measurements, should be compiled in the form of siting report whose detailed content is defined by the relevant resolution of the Council of Ministers.[63] The siting report is subject to assessment by NAEA Chairman as part of the procedure for issuance of a permit for construction of nuclear facility . One of the conditions for the Chairman to issue such permit is the obtaining by the applicant of a decision on the environmental conditions of approval of the investment project.

Adequate analysis of the site proposed for construction of a nuclear facility is of extreme importance for ensuring nuclear safety of the facility for the entire period of its functioning.

The nuclear facility investor is obligated to request the Chairman of NAEA for issuance of an anticipatory opinion regarding the planned site of the nuclear facility. The investor will attach a siting report to the request.

The adopted regulations on the assessment of the nuclear facility siting from the standpoint of NSRP are based upon IAEA's recommendations as laid down by item 3.3 and the subsequent items of the *IAEA Safety Standards. Licensing Process for Nuclear Installations (Specific Safety Guide No. SSG-12)*.

Design and construction

The Polish Atomic Law, as amended, determines the basic conditions to be met by nuclear facility design in terms of NSRP and safe functioning of the technical equipment installed at the nuclear facility.

The nuclear facility design should ensure NSRP and physical protection in the course of construction, commissioning, operation – including overhauls and upgrades, and decommissioning of the facility, as well as the possibility to deliver efficient response procedure in case a radiological emergency has

[63] Ordinance of the Council of Ministers of 10th August 2012 'on the detailed scope of assessment of area devised for the location of a nuclear installation', the cases excluding the possibility for such area to be deemed compliant with the nuclear installation location requirements, and on the requirements with respect to location report for nuclear installation (i.e. JL no. 1025).

occurred. Such design should take account of a sequence of safety levels ensuring prevention of deviations from the normal operational conditions, operational transients, design-basis accidents and beyond-design-basis severe accidents; or, if such deviations, transients or accidents cannot be prevented, controlling them and limiting radiological consequences of accidents.

The above-described requirement follows from so-called 'defence in depth' concept: the underlying principle is that no single safety system in a nuclear power station or plant can be trusted completely. What defence in depth ensures is backing up each safety system with the operation of other systems, so that in the event of a failure of one of the systems, there will be independent systems in place capable of fulfilling the necessary safety functions.

In the design and construction of nuclear facility under the amended Polish Atomic Law, no solutions or technologies can be applied that have not been tested in practice, in the course of construction of nuclear facilities or with use of adequate tests, investigations and analyses (Article 36b). The design of the nuclear facility should ensure its dependable, stable, easy to manage and safe operation, with special focus on the human factors and the factors related to cooperation between humans and the systems and technical equipment operated. Moreover, quite importantly – in line with the safety objectives for designing new-generation reactors, as set forth in the WENRA Declaration of 2010 and proposed by EC, as of 13th June 2013, for inclusion in the draft amended Directive 2009/71/EURATOM – in the amended version of the Polish Atomic Law (Article 36c, clause 2), there is the requirement to exclude core melting accidents that might lead to early or large releases of radioactive substances into the environment.

Before requesting the NAEA Chairman for issuing a permit for construction of a nuclear facility, the investor will carry out safety analyses and submit them for verification by a third party, which has not participated in the elaboration of the nuclear facility design. Based on the outcome of these analyses, a preliminary safety analysis report will be compiled, to be submitted to the NAEA Chairman together with the request for a NSRP permit for construction of a nuclear facility

In setting the exclusion area around the nuclear installation, the possibility of occurrence of a reactor accident without core-melt, will have to be taken into account. The amended Polish Atomic Law also contains regulations concerning detailed rules for developing an exclusion area around the nuclear installation.

The contractors and suppliers of the nuclear facility systems, structures and equipment elements, as well as contractors performing nuclear facility construction and producing equipment, should have the adequate quality assurance systems implemented for the work performed. The organisational unit performing the activities consisting in construction, commissioning, operation or decommissioning of a nuclear facility should provide the nuclear regulatory authorities with the possibility to inspect how these requirements have been satisfied, in particular through appropriate provisions of the agreements concluded with suppliers and contractors.

The amended Law has granted the NAEA Chairman the following supervisory measures with respect to the organisational unit performing the activities consisting in construction, commissioning, operation or decommissioning of a nuclear facility, inter alia:

1) ban on use of a specified system or nuclear facility structure and equipment element – in case an inspection has found that it might have an adverse bearing on the condition of NSRP of such facility ;

2) order to withhold certain work within the facility – in case an inspection has found that such work is carried out in a way that may have an adverse bearing on the condition of NSRP of such facility.

Controlling by the nuclear regulatory authority of the suppliers and contractors of nuclear facility construction and equipment elements of relevance to safety, and of the contractors of work performed in the construction and assembly of a nuclear facility is a substantial element of ensuring safety of such facility. The controlling activity of the nuclear regulator and his actions pursued for coordination with relevant State authorities, bodies and/or institutions, in order to satisfy the provision of Article 4, clause 1 of Directive 2009/71/EURATOM, are of particular relevance for a country that is commencing a nuclear power programme. Observance of adequately high quality standards will contribute to developing an infrastructure of nuclear safety culture.

Commissioning

As per the Polish Atomic Law, a nuclear facility is commissioned and operated in a manner that ensures NSRP with respect to workers and the general public, in line with the integrated management system implemented in the organisational unit. The detailed provisions specify the requirement to carry out the commissioning of nuclear facility (installation) in line with the nuclear facility commissioning programme; such document encompasses, in particular, a list of commissioning tests and the procedures of performing them for the nuclear facility construction and equipment elements.

The following regulatory powers of NAEA Chairman are connected with this particular stage:

1) issuance of a decision to withhold the commissioning (start-up) of the nuclear facility – in case that the results of the facility commissioning tests attest to a possibility that a threat has occurred or that the facility has proved noncompliant with the nuclear safety requirements. A decision of this kind can be issued by NAEA Chairman, based on analysis of the results of commissioning tests, the supply of which is obligation of the organisational unit's manager;
2) approval of a nuclear facility commissioning (start-up) report which specifies the commissioning outcome and is to be submitted by the date fixed in the nuclear facility commissioning permit. Such commissioning should be evidenced in the nuclear facility commissioning documentation.

Approval by the NAEA Chairman of the report on the commissioning of a nuclear facility is one of the conditions for granting the permit for operation of such facility .

The safety requirements for the stages of commissioning and operation of various types of nuclear facilities or installations are determined in the relevant ordinance of the Council of Ministers.[64]

The requirements regarding the nuclear facility commissioning stage have been based upon the basic safety levels as proposed by WENRA, and on the provisions of items 3.424 to 3.55 of the *IAEA Safety Standards. Licensing Process for Nuclear Installations (Specific Safety Guide No. SSG-12)*.

Operation

The Polish Atomic Law has introduced the obligation to keep operational documentation for nuclear facility and to keep the NAEA Chairman informed on the operating parameters of such facility, which

[64] Ordinance of the Council of Ministers of 11th February 2013 regarding the requirements with respect to commissioning and operation of nuclear installations (i.e. JL, item 281).

are of relevance in terms of safety, while the UDT is to be notified on an ongoing basis on the safety of functioning of the technical equipment installed and operated in the NPP. This is to enable ongoing monitoring of the nuclear facility NSRP as well as the safety of functioning of the technical equipment.

The Chairman of NAEA may order that the nuclear facility capacity be reduced or that such facility be closed down, in the event that further operation of such facility would pose a threat to NSRP. To reinstate the capacity of the nuclear facility or to bring it back to operation will in such a case require consent from the NAEA Chairman. Moreover, in the course of operation of a nuclear facility, any upgrade of the system or nuclear facility structure or equipment element of relevance to the nuclear safety, and any start-up of the reactor after an outage to reload nuclear fuel, or to upgrade a system or the nuclear facility structure or equipment element, is made upon written consent from the NAEA Chairman.

Any repair or upgrade of technical equipment covered by technical supervision regulations installed in NPPs requires to be agreed with UDT.

In the course of the operation of a nuclear facility, the operating organisational unit is under obligation to periodically evaluate the facility for safety, in terms of conformance to the operation permit, legal regulations, national and international standards of nuclear safety and of safe functioning of appliances, systems, structures and equipment elements forming part of the nuclear facility. Pursuant to such evaluation, the organisational unit manager will compile a report on the periodical safety evaluation, to be thereafter approved by the Chairman of NAEA. The detailed requirements regarding the periodical safety evaluation and the commissioning and operation of nuclear facilities have been determined in the relevant ordinances of the Council of Ministers.[65]

Decommissioning

Nuclear facility is decommissioned in a manner that ensures NSRP in regard of the workers and general public, in line with the related permit and integrated management system. In the course of decommissioning of such facility or installation, any action that might imply, in a future, any more serious consequences than as permitted today, should be avoided.

The programme of commissioning of a nuclear facility is to be submitted to the NAEA Chairman for approval, together with a request for permit for construction, commissioning, and operation of the facility – and, thereafter, in the course of operation, updated and submitted for approval at least every five (5) years, together with a forecast cost of the facility decommissioning. In the case that the operation of a nuclear facility has come to an end resulting from an extraordinary occurrence, the above action is effected immediately.

Once the decommissioning of a facility is completed, the organisational unit manager, holding a permit for such decommissioning, submits a report on the decommissioning of the nuclear facility to the NAEA Chairman for approval. The date the Chairman approves the report shall be formally regarded as the date as of which the nuclear facility in question has been decommissioned.

The legal framework for the nuclear safety of facility under decommissioning had to be developed because of Article 3.4 and Article 4.1 of the Council Directive 2009/71/Euratom and the IAEA

[65] Ordinance of the Council of Ministers of 11th February 2013 regarding the requirements with respect to commissioning and operation of nuclear installations (i.e. JL, item 281); Ordinance of the Council of Ministers of 27th December 2011 on periodical evaluation of the nuclear safety of nuclear installations (i.e. JL 2012, item 556).

guidelines as presented in *Decommissioning of Nuclear Power Plants and Research Reactors Safety Guide, IAEA Safety Standards Series No. WS-G-2.1*.

In view of coverage of the decommissioning cost, the organisational unit that has obtained a permit for operation of a nuclear power plant is under obligation to systematically credit the dedicated bank account referred to as the 'decommissioning fund'. The monies amassed in such a decommissioning fund can only be allocated for coverage of the costs of final handling of radioactive waste and spent nuclear fuel produced by the NPP as well as for coverage of the costs of decommissioning of the nuclear facility in question.

In order to enable the Chairman of NAEA to oversee the fulfilment by the organisational unit of its obligation to credit the decommissioning fund on a regular basis, the organisational unit's manager will submit to the NAEA Chairman quarterly reports on the amounts of payment made to the decommissioning fund and on the quantity of electricity generated within the correspondent period. In case the payment to the decommissioning fund has been delayed by at least eighteen (18) months, the Chairman of NAEA may order that the operation of the NPP concerned be suspended.

Physical protection

As per Article 41m, clause 1 of the Polish Atomic Law, as amended, the supervision of the physical protection of nuclear facilities is exercised by the Chairman of NAEA and the Head of the Internal Security Agency [ABW], each within their respective powers. The physical protection system is approved for the specified nuclear facility or installation by the Chairman of NAEA, based on a positive opinion received from the Head of the ABW. In parallel, Article 42s, clause 2 of the Polish Atomic Law proposes an optional power for the Council of Ministers to determine, by way of ordinance or decree, the requirements to be met by protection of buildings and appliances not being part of a nuclear facility, whose damage or disturbed operation might cause effects of relevance with respect to nuclear safety or security of the nuclear facility, as well as the need to ensure the appropriate standard of safety and security of such buildings and appliances.

The changes indicated above were justified by the necessity to reinforce the supervision of physical protection of nuclear facilities and of protection of facilities and appliances whose functioning is of substantial relevance to the functioning of nuclear facilities, in connection with the plans to build the first NPP in Poland and because of the need to satisfy the provisions of , the *International Convention for the Suppression of Acts of Nuclear Terrorism*, formally adopted by the General Assembly of the United Nations on 13th April 2005, and the *Convention on Physical Protection of Nuclear Material and Nuclear Facilities* adopted in 1979 (in force since 1987; amended in 2005).

Civil responsibility for nuclear damage

As per the amended Law, exclusive responsibility for nuclear damage caused by a nuclear accident within the nuclear appliance or connected with such appliance shall be borne by the operating person, unless the damage has occurred as an immediate result of warfare or armed conflict.

The Law also regulates the issues of nuclear damage caused in transport, defines the moment as of which the insurance obligation arises, and ordains that the responsibility limit for the operating person for nuclear damage is an amount equivalent to SDR 300 million, thereby harmonising the national solutions in this respect to the requirements implied by the *Protocol Amending the Vienna Convention on Civil Liability for Nuclear Damage* of 21st May 1963, which has been ratified by Poland.

Public information

Each investor is obligated to create a Local Information Centre (LIC) for, and affiliated to, every NPF that is a nuclear facility or installation, as of the date the investment project for construction of an NPF at the concerned site is determined, at the latest. The NPF investor and the NPF operator will be obligated to pursue the operations of such LIC until the decommissioning of the NPF concerned is completed.

LIC is an information point situated within the commune of venue for the NPF. The local nuclear power information, education and promotion strategy is pursued by the NPF investor and operator at the LIC.

The tasks of the NPF investor/operator running a LIC include:

1) publishing current information on the operation of the NPF;
2) publishing current data on the condition of NSRP around the NPF;
3) cooperation with the administrative bodies or authorities, state legal persons and other organisational units in pursuance of actions related to public information, education, popularisation, and scientific and technical information as well as legal information in the field of nuclear power and the NSRP of the NPF – pursuant to the Polish Atomic Law.

In order to ensure the relevant level of knowledge on the progress of the investment project and the ongoing operation of the NPF (which is, simultaneously, a nuclear facility), the local community has the right to establish a Local Information Committee (LIC) to act as a link between this community and the NPF investor/operator. The Committee's members include:

representatives of the local community's local government (one individual from each commune wherein the NFP or a part thereof is situated OEJ);

exponents of the local community (in any number).

The Council of the Commune in whose area the construction project is to be scheduled, and where an NPF being a nuclear facility is to be constructed or to function, may moreover establish a Communal Information Point (CIP) where it will deliver its communal nuclear power information, education and promotion strategy.

6.5. SUBSEQUENT AMENDMENTS TO THE POLISH ATOMIC LAW

The Polish Atomic Law, as it is worded at present, fully enables the implementation and delivery of the PNPP, whereas the subsequent amendments to this Law will expectedly ensue from the need to implement the new legal acts of the European Union and the new needs identified in the course of application of the Law in question and stemming from the changing realities, including those related to the development of nuclear power.

The most recent draft amendment to the Polish Atomic Law has been prepared in order to implement the Council Directive 2011/70/Euratom in the Polish national legislation.

The said Directive imposes upon the Member States the obligation to introduce national legal, regulatory, and organisational frameworks ensuring high level of safety of management of spent nuclear fuel and radioactive waste. Directive 2011/70/Euratom reinforces the principle whereby the final responsibility for spent nuclear fuel and radioactive waste is incurred by the Member State wherein they have been generated.

The basic instrument ensuring the delivery of the obligations stemming from the said principle is the national plan for management of spent nuclear fuel and radioactive waste, as compiled and implemented, on an obligatory basis, in each Member State. Safety of the actions specified by the Directive is moreover to be ensured by the appropriate regulatory authority which is to be completely independent of any other authority, body or entity acting in any fashion in the area of nuclear power, as a broad concept. Another obligation imposed by the Directive on the Member States is to provide trained staff and indispensable funds to the spent nuclear fuel and radioactive waste handling scheme being delivered.

As indicated by the Directive, the scheme in question is meant to ensure transposition of political decisions into specified regulations concerning timely implementation of all the stages of management of spent nuclear fuel and radioactive waste: from generation to durable storage.

In order that the Directive under discussion be implemented in the domestic legal framework, the amended Polish Atomic Law has proposed regulations for compilation and update of a *National plan for the management of radioactive waste and spent fuel*.

6.6. PROCEDURE IN CASE OF RADIOLOGICAL EMERGENCY

Safe use of nuclear power calls as well for a response system to be developed and made operational in extraordinary situations (emergencies). In the area of use of ionising radiation, such situations are referred to as radiological emergencies. A radiological emergency is an occurrence, within or outside the country, connected with a nuclear material, ionising radiation source, piece of radioactive waste, or other radioactive substance, causing or such that may cause a radiological threat, posing a chance that the limit values of ionising radiation doses as defined in the binding provisions may be exceeded, and thereby, calling for urgent action to be taken in order to protect the workers or the public.

Exposed to radiological emergency are, primarily, humans dealing with radiological sources on a professional basis: in NPFs (such as NPP, radioactive waste/spent nuclear fuel storage facilities), medicine, industry, agriculture and science; moreover, patients submitted to treatment or therapy with use of radiation, and, selected groups of the general public staying in areas adjacent to the location of the potential sources of radiological threat.

In the event of an emergency radiological situation, taking intervention action is envisioned, as detailed in the ordinance of the Council of Ministers.[66] With regard to the reach of the effects, three types of radiological emergency are specified:

1) causing threat to the organisation unit (power plant);
2) causing public threat whose reach is province-wide;

[66] Ordinance of the Council of Ministers of 18th January 2005 on contingency procedure plans in the event of radiological emergency (i.e. JL no. 20, item 169, as amended).

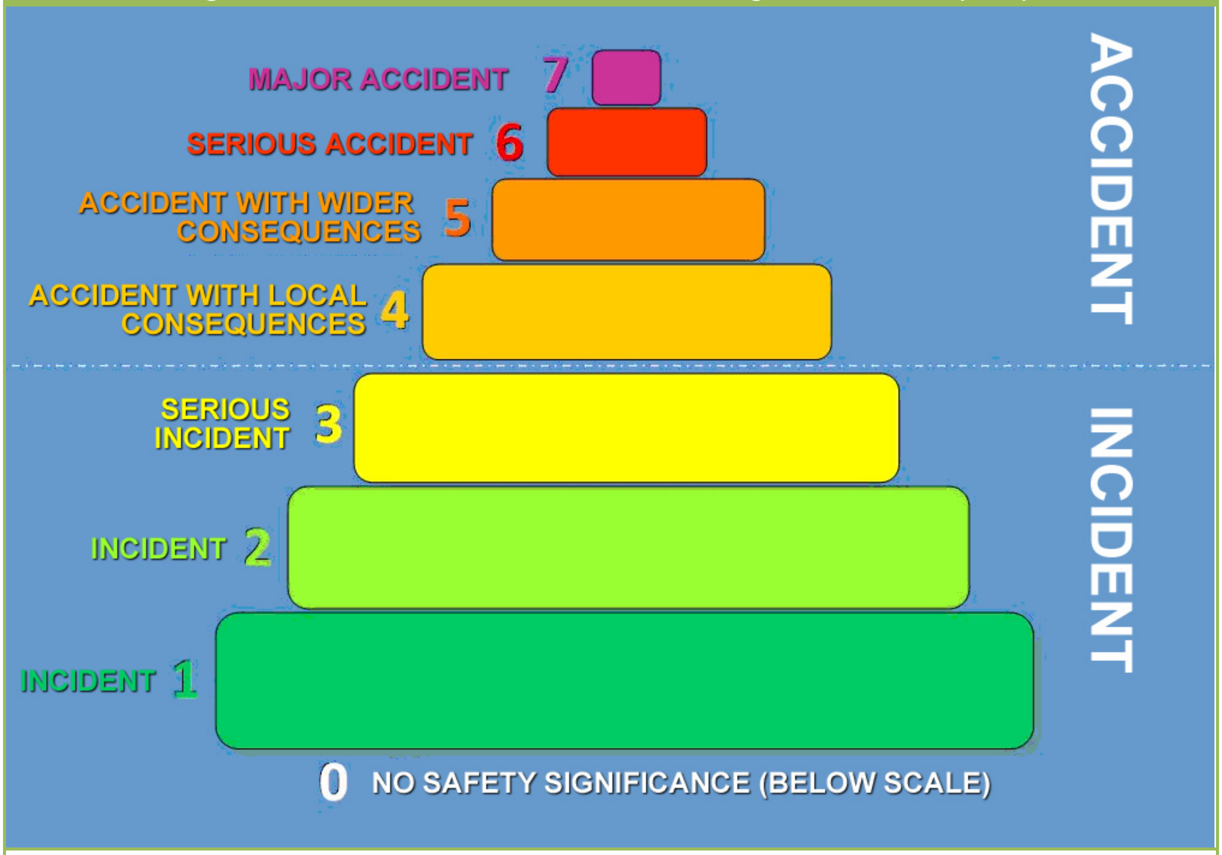
3) causing public threat whose reach is countrywide.

An instrument that is auxiliary in informing the public in a fast and substantively unambiguous manner about the threats caused by incidents in nuclear facilities or installations is the International Nuclear and Radiological Event Scale (INES). INES enables experts, mass media and the general public to correctly interpret the incidents. IAEA and its member countries, Poland included, commonly apply this particular scale in determining the categories of nuclear and radiological emergencies. INES was compiled by IAEA in the 1990s, initially used for describing incidents occurring at NPPs. The most recent (modified) version of INES also enables to describe the possible incidents occurring while transporting radioactive materials, as well as in respect of any other radiological emergencies.

The scale is in the range of 1 (anomaly) to 7 (severe accident). The zero level, set below the scale, denotes occurrences with no bearing on safety or security. The occurrences classed between level 1 and 3 are referred to as incidents, whereas those between 4 and 7, as accidents. The highest, seventh level denotes severe accident, whose consequences for human health and the environment would be far-reaching (Fig. 6.1). fFor instance, the Chernobyl NPP accident has been INES-classed 7.

Most nuclear and radiological emergencies are classed below the scale or on level 1; while accounting for an overwhelming majority of the occurrences, it is them that attract the attention of mass media and means of public communication.

Fig. 6.1. The International Nuclear and Radiological Event Scale (INES).



Source: National Atomic Energy Agency.

The intervention actions carried out in case of a radiological emergency are, respectively, based on the company, provincial, or national emergency plan. Regardless of the case, the obligation is incumbent on the operator to safeguard the place of incident and to forthwith notify the Chairman of NAEA. Conditional upon the reach of the effects of such an occurrence, the action to eliminate the threat and remove the effects is managed, respectively, by: the manager of the unit operating the facility, the Province Governor (Voivode) or the Minister in charge of the interior. The intervention actions to be possibly taken include: evacuation, instruction to stay in closed premises, application of a preparation with stable iodine, ban or restriction on consumption of foodstuffs and water by humans, and on feeding, watering and grazing animals; also, temporary or permanent displacement of people. It is also obligatory to keep the public informed on the potentially applicable means of health protection and the actions to be taken in case a radiological emergency has occurred. The authority running the action to eliminate the threat and remove the effects of the emergency may introduce, in certain special cases, a duty of performance, personal or in kind. In order to ensure the efficiency of a possible action, the manager of the facility operating unit, the province governors and the minister in charge of interior carry out periodical exercises in order to check the emergency plans.

The Chairman of NAEA fulfils his informative and consulting role in assessing the radiation doses and the contaminations, and any other expert evaluations and actions performed at the place of incident through the Centre for Radiation Emergencies – CEZAR, acting under his supervision. Moreover, the Chairman discloses to exposed communities information on radiological threats resulting from an incident, s well as to the international organizations and neighbouring countries. Such procedure is applied also in case illegal trafficking in radioactive substances is discovered (including illegal carriage thereof through the state border).

CEZAR offers a dosimetric crew that can perform on-the-spot measurements of the radioactive dose rates and contaminations, identify the contaminations and the abandoned radioactive substances, and remove the local contaminations (a local reach); and, subsequently, transport the safeguarded radioactive waste from the place of the incident to RWDE.

CEZAR's functions include: emergency service to the Chairman of NAEA; National Contact Point (NCP) for IAEA (Unified System for Information Exchange in Incidents and Emergencies, USIE), the European Commission, (European Community Urgent Radiological Information Exchange, ECURIE), the Council of Baltic States, NATO, and the countries related to Poland based on bilateral agreements, including that for notification and cooperation in case of radiological emergency – permanent 7/24 duty service. CEZAR evaluates the country's radiological situation on a regular basis, and is equipped with the indispensable IT tools (RODOS and ARGOS computerised decision-making support systems for forecasting the developments in the event of occurrence of a radiological emergency.

Similarly to the other countries making peaceful uses of nuclear energy incessant mastering of the systems enabling preparation for unique situations of any and all sorts is indispensable. This may be delivered through relevant legal regulations and construction of infrastructure, as well as through permanently perfected procedures, training of the key personnel, ongoing monitoring of the situation, and domestic and/or international exercises preparing for carrying out appropriate actions in case of radioactive emergency. Exercises in nuclear power are meant to check and incessantly improve contingency plans across the levels as defined in the Polish Atomic Law. The exercise scripts should take account of any and all plausible situations posing threat to the safety of nuclear facilities (installations), including terrorism, cyber-terrorism, 'conventional' and typical situations (fire, earthquake, flood, etc.). Reports from exercises of this kind should become the basis for improvement actions.

6.7. THE FUKUSHIMA ACCIDENT

In March 2011, the Fukushima I (Fukushima Dai-ichi) power plant, situated in Japan, on the shore of the Pacific Ocean, was affected by a nuclear accident.

The occurrence that initiated the events was an enormous earthquake whose magnitude was 9 on the Richter scale. While the earthquake did not cause much damage within the NPP itself, it did initiate a tsunami wave which flooded the poorly protected Fukushima I plant. As the transmission network was damaged by the earthquake, the plant safety systems were powered by standby diesel generators. The water broke into the engine room and flooded the unsecured spaces containing power generators, which led to a complete loss of standby power supply and disabled almost all the safety systems. The chain of events so initiated caused damage to the buildings of reactors nos. 1–4, with the resulting considerable release of radioactive substances. The authorities evacuated the population living within 20 kilometres of the NPP – and, subsequently, in some other, more distant areas.

Based on the information presently available, **nobody has suffered from the ionising radiation** resulting from the accident. Presently, the contaminated area is being decontaminated, the evacuated individuals receiving their indemnities. Some of those evacuated during the accident have already returned home.

Resulting from the accident, the Japanese authorities resolved to reform the national nuclear safety system and to set up a new, homogeneous and independent nuclear regulatory authority. A review of all the local power plants was ordained. In outage now, they are being prepared for progressive start-ups and inclusion in the Japanese power system, once the new authority has issued the relevant permits.

The Fukushima accident bears no immediate or direct consequence with respect to Poland whatsoever. In particular, there is no resulting need to amend or modify the strategic governmental documents. Fukushima I reactors are early second-generation reactors that have been in operation for some forty years. The regulations in force for Poland only enable this country to have modern reactors of generation III and III+ constructed, whose designs prevent the possibility of occurrence of an event analogous to the Fukushima accident. In particular, these designs ensure safety in the case of loss of standby power supply. Such NPPs are moreover equipped with a containment resistant to terrorist attacks and can withstand the impact of large airliner. Notwithstanding these considerations, Poland is not situated within a region exposed to tsunamis or earthquakes.

6.8. NUCLEAR SAFETY TASKS

6.8.1. NAEA TO ACT AS THE REGULATOR FOR NUCLEAR POWER IN POLAND

Among the major challenges for the government administration in terms of safety and security is to reinforce the nuclear regulatory and inspection function so that it can efficiently exercise oversight of safe functioning of nuclear power in Poland.

Due to potential threat to human health and life, the topmost values, independent status of nuclear regulatory authority is the foundation for an efficient nuclear power regulatory system. The need to provide such autonomy stems directly from the international regulations and secondary EU laws that are binding for Poland, along with IAEA recommendations. With no such autonomy in place, there would be no certainty that the safety assurance priority is the central criterion behind the regulatory decisions made. Nuclear regulator should be protected against unjustified interventions in the regulatory decision-making process, both from the entities performing the regulated activities, the public administration, as the one which promotes the applications of ionising radiation, and political factors. Being a public trust institution, the nuclear regulatory authority can pursue no activity which would promote the use of nuclear power. The independent status of the nuclear regulator should be ensured with use of the legal measures (statutory warranties) and factual measures (interpretation of the regulations, the attitude of the government administration and users of ionising radiation). Resulting from the recent legislative changes, legal warranties of the regulatory function's independence have been reinforced by, among other aspects, transferring the NSRP subsidies into the powers of the Minister in charge of economy, banning promotion of nuclear power, limiting the regulator's tasks to NSRP-related issues only, replacement of the Atomic Energy Council [*Rada do Spraw Atomistyki* (RdSA)] by an NSRP Council. With respect to off-legislative matters, it has been resolved that the obligation to pay contributions to international organisations whose activities are not related to NSRP is transferred to the responsibilities of other competent bodies or authorities. The obligatory principle of rotation in office for the Chairman of NAEA, with the possibility of his dismissal being limited to certain enumeratively defined circumstances, would further reinforce the regulatory autonomy, in compliance with the international requirements. Moreover, a change of the name of the authority in question as well as the office handling its operations should be considered. The NAEA [*Państwowa Agencja Atomistyki*] is, namely, not an executive agency, within the meaning of the Public Finance Act[67], but, instead, an office handling the Chairman of NAEA, being a central government administration authority. The NAEA Chairman is, furthermore, not responsible for the atomic energy issues in their entirety, including promotion of nuclear power, as the authority's existing name might suggest, but only for supervision of nuclear safety and radiological protection, physical protection of nuclear facilities, installations and materials, and safeguards of nuclear materials.

Another indispensable element of efficient nuclear regulatory function is access to adequate financial and human resources, so that the authority may appropriately perform its role. Also in this case, the obligation is incumbent on the State to ensure the nuclear regulator has a budget whose amount is correspondent with the scale and type of the responsibilities it performs and the adequate staffing resources (in both quantitative and qualitative terms). This is also true for financial potential of acquiring third-party expert support from specialist technical support organisations. Again, this obligation is rooted in the international and EU legal acts binding for Poland. Increased competencies of the nuclear regulator are inextricably interlinked with the necessity to develop staffing resources through gradual increase of the personnel and incessant improvement of the employees' skills. To educate competent staff takes time and money. Hence, it should be of priority not only to prepare but also to retain the experienced staff in the nuclear regulatory institution, which in particular means to prevent outflows of personnel to entrepreneurs operating NPPs or to other nuclear industry branches. To this end, the emoluments of the expert nuclear regulatory staff need being gradually increased, so that, as a target, following the pattern of other similar institutions in Europe

[67] The Public Finance Act of 29th August 2009 (i.e. JL 2013, item 885, as amended).

and elsewhere, the remunerations of regulatory institution personnel become comparable with the salaries offered by the nuclear industry.

The meeting by Poland of the obligations in this respect will not only contribute to adaptation of the nuclear regulator to appropriate exercise of supervision and control of fulfilment of safety and security requirements in nuclear power but also cause that the public opinion will perceive the regulator as a reliable and unbiased authority whose only purpose is to care for the safety and security of the citizens and the environment in the context of use of ionising radiation. Without public trust for the nuclear regulator as the guarantor of safety, gaining and sustaining public support for nuclear power in the long run would not be possible.

6.8.2. SUSTAINING NUCLEAR SAFETY EXCELLENCE

Safety is the priority in PNPP. The obligation to maintain high level of safety is the duty of all the stakeholders, which is particularly true for the investors/operators of nuclear power plants and other nuclear facilities with whom rests the primary safety assurance obligation. The responsibility of an NPP operator is to implement and demonstrate a **culture of safety at** every step of the way, that is, the philosophy of functioning of the organisations involved in taking advantage of nuclear power, as appropriate for the type of activities in question. Such culture stands for a set of group and individual values, competencies, daily behaviours, attitudes, features as well as good practices and procedures, causing that top priority is granted to safety of NPP, among all the aspects of its functioning. This concerns any and all areas of NPP operations, across the structural levels: from the management team to each individual worker, regardless of the post or position occupied. It should be obligatory for every person employed with an NPP to report on any doubt he or she may have with respect to the facility safety and to suggest any feasible improvements to the existing procedures and mechanisms of functioning of such facility, which would improve on its safety or security.

The State's core task in this respect is that the regulatory functions (regulation and control, supervision, and inspection of NPP activities) be efficiently fulfilled by an independent and competent regulatory institution, equipped with adequate financial and human resources. The other responsibility of the State is to continually improve the excellence of the nuclear safety and security system. The public institutions ought, in particular, to perfect the legal and regulatory system, on an ongoing basis, through proactively co-creating and implementing the international and EU safety/security standards that take into account the most recent scientific and technological achievements in this respect.

CHAPTER 7. PNPP IMPLEMENTATION COSTS AND SOURCES OF FUNDING

7.1. INFRASTRUCTURE PREPARATION AND PNPP IMPLEMENTATION COSTS

Implementation of nuclear power is a long-lasting process. it is necessary to prepare the infrastructure and to provide the investors with the conditions for construction and commissioning of power plants based on safe technologies, with the underlying social support and ensured high culture of nuclear safety/security across the stage, including: siting, design, construction, commissioning , operation, and decommissioning of NPP. This implies the need for the State Budget as well as the Investor to expend considerable funds.

Within the preparation for compilation of PNPP, ME has assessed the public spending on the development of nuclear power, taking into account the following actions:

1. **Prepare the necessary expert appraisals and surveys for the formation and operation of the legal framework determining the functioning of nuclear power.** The purpose is to prepare draft legal acts indispensable for enabling the construction and functioning of nuclear power facilities and the related infrastructure.

2. **Carry out the analyses related to implementation and updating of PNPP.** The purpose is to provide comparative information concerning the cost of energy generation in NPP as compared against the other generation sources, in view of evaluating the economic legitimacy of introduction and functioning of nuclear power and the indispensable contribution of nuclear power to the energy balance (energy mix); to evaluate the effects of the actions performed; to assess the potential actions for supporting the assumed objectives through provision of stable and foreseeable conditions for the construction and operation of NPPs.

3. **Implementation of the *Plan for the development of human resources for the needs of nuclear power.*** The purpose is to prepare the personnel/human resources for the Polish nuclear power sector, for the needs of PNPP preparation and delivery as well as operation of NPPs, including for the needs of the NPP investor/operator.

4. **Conduct informative and educational actions for nuclear power**. The purpose is to offer the public reliable and credible information on nuclear power and to improve public knowledge in this respect through educational action. This should increase the public acceptance for the development and functioning of nuclear power.

5. **Ensure the functioning of the nuclear regulatory authority and other services/institutions indispensable in implementation of nuclear power.** The purpose is to ensure the functioning of an independent, modern, and professional nuclear regulator function; as a public trust institution, the regulator will be able to meet the challenge implied by the development of nuclear power in Poland and the preparation of the services and public institutions, including inspection/control ones, for the development of nuclear power.

6. **Carry out location analyses for the NRWSF, including the waste storage facility design and construction and the implementation of National plan for the management of radioactive**

waste and spent nuclear fuel (NPMRWSNF). The purpose is to determine the location for a new storage facility for a new low- and medium-level radioactive waste, as the presently operated facility – the NRWSF in Różan – is nearing complete fill-up, to prepare a design for such facility and to construct it, to conduct preparatory work for the construction in Poland of a deep storage facility for spent nuclear fuel, and to introduce reasonable management of nuclear waste in this country.

7. **Provide a scientific and research infrastructure**. The purpose is to create and develop a powerful scientific-and-research infrastructure that will work to meet the needs of nuclear power, as is indispensable for Poland to make a multi-aspect and full use of the potential related to such infrastructure, once it is in place.
8. **Prepare the Polish industry for participation in PNPP.** The purpose is to ensure a maximised participation of Polish industries in supplies of equipment/appliances and services for nuclear power purposes, and of Polish enterprises, in the construction, operation, and decommissioning of NPPs in Poland.
9. **Seek for resources of uranium within Poland.** The purpose is to acquire information on the resources of uranium situated in the territory of Poland and the possibilities of their potential use.
10. **Incur the costs of participation in international organisations and research programmes.** The purpose is to gain experience and knowledge indispensable for implementation and functioning of nuclear power in Poland.

Calculation of the costs and expenses related to the launch of nuclear power in Poland has been made for the period 2014 to 2024. The estimate cost of implementation of PNPP as a long-term scheme using public funding is **PLN 48,843,000** (incl. PLN 15,000,000 from the disposers' limits, without increasing the amounts of limits).

The expenditure by task until 2024, including detailed expenditure as for 2014–2017, related to the launch of nuclear power is specified in Appendix no. 2. Due to the advancement of the work on the year-2014 State Budget, no expenditure related to the establishment of a long-term programme has been provided for the year 2014.

In order to ensure funding and simplify the procedure for releasing the funds for development of nuclear power in Poland, PNPP has been afforded, under Article 108d, clause 2 of the Polish Atomic Law, the status of a long-term (multiyear) programme, within the meaning of Article 136 of the Public Finance Act of 27th August 2009.

7.2. CONDITIONS, DETERMINANTS AND MARKET MODELS OF SUPPORTING INVESTMENTS IN ZERO-EMISSION AND LOW-EMISSION POWER INDUSTRY

Taking into consideration the present-day situation in the electricity market (low wholesale prices, low prices of carbon emission allowances, low growth curves in demand for electricity) and no possibility to forecast the pricing trends in a long term context, which is additionally burdened with considerable uncertainty with respect to the regulatory sphere (including on the European level), the construction of any new generation unit, such as a coal- or gas-powered unit or a nuclear unit – is a tough matter to tackle. Large-scale investments characterised by a complexity of the design or project, time-consuming construction process, and long term operation, are presently charged with quite a remarkable risk.

Power industry is a specific economy sector, one whose impact on the state's economic security is essential. Moreover, characteristic of this sector are long investment cycles, virtually not to be met in any other sector. This is particularly true for nuclear power, in implementation of which there appears a combination of high investment outlays and a long project completion time, with the consequent extended timeline for return on the capital invested. Furthermore, characteristic of the investment of this type is the necessity to apply a detailed process of issuing permits necessary for construction and operation of nuclear facilities, such that are otherwise not required for other technological options. In order to satisfy the growing needs of the economy, new power units have to be built regardless of the momentary situation in the energy market, as lack of energy generates costs many times higher than the potential short-term losses of the producer occurring when energy is sold below its cost of production. This applies to system failures (blackouts)[68] as well as to intervention-related limitations of the demand for power.[69]

Economic and regulatory solutions ought therefore to ensure the realisation of state interest and take account of the interests of power enterprises (regardless of the State Treasury holding or not holding a share therein) that have to operate in the market conditions. The investment project should be prepared in a way to render it profitable under market conditions, and assure for the new power units that they will generate additional cash flows. The regulatory and legal environment and the economic policy tools applied should additionally guarantee the project's profitability, stability, and predictability.

The first, and the most important, condition for implementation of the nuclear power development programme is for the Government to ensure stability and credibility of the decisions it makes with regard to the power sector. Regulatory stability is no less important in this context, particularly if it can inform the venture's economic conditions.

The international experiences gained to date show varied attitudes in this respect, depending on the domestic legislation, industrial structure, and energy market(s). The first step made by the investor is usually to seek partners disposed or inclined toward investing in the project, which allows for building a group with a stronger equity position for implementation of the project. Partnerships may get formed in a variety of configurations, conditional upon the domestic legal framework, the competition legislation being of special importance. This enables to reduce the cost of acquisition of debt financing, which in the case of NPP is the key factor, since cost of project funding accounts for 60%–70% of the unit cost of energy generation. PGE Polska Grupa Energetyczna S.A., the investor of the first Polish NPP, has entered into talks with TAURON Polska Energia S.A., Enea S.A. and KGHM Polska Miedź S.A. for these enterprises' equity participation (capital commitment) in the construction of NPPs. On 5th September 2012, these companies signed a letter of intent concerning their participation in the preparation, construction, and operation of NPP. An understanding was concluded on 25th June 2013 for continuation of the work related to elaboration of a draft contract for acquisition of share in the special-purpose vehicle (SPV) devised for construction and operation of

[68] For example, a local system failure that occurred in the urban agglomeration of Szczecin lasted almost 24 hours causing an economic loss totalling PLN_{2008} 55.5 million, according to a PSE-Operator report; the cost of undelivered electricity equalled 63.485 to 95.407 Mio. in PLN_{2008} terms.

[69] In early March 2013, PSE concluded a tender for the contractor of the service described as 'Intervention Task: Reduced Demand as ordered by DSO'. The service provision cost was estimated at PLN 750 per 1 MWh; it is worth of noting that the wholesale price of energy was around PLN 170/MWh at the time.

NPP. As of 23rd September 2013, the parties have initialled a shareholders' agreement regarding acquisition of shares in PGE EJ1 Sp. z o.o. (a limited-liability company). As per the draft agreement, PGE is to transfer to the other parties a 30% block of shares in the share capital of PGE EJ 1 Sp. z o.o., 10% for each of the shareholders-to-be, with the result that PGE holds a 70% share in PGE EJ1 sp. z o.o.'s share capital. The share acquisition contract also specifies the rules for the parties of participation in the implementation and completion of the project. PGE and each of the business partners will be obligated to enter into a Share Acquisition Agreement after two conditions precedent have been fulfilled: the decision is obtained for unconditional consent of the Chairman of the Office for Competition and Consumer Protection [UOKiK] for concentration, and the *Polish Nuclear Power Programme* has been adopted by way of a resolution of the Council of Ministers.

The last years have seen the emergence of technology supplier participation, as a new form of partnership. Some technology vendors, in order to increase the probability of completion of the project, are inclined to propose buying shares in the facility under construction. With the issue of conflict of interest resolved, this proposed path is an advantageous formula for limiting the risk involved in the construction. In this particular case, the vendor/supplier has a special interest in timely completion of the project and in the project's financial expenses. In Europe, such partnership formula appeared for the first time in 2012, when it came to delivering the Visaginas NPP project in Lithuania.

An interesting approach, referred to as the Mankala, or Finnish, model, has been implemented in Finland. TVO, the main investor of the local NPP and, thereafter, its operator, together with representatives of Finnish industries have developed a partnership based upon the rules of energy reception whereby the shareholders have volumes-to-be-supplied guaranteed, corresponding with their respective equity interest (construction cost sharing). Instead of collecting dividends, participating-interest companies may (and, in fact, are obliged to) purchase energy at the cost of generation, irrespective of whether such generation cost is below or above the current market price. Such companies can deal with the electricity thus purchased at their liberty. Any possible surplus of energy that the shareholders are not in a position to receive due to insufficient demand are sold through the energy market and the profit thus gained may be credited to the establishment's repair-and-renovation reserve fund or be allocated for dividend payment.

The debt financing consists for the most part of direct commercial funding of the TVO enterprise via a quasi-corporate lending facility based on TVO's balance sheet and other, short-term facilities. A portion of the debt (EUR 619 Mio.) has been guaranteed by the French export credit agency COFACE.

Another instrument used to support investment projects is long-term contracts concluded by the power plant investor with energy-intensive enterprises, via the SPV set up by the latter. Such SPV redeems 'in advance' the right to purchase a specified amount of electricity from the investor/producer, at the defined price. The energy is subsequently resold to the SPV shareholders at the cost of its purchase from the producer. Thus, the energy-intensive businesses provide themselves with reliable long-term supplies of energy at competitive and predictable prices, whilst the investor gains access to low-cost external funding. A model of this type has also been applied for the Flamanville-3 unit in France (the Exeltium model). The 'investors' (holding no share in the construction project itself) from various industry sectors, by contributing their respective guarantee-supported shares to the SPV named Exeltium, have become the parties to long-term (over twenty years') contracts for supply of electricity at fixed prices, with certain variable elements taken into account. By making monthly advance payments for the contracted amount of energy, they secure for themselves supplies of energy with an option to deal with it at their liberty. In parallel, the Exeltium shareholders bear no investment risk, since the investor/producer (EDF, in this case) puts its entire manufacturing base as a guarantee of performance of the contract. The Exeltium model has been approved by EC.

For the units at Flamanville-3, France, and Mochovce-3 and -4, Slovakia, the funding has been mainly based on the enterprise's equity capital (balance-sheet financing). EDF, the French national public operator (with the State's share of 84.49%), whose assets exceed EUR 240bn, funds most of the Flamanville-3 outlays from its current income and balance sheet. ENEL, the major Italian operator, holding a 12.5% share in Flamanville-3, has participated[70] on a pro-rata basis in the costs of the French project.

The Mochovce-3 and -4 nuclear units are chiefly funded based on operating financial flows of the investor (i.e. Slovenske Elektrarne, member of the ENEL Group), supported with a multifunctional loan colaterallised with corporate financial flows.

Having regard to considerable needs of energy-intensive industrial branches as far as supplies of electricity are concerned, participation of entities from these sectors in construction and operation of NPPs seems to be the best solution in view of ensuring safe supplies of energy at reasonable price.

Long-term contracts, in some form, ought not to be excluded, though. True, the possibility to apply this particular instrument is presently limited, given the prevalent conditions of granting public aid in the EU; yet, due to the context of the special legal framework for investments in nuclear power in the EU, it still has to be analysed.

At this point, the obligation, based on the EU legislation, to support nuclear power investments should be indicated. In this particular case, the legal basis is of the strongest, treaty-based type. As per the EURATOM Treaty, the main purpose behind the EURATOM Community is to establish the indispensable conditions for creation and fast development of nuclear industry. In particular, the obligation is incumbent upon the EURATOM Community institutions (such as the EU Council, EC) and its Member States to introduce investment incentives and to take other actions in view of constructing NPPs (through stimulating the actions taken by enterprises, among other things), including based on cooperation with other countries and international organisations. In this context, the possibilities for the nuclear power sector to obtain public aid are much larger than is the case with other industrial branches, as all the forms of public aid supporting the nuclear sector should be considered, in the first place, through the prism of contributing to the purposes of EURATOM as determined in the Community's establishing treaty. The existing instruments supporting the nuclear sector, even if deemed to be instances of public aid, have never been called into question.

Contracts for supplies of electricity from the NPP, concluded on an arm's-length basis, according to a formula approved by EC, should be yet another instrument with which to support the investment project.

Changes in the market structure will also be necessary in order to facilitate the delivery of a zero-emission and low-emission power project. The United Kingdom Government takes actions benefiting safe and secure, low-emission and affordable energy through what is called the Electricity Market Reform (EMR): the reform package launched in the UK is meant as a tool with which to achieve the climate-related objectives by creating identical conditions for all the zero-emission and low-emission technologies, without a predetermined preference. The EMR consists of:

[70] In January 2013, ENEL resolved to withdraw from this project.

- **minimum price for carbon emission allowances** (determined in an administrative way);
- **CO_2 emission level standards** (maximum level determined administratively);
- financial support mechanisms for selected technologies (zero-emission and low-emission:
  - **contract for difference** – long-term contract ensuring stable proceeds for the energy producer;
  - **power contract** – contract for availability of capacity in the system, ensuring fixed proceeds for the producer;
  - **mixed contract** – contract for availability of capacity in the system, ensuring support in certain defined market-related situations.

Some of the above solutions are interesting with regard to the options for support of investment projects in Polish power industry as well.

Apart from the organisational structure, the other way to limit the risk related to implementation of a nuclear project, including the financial risk, is to opt for a well-tested reactor technology, because the experience gained in the process of construction and operation provide a bulk of useful data for the investors intending to get involved in the project. Construction of a series of units (of an identical type implies reduced unit outlays for each subsequent unit.[71]

In parallel to the 'industrial' paths outlined above, also the financial sector has introduced a number of instruments to reduce the risks, such as bank guarantees, project bonds, etc. 2012 saw the launch by the European Investment Bank and EC of a pilot phase of the Project Bonds initiative, meant to increase the funding for the key infrastructural projects (transportation, power, telecommunications) through attracting institutional investors (such as pension funds, insurance institutions/companies).

However, all these instruments will only be available for a project with a sound business foundation. The nuclear project is to be based on a clear vision of the national energy policy and on a possibly favourable long-term forecast with respect to the market conditions. Moreover, it will be implemented by an enterprise with strong management principles and reliable partners, on the grounds of a good business plan determining the expected financial flows and returns on investment.

The recent financial crunch has increased difficulties in access to financial markets and reinforced the expectations of prospective financial partners with respect to restricting the risks and gaining return on investment. For these reasons, in case new projects are implemented, it will be useful to request intergovernmental and national public institutions for collateralising a part of the project, thereby increasing the trust in the entire scheme.

7.3. PROJECT IMPLEMENTATION COSTS AND SOURCES OF FUNDING

Construction of NPP is a relatively long-lasting and costly process. Based on the investor's information, the experience gained in the last several years indicates an increase in forecast investment outlays for nuclear facilities as related to the forecasts from before the date when construction of generation-III reactor units began in Europe and the U.S. As compared to 2009, the official forecasts of investment outlays on prototype projects constructed in Europe (the EPR units at Olkiluoto and Flamanville) have significantly grown, exceeding EUR 5.0 million per 1 MW. The

[71] This has been confirmed e.g. by a PricewaterhouseCoopers analysis for UK Government: *The fleet effect: The economic benefits of adopting a fleet approach to nuclear new build in the UK*, PricewaterhouseCoopers, London, December 2012.

increasing unit investment costs are stimulated by the fact that the presently delivered projects are the so-called FOAK – i.e. first-of-a-kind, that is, prototype units (in a given technology). The subsequent implementations should be more cost-effective, as confirmed by the construction of a series of four APR1400 in the United Arab Emirates, for which the investment outlays equal USD 3.57 Mio./MW, i.e. EUR 2.68 Mio./MW. Rather than prototypic, these units are the subsequent ones in a series once initiated in the producer's country.

In its analysis, ARE has assumed an expenditure per 1 MW of installed capacity at EUR 4 million as the upper limit. Therefore, the assumption seems legitimate that the investor of the first Polish NPP will receive from the technology vendors offers with prices significantly lower than those for the prototypic units presently under construction in Europe and the U.S. – especially that over the coming ten years, the nuclear units market will be a buyer's market.

The technology to be chosen and the related power plant total capacity are of importance as well. At present, only approximate expenditure necessary for implementation of the Polish project can be determined. Based on the above-specified benchmarks, it can carefully be assumed that estimated investment outlays related to the preparation of the construction, and the construction of Poland's first NPP with the capacity of approx. 3,000 MW may be around PLN 40bn to 60bn, taking into account the expenditure on preparation of the area and the power plant's auxiliary infrastructure.

The OVN for the newly-built nuclear units in Europe and the United States are detailed in the table below.

Table 7.1. OVN for newly-built units at NPPs in Europe and the U.S.

Powerplant/unit	Reactor type	Project stage	thousand GBP'2011/MW	thousand EUR'2012/MW
Turkey Point 6&7	2*AP1000	Design	2,635	3,069
Bellefonte 3&4	2*AP1000	Design	2,347	2,734
Callaway	1*EPR	Design	2,874	3,348
VC Summer	2*AP1000	Design*	2,843	3,311
Lee Plant	2*AP1000	Design	3,226	3,758
Vogtle 3&4	2*AP1000	Design*	3,249	3,784
Calvert Cliffs 3	1*EPR	Design	3,606	4,200
Levy Country 1&2	2*AP1000	Design	3,257	3,794
Bell Bend	1*EPR	Design	4,351	5,068
Flamanville-3	1*EPR	Construction	3,527	4,108
Olkiluoto-3	1*EPR	Construction	3,131	3,647

Source: *Cost estimates for nuclear Power in UK*, Imperial College Centre for Energy Policy and Technology, UK, August 2012.

The conversion rate of EUR 1 = GBP 0.88 was applied (as per the source material), the CPI equaling .2.5% for the Euro Zone, as of 2012 (data by Eurostat).

* The construction of these units began in March 2013.

The concrete outlay/expenditure amounts and model of financing will become known after the investor has completed the tender procedure for selection of the reactor technology provider and the main contractor (an Engineering, Procurement and Construction [EPC] contract).

As shown by the analysis made by the investor, participation of a strategic investor is indispensable for the delivery of the project in question, once a domestic consortium is established. A few of such investors have already expressed their interest in taking part in the project.

Preparation and delivery of the project may be financed using the funds of the investor or strategic investor, and from third-party sources (loans, credits, bonds/debentures).

For the purpose of the NPP construction investment project, funding to be used can be provided by:

- export credit agencies,
- international financial institutions, incl. banks.

In addition, with regards to the scale, complexity, and high level of risk related to the investment project to be delivered, an active role of the State in supporting the investor's actions to ensure financing may appear necessary.

7.3.1. EXPORT CREDIT AGENCIES

Given the present-day conditions, with the world economy characterised by a limited liquidity of foreign sources, export credits offered by export credit agencies from the countries where such institutions are situated gain special importance, stimulating the exports of goods and services through ensuring long-term funding on attractive terms and conditions.

Export credits are financial instruments of a special sort; what they do, among other things, is enabling a foreign purchaser of exported commodities or services to defer the payment, obtain collaterals or guarantees. Such instruments are usually correlated with governmental support: Government loans, export credit insurance, export credit interest subsidies, or another official support instrument.

OECD's *Arrangement on Officially Supported Export Credits* determines the boundary, i.e. the most advantageous admissible, parameters of export credits for importers that may enjoy official support. The Arrangement offers special approach to, inter alia, official supporting of loans for exports related to NPPs, determining the most advantageous financial conditions that might be used by, for instance, Poland in acquiring the technology for NPPs from foreign suppliers. This concerns contracts for:

- export(s) of NPP, in whole or in part;
- upgrade of the existing NPPs;
- supplies of nuclear fuel and enrichment of uranium;
- handling spent nuclear fuel.

As per the *Arrangement*, export credits, when granted on special conditions, enable to fund up to 85% of the cost of equipment or appliances, engineering services, spare parts, and materials originating in the countries where the export credit agencies' have their registered offices. The said rate may be increased by funding local costs/expenses, up to 30% of the value of imports, insurance contribution, and interest under construction.

7.3.2. INTERNATIONAL FINANCIAL INSTITUTIONS

The sources of financing the preparation and the delivery of the project can be based on the investor's own funds or on third-party capital. Financial institutions, banks among them, play an important part in this respect. The economic slowdown and international financial crisis has, however, essentially limited the possibilities of funding large investment projects by individual institutions. The international financial institutions that offer financing for projects of this kind include, for instance, the European Bank for Reconstruction and Development (EBRD) and the European Investment Bank (EIB). Acquiring funds from EURATOM, with use of the Euratom Loan Facility, is another option. The role of these institutions and instruments in delivery of nuclear power investment projects is supplemental, though.

7.3.3. THE STATE TREASURY

Owing to the scale, complexity, and considerable business risks involved in the investment project to be delivered, an active role of the State may prove necessary in order to ensure economic stability of the project. Such stability is attainable through ensuring economic predictability as well as stability of the regulatory environment. This will enable and facilitate the investor's negotiations with the foreign partner and financial institutions.

The options and proposals for financial support will be specified once the investor completes a project feasibility study. As part of the study, a financial model will be prepared, to be detailed as the work on the project progresses.

At that time, it will be possible to determine the scope of the required state support for construction of the NPP – for instance, by granting State Treasury's credit guarantees or applying other financial or regulatory instruments, as may prove indispensable for implementation of this strategic project. The Council of Ministers is to take decision in this respect, following comprehensive, detailed analyses of the mechanisms of functioning of the energy market, taking into account the necessity to ensure the State's energy security.

It has to be borne in mind that the state's support for the nuclear project does not have to be of financial character. It can also be in the form of actions consisting in implementing appropriate market mechanisms, or in ensuring the operation of the NPP(s) at power system baseload.

ME monitors on an ongoing basis the project support systems implemented in various countries in view of the possibility to apply them in Poland. Elaboration of the support system can for instance build upon the British experience, including the procedure of bargaining with EC. Nevertheless, owing to the specificity of the domestic market, certain issues of primary importance only refer to Poland, as is the case, for instance, with State-owned infrastructure, prices of energy dependent on external factors, or the time horizon for the process to be carried out and completed. Hence, at the present stage of the works, it would be too early to present concrete solutions whose implementation would require cooperation between the administration and the investor.

CHAPTER 8. CHOICE OF SITE

8.1. SURVEY OF NPP SITING STUDIES CARRIED OUT FOR POLAND BEFORE 1990

Studies aiming at choosing the site for the first NPP, of the capacity of approx. 2,000 MW, were commenced in mid-1960s. The search focused on two seaside regions: Szczecin–Kołobrzeg and Hel–Ustka. After the decision to build the 'Dolna Odra' Power Station the former region was excluded from further siting work. The lower Vistula River area was included in the siting analyses in 1969.

The siting studies carried out in 1969–1970 for the region of Hel–Ustka and in the lower Vistula area have enabled the Planning Committee affiliated to the Council of Ministers to issue, in December 1972, a decision determining the site for the first NPP in Poland: the area by the Żarnowieckie Lake. Construction of the 'Żarnowiec' Nuclear Power Plant was commenced in 1982 (the works covered by NSRP started in November 1985).

The siting studies for a second Polish NPP were initiated with the assumption that the NPP would be based on four units of 1,000 MW in capacity each. The research was carried out in the north of the country (north of the conventional Warsaw–Poznań line), owing to larger resources of water available there, the country's main resource of fuels – hard coal and lignite – being situated in its southern part.

Based on the studies and investigations, as well as opinions and approvals received, the Council of Ministers' Planning Committee approved the Warta–Klempicz site; consequently, the Governor of the Province of Piła resolved in June 1988 that the site for the NPP, named 'Warta', be the vicinity of Klempicz locality.

In parallel to the conclusive phase of studies and siting research for Poland's second NPP, siting research was conducted in order to prepare the materials for initiating the siting process for a third NPP, and subsequent ones.

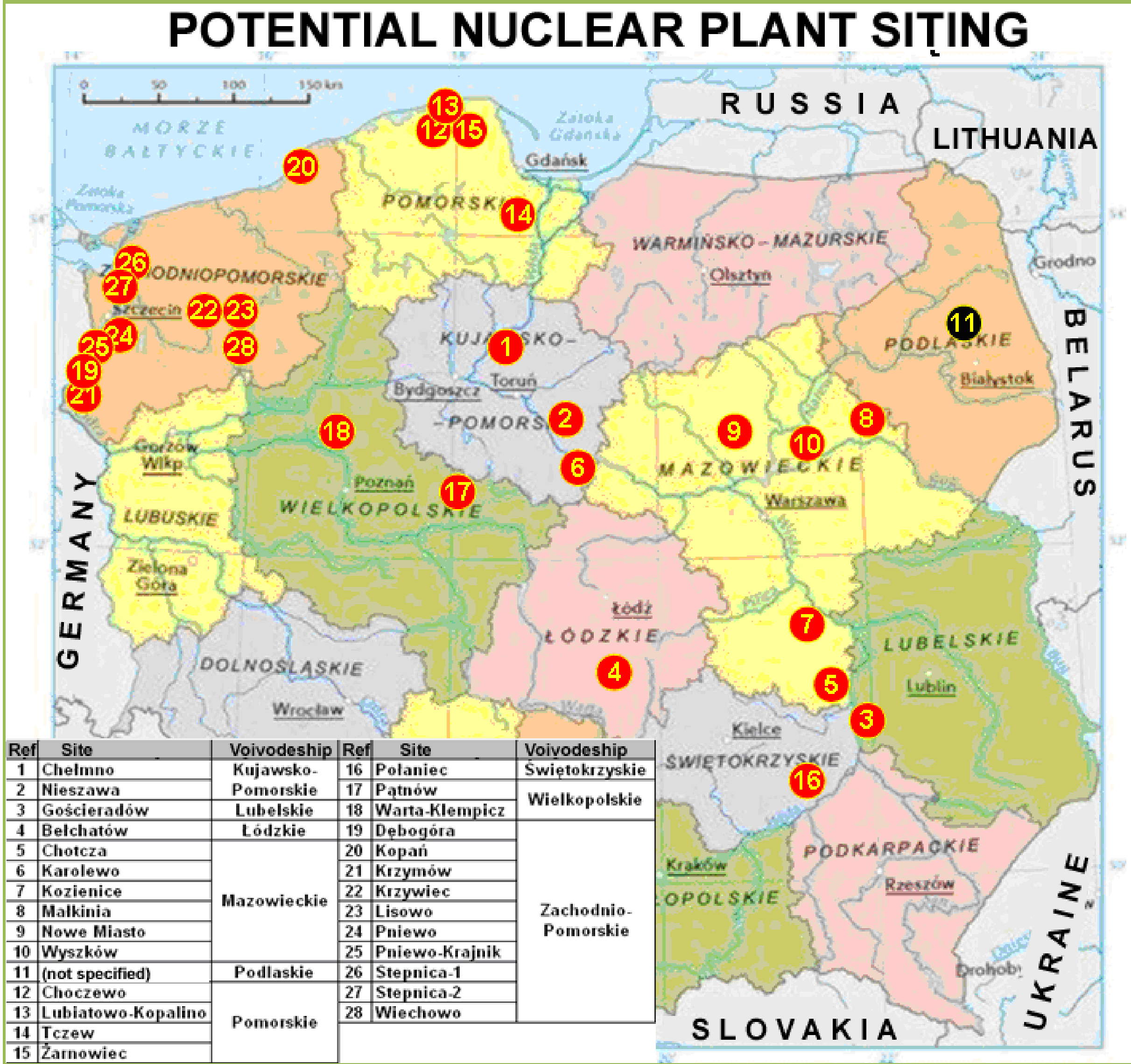
As part of the first stage, a macro-spatial analysis for potential sites of NPPs was carried out across Poland, selecting sixty-two potential site areas; this stage was completed by 1989. The list was limited to twenty-nine areas in the second stage. The course of research and studies was discontinued as the nuclear power development programme was eventually given up.

8.2. STATUS OF CHOICE OF THE PLANNED NPP SITE

The Ordinance of the Council of Ministers of 12th May 2009 on the appointment of a Government Plenipotentiary for Polish Nuclear Power has obligated the Plenipotentiary to prepare a programme for development of nuclear power, which would include the potential sites for NPPs.

In 2009, by agreement with the local governments, ME updated the proposed NPP sites considered until 1990. New proposals were also received. A list of twenty-eight potential sites was finally compiled, as shown in the map below – Fig. 8.1.

Fig. 8.1. Proposed locations for NPP, as received by the Ministry of Economy in 2009.

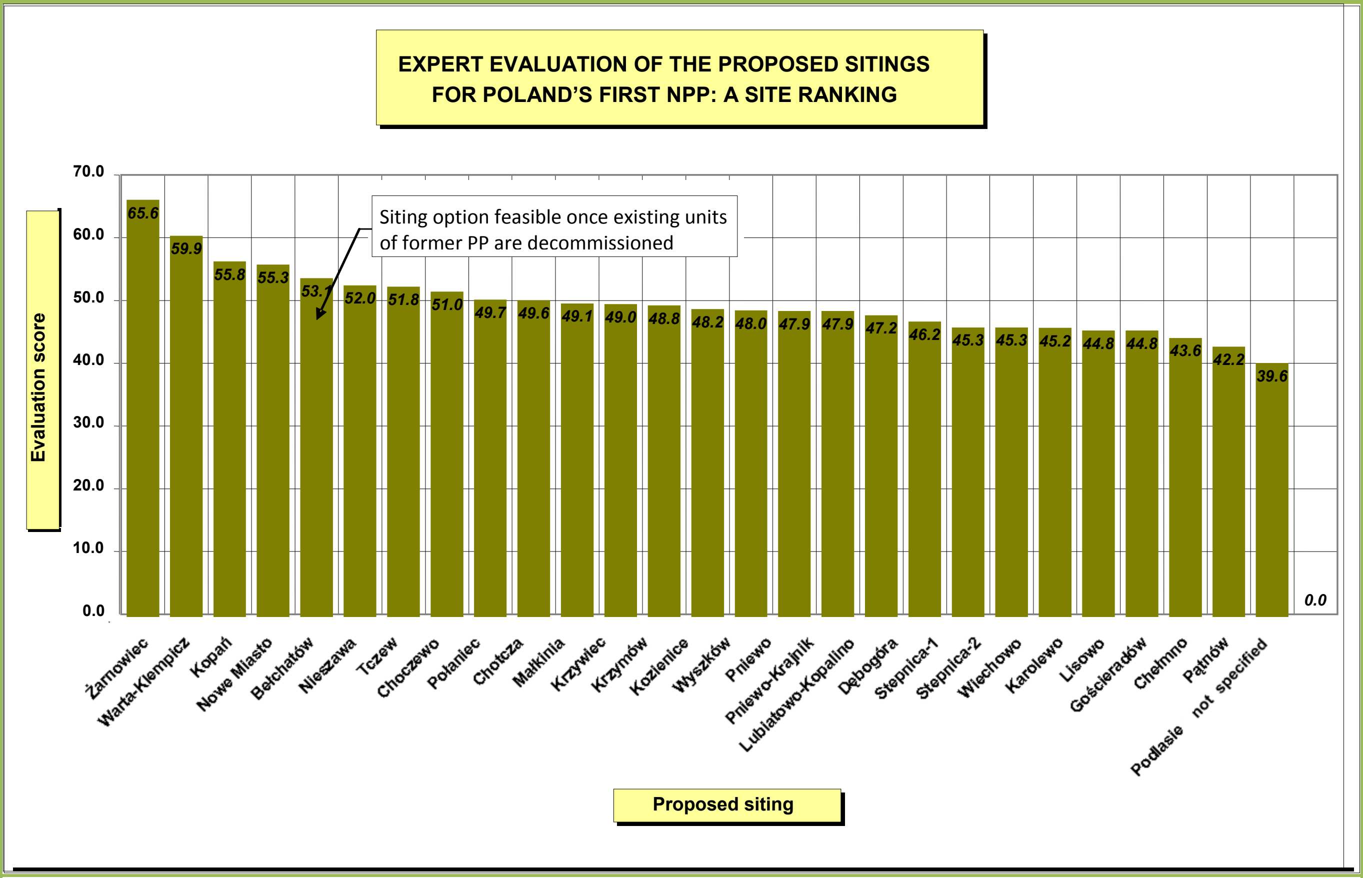


Ref	Site	Voivodeship	Ref	Site	Voivodeship
1	Chełmno	Kujawsko-Pomorskie	16	Połaniec	Świętokrzyskie
2	Nieszawa		17	Pątnów	Wielkopolskie
3	Gościeradów	Lubelskie	18	Warta-Klempicz	
4	Bełchatów	Łódzkie	19	Dębogóra	Zachodnio-Pomorskie
5	Chotcza	Mazowieckie	20	Kopań	
6	Karolewo		21	Krzymów	
7	Kozienice		22	Krzywiec	
8	Małkinia		23	Lisowo	
9	Nowe Miasto		24	Pniewo	
10	Wyszków		25	Pniewo-Krajnik	
11	(not specified)	Podlaskie	26	Stepnica-1	
12	Choczewo	Pomorskie	27	Stepnica-2	
13	Lubiatowo-Kopalino		28	Wiechowo	
14	Tczew				
15	Żarnowiec				

Source: *Expert appraisal of the siting criteria for nuclear power plants and initial evaluation of the agreed sites*, **Energoprojekt-Warszawa S.A., Warsaw, 2009.**

A document entitled *Expert appraisal of the siting criteria for nuclear power plants and initial evaluation of the agreed sites* [Polish, *Ekspertyza na temat kryteriów lokalizacji elektrowni jądrowych oraz wstępna ocena uzgodnionych lokalizacji*] was prepared in 2010 on commission of ME. The study includes a ranking of the proposed sites, taking into account the expert appraisal of the seventeen evaluation criteria (the site ranked last is one for which no geographical coordinates had been given, which, for formal reasons, disqualified it in the ranking). Diagram 8.1 shows the outcome of the appraisal/evaluation.

Diagram 8.1. A ranking of the twenty-eight prospective locations.



Source: ***Expert appraisal of the siting criteria for nuclear power plants and initial evaluation of the agreed sites,*** **Energoprojekt-Warszawa S.A., Warsaw, 2009.**

The results of the exercise were published on the ME's official website and forwarded to PGE Polska Grupa Energetyczna S.A., the prospective investor of Poland's first NPP, for further research and analysis.

The Polish Atomic Law provides that selection of the site for NPP and conduct of detailed siting analyses is part of the responsibilities of the investor.

Therefore, PGE S.A. has carried out its own examination of the potential sites for the first NPP. As of 25th November 2011, PGE S.A., the Investor, announced the list of three prospective sites :

- Choczewo, Pomeranian Voivodeship, Commune of Choczewo;
- Żarnowiec, Pomeranian Voivodeship, Communes of Krokowa and Gniewino (the area of former 'Żarnowiec' NPP construction site);
- Gąski, West-Pomeranian Voivodeship, Commune of Mielno.

This information has been taken into account for the *Forecast environmental impact of PNPP* and in the public consultations.

The indication of the above sites was preceded by analysis and evaluation of the prospective sites, in line with the *Strategy of evaluation and selection of the site for the nuclear power plant* of June 2011.

The process of selection and final choice of the site for NPP, as described in the aforementioned *Strategy* document, consists of three main stages:

1. Seeking and evaluation of the site. Indication of the site for the purposes of siting and environmental research.
2. Siting and environmental research for the three recommended sites.
3. Selection of the target site.

The process of seeking and evaluating the site has been elaborated taking into account the provisions of the law, international guidelines, and best practices, with support from international engineering enterprises and experienced advisors with evidenced experience in supporting the selection of NPP siting and management of projects and investments in nuclear power sector. In the course of the evaluation, the geographic area has been defined for examination; within it, based on the set of qualification criteria as well as technical and organisational criteria specified for the purpose, a list of candidate sites has been defined by elimination and restriction of choice. The list was subsequently subjected to multi-criteria analysis, with the weights specified for the individual criteria, depending on their significance for the NPP project, so as to arrive at a ranking determining the appropriability of these individual locations. Based on the ranking, the candidate sites were shortlisted and recommended for further siting and environmental research. Founded upon the legal regulations binding in Poland, the siting and environmental investigation is meant to conclusively confirm the suitability of the sites under examination for the foundation of the NPP structure and enable to obtain any permits required by the law as indispensable for the project to be undertaken.

Preparations for location and environmental research were kicked off in February 2013 for the sites of 'Choczewo' and 'Żarnowiec', in parallel. The outcome will enable to finally indicate the site for the first Polish NPP.

8.3. NPP SITING REQUIREMENTS CONSIDERED BY INVESTOR

The selection of appropriate site is an important element in ensuring the safety and security of the NPP to be constructed. The following aspects call for being considered:

- the impact of the NPP on its surroundings, both under normal operation and during design and beyond-design basis accidents. Any such impact must not cause effects any more severe than as admissible under the rules in force. What it means is that the design, construction, and operation of the NPP have to take into account the limitations ensuing from the site conditions;
- the impact of the natural environment and humans on the NPP. Such impacts must not cause or imply any effects that may pose a threat to the NPP. Hence, the NPP shall be designed, constructed, and operated with any and all potential threats resulting from its site being taken into account.

The most important factors taken into account in the site selection process will include: the available space of the building plot where to found the NPP and the contractor's temporary plant and facilities; access to cooling water; possibility to feed the grid with the power generated at the plant; the area's geological structure and seismic stability; density and distribution of population in the NPP's vicinity; restrictions or limitations affecting the construction and operation of the NPP owing to the conditions of its surroundings, including environmental protection and land development conditions; access to transport routes; no threats posed by nature and activities of humans; and, appropriate meteorological conditions. The siting research is to be carried out in line with the Polish Atomic Law and its secondary legislation – particularly, the Ordinance of the Council of Ministers of 10th August 2012 'on the detailed scope of assessment of area devised for the siting of a nuclear installation'. Account will be taken of any occurrences excluding the recognition of an area as satisfying the requirements for siting of a nuclear facility, as well as of the requirements of the siting report for such a facility.

CHAPTER 9. PREPARATION AND REQUIRED CHANGES OF NATIONAL TRANSMISSION SYSTEM

9.1. MAJOR CONDITIONS AND DETERMINANTS

In order to ensure reliable operation of the NPP, it is necessary to appropriately interrelate the power plant in question with the National Power System (NPS). The way the NPP is interrelated with the NPS should ensure reliable feed of the grid with the power generated by the plant as well as adequate reliability in supplying power to meet its own needs under normal operation of the grid and in post-disruption conditions.

Due to its capacity, the NPP will be connected to the National Transmission Grid (NTG) encompassing lines and stations of the voltage of 220 kV and 400 kV. The 220 kV grid is an expanded and multiply-closed structure; the 400 kV grid is relatively well-developed in the south of Poland, whereas in the eastern and northern parts of the country it does not form a completely closed network system.

9.2. PROPOSED ACTIONS TO DEVELOP NPS

In Poland, the role of the Transmission System Operator (TSO) is performed by Polskie Sieci Elektroenergetyczne S.A., a joint-stock company (PSE). TSO plans to develop the transmission grid in the long term (fifteen years minimum), so as to ensure satisfaction of the demand for electricity and reliable operation of the entire NPS, and to create appropriate conditions for the electricity market actors – the producers and the consumers.

The strategic actions of TSO, as identified and described in the Transmission Grid Development Plan (TGDP), are meant to:

- increase the NTG through construction of new multi-track 400 kV lines (including the use of the existing 220 kV line corridors);
- carry out grid investment projects to redevelop/extend and upgrade the 400 kV and 220 kV lines and stations;
- increase the certainty of supplying the electricity consumers, including those populating large urban agglomerations;
- increase the certainty and reliability of operation of NPS and reduce transmission losses;
- reinforce the cross-border connections enabling reciprocal supplies of electricity between Poland and its neighbour countries.

At the stage of preparatory work for the construction of the NPP, it is necessary to make efforts to determine the basic system criteria to be fulfilled by a system connecting the NPP with NPS. The following questions call for elaboration, inter alia:

- selection of the master scheme for the design of the station adjacent to NPP;
- the admissible (with respect to reliability) maximum length of the lines transmitting power from unit transformers to the station;

- the number of the lines transmitting power from NPP and their transmission capacities (depending on the installed capacity at the power plant);
- development of an appropriate power supply system for the NPP auxiliaries;
- the criteria for operation reliability of the transmission and distribution grids influencing the operation of the NPP.

These tasks should be delivered based on close cooperation between PSE, the local Distribution System Operator (DSO) and the investor, with support from independent consultants and experts.

Regardless of the site, to connect the NPP to the grid will require extended transmission network, which is primarily true for the 400 kV grid. Therefore, the actions related to extension of the grid infrastructure, with regards to both stations and lines, should be undertaken well in advance of the NPP construction process. To this end, systemic multi-variant analyses, taking into account the construction of an NPP in all the considered sites, should be carried out at a possibly early stage. A defined scope of the necessary expansion of the transmission system, common to all the options, will be made part of PSE's power system development plan immediately after the outcomes of all the analyses have been obtained, and the relevant investment projects commenced.

The target scope of expansion of the transmission network for connecting the NPP to the grid will be determined after the investor has submitted the request for issuance of the terms-and-conditions of such connection, specifying, among other things, the final location and the capacity of the power plant. This is the moment as from which grid investment projects specific for the given technology and location should be commenced.

9.3. PROBLEMS TO SOLVE

Implementation of grid investment projects for the purpose of taking off power from large generation units, NPP included, in order tofeed the grid, calls for several years of preparation and, subsequently, a delivery stage. Founded upon the binding legal regulations, this process may take approximately seven to ten years. Analysing the individual stages of the investment process with regard to grid projects, one finds that the project preparatory phase takes, relatively, the longest.

The approach to the development of NPS as described above will enable the expansion of the transmission grid in line with the schedule for the construction of the NPP – and, consequently, taking off the full capacity from the NPP to feed the grid with, since the start-up.

The Act on preparation and delivery of investment projects in the area of nuclear power installations and their accompanying projects[72] has introduced certain conveniences in the area of grid projects for nuclear power. The legal instruments enabling more effective conduct of any grid investment projects are laid down, in turn, by the draft Transmission Corridors Act (the entry-into-force date thereof not being known at present).

Noteworthy, moreover, is the most recent Regulation of the European Parliament and the Council (EU) 347/2013 of 17th April 2013 'on Guidelines for trans-European energy infrastructure, repealing

[72] I.e. JL no. 135, item 789; and, JL 2012, item 951.

Decision 1364/2006/EC and amending Regulations (EC) 713/2009, (EC) 714/2009 and (EC) 715/2009[73].

In the event that power is taken off from the NPP along the lines whereto the PCI ('Project of Common Interest') status extends (which is possible, due to the TEN-E South–North corridor), additional privileges for a "fast track in issuing permits for construction of such transmission infrastructure" can be taken advantage of.

[73] I.e. OJ EU L 115 of 25.04.2013, p. 39.

CHAPTER 10. ENVIRONMENTAL PROTECTION

10.1. NUCLEAR POWER CONTRIBUTES TO ENVIRONMENTAL AND CLIMATE PROTECTION

Climate protection, together with the EU climate and energy package, make it necessary to switch the electricity production into technologies with low or zero emissions of CO_2. Given the situation, use of any zero-emission and low-emission technologies available, with a parallel increase of energy security and reduction of pollutant emissions, whilst observing economic efficiency, has particularly gained in importance.

These determinants have been reflected in *the Energy Policy of Poland Until 2030*; as mentioned earlier, one of it's policy's goals is to "limit the environmental impact of power industry"

The main goals of energy policy in this area are to:

- limit CO_2 emissions by 2020, while maintaining a high level of energy security;
- limit the emissions of SO_2, NO_x and PM to the levels defined by the presently valid and projected EU regulations;
- restrict adverse effects of power sector on the condition of surface waters and underground waters;
- minimise the storage of waste by a possibly extensive use of waste in economy;
- cause the energy generation structure to evolve toward low-emission technologies.

The efforts made recently to increase the safety of reactors have also caused reduced impacts of NPPs on the environment in case of a possible major accident. NPPs emit no sulphur oxides or nitrogen oxides, PM, or toxic chemical substances. They emit no carbon dioxide, either. The volumes of emissions appearing at the other stages of the fuel cycle (for instance, when transporting uranium ore from the mine to the purification site) are comparable with the emission levels for wind power stations or water turbine plants.

Figure 10.1 shows a comparison of greenhouse gas emissions in generation of electricity using various carriers of primary energy, pursuant to the World Energy Council data. Figure 10.2 compares external costs of electricity generation for different technologies.[74]

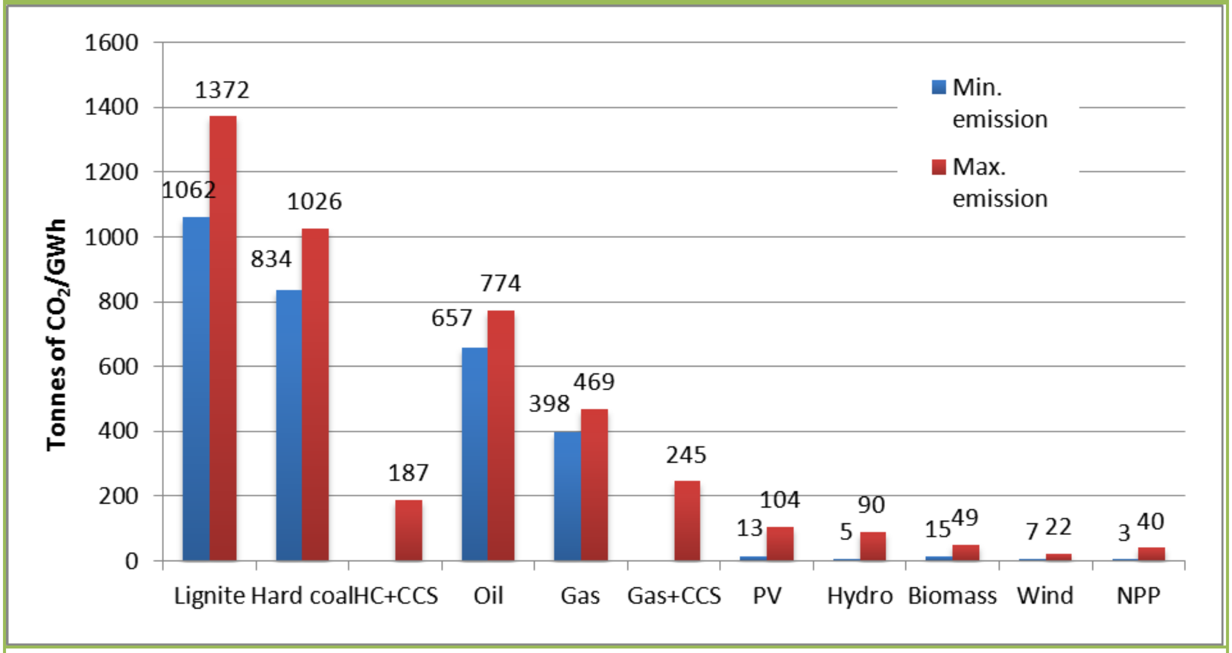
The data systematically gathered by nuclear regulatory authorities in various countries have shown that the annual dose of radiation at the borderline of the reactor exclusion area (restricted use zone) is between 0.01 to 0.03 mSv per year, whereas the natural background dose is 2.5 mSv/year for Poland; the corresponding rate for Finland is 7 mSv/year, for instance. What it means is that additional radiation from NPPs is a hundred times lower compared to the natural differences in radiation between Finland and Poland. What is more, the differences in natural radiation occurring within Poland alone prove manifold in excess of the radiation emitted by NPPs.

[74] Data quoted after a European Environment Agency study: External Energy Costs – ExternE, http://www.eea.europa.eu/data-and-maps/figures/estimated-average-eu-external-costs.

As far as external costs (environmental and health-related) are concerned, nuclear power performs very advantageously, as confirmed by EEA[75]. The total external cost for nuclear power are comparable with those for renewable sources of energy; a detailed breakdown is pictured in Figure 10.2.

In order to meet the environmental requirements, related to the project impacts on the environment, environmental impact assessments will be made at the consecutive stages of the NPP construction project – in line with the Act of 3rd October 2008 'on disclosure of information on the environment and its protection, public participation in environmental protection, and environmental impact assessments'[76].

Fig. 10.1. Greenhouse gas emissions in generation of electricity using various primary energy carriers.



Source: World Energy Council report, 2004.

The main issues related to environmental impact assessments for nuclear power facilities are regulated by the following normative acts:

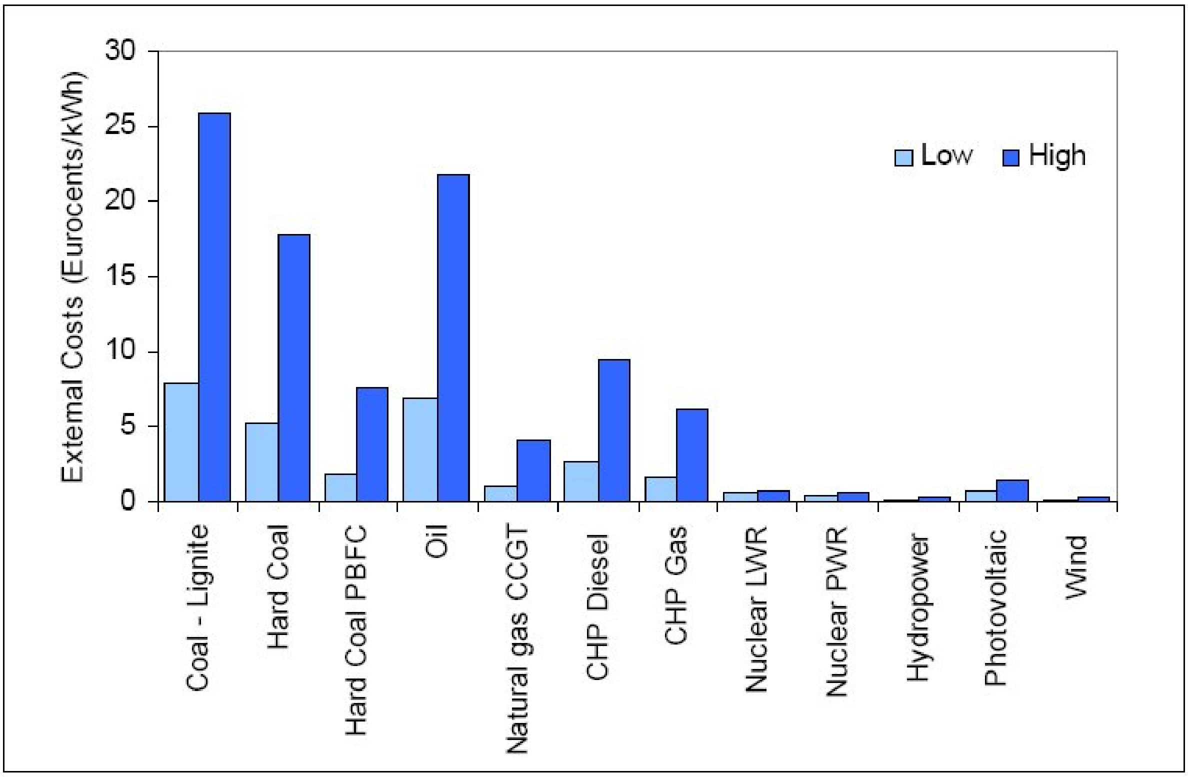
- The **EIA Act** – i.e. the Act of 3rd October 2008 'on disclosure of information on the environment and its protection, public participation in environmental protection, and environmental impact assessments'.
- The **Investment Act** – i.e. the Act of 29th June 2011 'on preparation and delivery of investment projects in the area of nuclear power installations and their accompanying projects';
- The **EIA Ordinance** – i.e. the Ordinance of the Council of Ministers of 9th November 2010 'on enterprises with potentially significant environmental impact'[77].

The authority in charge of the EIA procedure for nuclear power installations or facilities in Poland is, obligatorily, the **General Director for Environmental Protection (EIA Act, Art. 61.3a)**. It is the central government administration body for environmental protection and nature conservation, performing

[75] Ibidem.
[76] I.e. JL 2008, no. 199, item 1227, as amended.
[77] I.e. JL 2010, no. 213, item 1397.

its responsibilities with support from the General Directorate for Environmental Protection (GDEP). The General Director for Environmental Protection reports to the Minister in charge of the environment.

Fig. 10.2. External costs of nuclear power, compared to other sources of energy, according to European Environment Agency.



Source: *Estimated average EU external costs for electricity generation technologies in 2005*, European Environment Agency, http://www.eea.europa.eu/data-and-maps/figures/estimated-average-eu-external-costs.

10.2. TRANSBOUNDARY CONSULTATION FOR PNPP

Acting under the Environmental Impact Assessment (EIA) Act, the draft PNPP has been subjected to the Strategic Environmental Impact Assessment process.

In 2010, ME prepared a *Forecast environmental impact assessment of the draft PNPP*. Public participation in the compilation of a *Strategic Environmental Impact Assessment of the Draft PNPP* was initiated as from 30th December 2010. It took three months, between 30th December 2010 and 31st March 2011, for the procedure of formal public consultations of the *Forecast environmental impact assessment of the draft PNPP* to be completed, with comments or remarks received from some 300 institutions and organisations from all over the country.

Since the aforesaid *Forecast* demonstrated a possibility that certain cross-border impacts of PNPP may occur, a trans-boundary procedure was carried out also for PNPP itself – in line with the EIA Act and the relevant international conventions ratified by Poland, i.e. those of Espoo[78] and Aarhus.

Trans-boundary consultation for the *Forecast* and PNPP were started on 18th July 2011, conducted by ME in cooperation with GDEP. As part of the process, Poland forwarded to the interested (exposed)

[78] Convention on Environmental Impact Assessment in a Transboundary Context, executed at Espoo on 25th February 1991 (i.e. JL 1999, no. 96, item 1110).

countries copies of the relevant translated documents (PNPP and *Forecast environmental impact*) to enable evaluation of such potential impacts.

Ten countries were invited to participate in the cross-border consultations were: Lithuania, Latvia, Estonia, Sweden, Denmark, Germany, Austria, Czech Republic, Slovakia, and Finland. Lithuania, Latvia and Estonia have declined the offer. With the other invited countries, the final date for participation of their public in the consultations was agreed at 31st October 2011. On 26th October 2011, the GDEP, as the body coordinating the procedure in the trans-boundary context, received Germany's request to extend the public consultation timeline until 4th January 2012. Austria and Finland have submitted their similar requests.

In order to meet the expectations of Finland, Austria and Germany, and having regard to the regulations of law providing for equal treatment of all the participants, it was resolved that the social consultations timeline be extended for all the countries till 4th January 2012.

On 25th November 2011, PGE S.A., the Investor, announced the list of three prospective locations for NPP, featuring Gąski, Choczewo, and Żarnowiec.

As the locality of Gąski, which was missing in the list of twenty-seven locations selected by ME, is mentioned by the Investor as one of the potential sites, ME has prepared the corresponding Annexes to:

- *Forecast environmental impact assessment of PNPP*, and,
- PNPP.

These Annexes were forwarded to the countries partaking in the consultations on 8th January 2012, offering them a twenty-one-day timeline for proposing their remarks or comments. The trans-boundary consultation of the Annexes was concluded on 27th February 2012, since Germany had commenced their public consulting procedure only as from 6th February 2012.

13th January 2012 marked the beginning of 21-day national public consultation of the aforementioned documents; the procedure was completed by 3rd February 2012. The shortest timeframe allowed under the applicable law was applied to this procedure, owing to a small number of amendments made by means of the Annexes, compared to the documents as submitted for consulting beforehand.

A series of remarks or comments were received from the participating countries within the consultations. ME prepared the replies and, once translated, delivered them to the respective countries via GDEP. Whenever the explanations proved unsatisfactory, it became necessary to hold trans-boundary consultation in the form of a meeting of experts on the intergovernmental level. Austria, Slovakia, Denmark, and Germany have each requested such a meeting. Any discrepancies were clarified at the consultation meetings and replies were given to any additional questions posed. Moreover, any indispensable complements or additions were reconciled at that point, to be forwarded to the exposed countries; also, consents for signing of the minutes were preliminarily given.

On 23rd July 2012, the first bilateral meeting was held, with the Slovak partners. It was concluded with signing of the minutes, which marked the completion of trans-boundary consultation with Slovakia.

An analogous procedure was applied for the other countries. Bilateral meetings were held with Austria, 22nd November 2012; with Germany, on 27th November 2012; and, with Denmark, on 4th December 2012. The talks were concluded with signature of relevant minutes. The minutes of the talks with Austria were signed only early in May 2013, which marked the **formal conclusion of the process of transboundary consultations for PNPP**.

The conclusions drawn from the *Strategic Environmental Impact Assessment of the Draft PNPP* form Appendix no. 5.

Environmental impact assessment will be carried out for at least two sites, as part of the procedure for obtaining the decision on environmental constraints. Resulting from this EIA, the terms-and-conditions for delivery of the project for the specified site will be indicated. A detailed EIA for the specified technology and site will be carried out in line with the binding national laws at the stage of so-called environmental impact reassessment, within the process of requesting the building permit.

CHAPTER 11. ENSURING SUPPLY OF SPECIALISED STAFF/HUMAN CAPITAL

11.1. HUMAN RESOURCES AT PRESENT

Acquisition of the knowledge and skills indispensable for construction of nuclear power, including construction of NPP, and education of an adequate number of experts in various relevant fields, is the key element for mobilisation of nuclear power in Poland.

There is scarcity of specialists in this area in Poland, though. Most of them worked actively in the course of construction of 'Żarnowiec' NPP (1982–1990) and now are in their retirement age, or very near it. Not only Poland has to do with this problem – it is shared by other countries that are willing to develop nuclear power from the scratch, or even some of those with a functioning nuclear power sector.

11.2. FIELDS OF STUDIES RELATED TO NUCLEAR SECTOR

As per the amended version of the Higher Education Law Act of 27th July 2005, Polish higher (tertiary) schools enjoy autonomy and decide for themselves as far as their fields, faculties or majors are concerned. A central list of fields or subjects and their related standards of education has been abandoned. The State-defined list of more than 100 fields, in force until recently, missed the needs of the labour market and did not correspond with the students' educational aspirations. Presently, universities or colleges are free to develop their new, original fields or majors, in response to the social and economic challenges of today – including the activities connected with development of safe nuclear power.

Below follows a list of Polish higher schools which have opened fields or programmes related to nuclear power (in alphabetic order):

1. Academy of Mining and Metallurgy, Krakow
2. Gdansk University of Technology
3. Krakow University of Technology
4. Łódź [Lodz] University of Technology
5. 'Maria Curie-Skłodowska' University, Lublin
6. Opole University of Technology
7. Poznań University of Technology
8. Rzeszów University of Technology
9. Silesian University of Technology
10. University of Warsaw
11. Warsaw University of Technology
12. Wroclaw University of Technology

As part of preparations for implementation of PNPP, most of the Polish technological schools and some universities have opened, or are planning to open, programmes or majors (undergraduate and graduate) directly connected with nuclear power. A series of trainings of educators for the needs of

Polish higher schools held between 2009 and 2012 by ME were meant to support these activities, which are expected to continue in the years to come.

As part of Priority 4 of the Human Capital Operational Programme, fields of studies, subject or majors can be specified in view of seeking support from the European Social Fund, primarily as part of Sub-measure 4.1.2 – 'Increasing the number of graduates majoring in disciplines with key importance for the knowledge-based economy'. As for the task in question, the Ministry of Science and Higher Education carried out, beginning with 2008, competitions concerning the so-called 'Ordering for education' in technological, mathematical, and environmental/natural-sciences fields. Power engineering was listed among 'ordered-for fields' in 2010; within it, the universities can provide Nuclear Power as a unique major. A total of over PLN 1bn was allocated for the entire 'Ordering for education' scheme by the end of 2013.

The institutions directly involved in the process of preparation and implementation of PNPP, as far as development of HR for new NPPs is concerned, include ME, Ministry of Science and Higher Education, Ministry of National Education, Ministry of Labour and Social Policy, NAEA, UDT, RWDE and other inspection/control bodies or authorities, as well as the investor. NAEA has so far been training its staff on its own; in face of the new tasks, using third-party support will be a must.

11.3. HR/WORKFORCE DEVELOPMENT FOR THE NEEDS OF PNPP: THE OBJECTIVES

Construction of nuclear power plants and their related infrastructure implies creation of thousands of jobs. Construction of a single unit (excluding the accompanying projects, such as power lines, transport infrastructure, etc.) requires that some 3,000–4,000 people be employed in construction and assembly work, with an array of professions: workers and labourers (to be specially trained for working at a nuclear facility construction site), welders and plumbers, mechanics, crane operators, construction vehicle drivers, electricians, robotics designers, land surveyors, electrical fitters/installers, pipeline fitters/installers, steel fixers/concrete finishers, concrete placers, as well as engineers, architects, and many others. IAEA's *Workforce planning for New Nuclear Power Programme, no. NG-T-3.3* suggests that it is necessary to provide 700 to 1,000 specialists in more than 40 specialties (power-related and other) during the operation of NPP equipped with one or two reactors, respectively.

Therefore, the objective of PNPP as far as HR development is concerned is to achieve the quantity and quality of the staff which will ensure efficient and safe construction and operation and, at a later stage, decommissioning, of NPPs.

Development of the domestic resource of nuclear power specialists and experts is, in the longer run, a mode of action that proves the most rewarding for the country. However, given the ambitious plan of completing the construction of the first NPP by the end of 2024, a compilation of the various methods of action will be necessary, including:

- development and education of human resources at home;
- use, to the extent necessary, of international HR – for instance, the IAEA network of experts, and experts from the countries that have their nuclear programmes implemented;
- cooperation with suppliers of nuclear technologies;
- cooperation with foreign regulatory institutions, nuclear sector organisations and educating institutions;

- cooperation with higher schools (universities, etc.) and economic organisations from countries with developed nuclear power.

To enable foreign training of Polish specialists, ME has taken actions aiming, among other things, at establishing a possibly broad international cooperation. Relevant cooperation agreements have been signed so far with:

- Japan,
- the United States of America,
- France,
- Korea.

In implementing the human resources development scheme, the MAEA guidelines, as set forth, inter alia, in *Milestones in the Development of a National Infrastructure for Nuclear Power No. NG-G-3.1*, need being followed.

11.4. BASIC KNOWLEDGE INDISPENSABLE FOR IMPLEMENTATION OF PNPP

NSRP of a nuclear facility such as NPP requires that a quality management system be developed, with exacerbated procedures and requirements, compared to these presently binding for the industry; also, advanced programme and technical tools need being applied for analysing and designing the installations of NPP components and structures. Apart from NSRP, most of the technical skills necessary for designing, constructing, and operating an NPP is close to the skills needed in other large industrial and energy investment projects. This being said, and in line with the IAEA guidelines for nuclear programmes, competencies should be developed, in particular, in the areas of:

- analysis of the NPP design,
- quality management and control,
- project management,
- operation and renovations.

11.5. MEASURES AND METHODS OF ACTION

Assessment of the staffing needs in Polish nuclear power sector will be followed by a *Human resources development plan*, to be prepared by the Minister in charge of economy. To implement the *Plan*, actions will be taken to develop the staff training infrastructure. One of the solutions being considered is to modify and upgrade the existing infrastructure in vocational, secondary, and tertiary schools. The *Plan* will specify and detail the tasks to be delivered and the measures enabling to achieve them. It will take into account the needs of the administration and State services of all sorts (incl. NAEA – for nuclear regulation inspectors, expert and administrative personnel), schools, universities and research and development infrastructure, and entrepreneurs. The *Plan* is to determine the indispensable qualifications and the numbers of experts necessary for every single stage of PNPP's implementation. Apart from the actions taken by the administration, mainly in ensuring adequate conditions for education and training, it is necessary that a system be put in place for the investor to educate and provide in-service training to its own staff.

CHAPTER 12. TECHNICAL RESOURCES AND RESEARCH FACILITIES OF THE POLISH NUCLEAR POWER

Research institutions and centres such as NCBJ, INCT [IChTJ], dealing with research on peaceful uses of nuclear energy, have been active in Poland for a number of years now. The 1970s and 1980s saw them do research in view of development of nuclear power in Poland.

Polish scientific units (research institutes, scientific institutes of the Polish Academy of Sciences, higher schools/universities) are also very important entities taking actions to the advantage of the development of nuclear power.

According to the IAEA guidelines and the experience of other countries developing nuclear power, it is essential that a scientific and research infrastructure be in place to ensure support for the nuclear regulatory and inspection functions and the government administration in the process of granting permits for construction, commissioning, operation, and decommissioning of NPPs as well as in the course of their construction, operation, and decommissioning. The point is, mainly, about expert activities carried out for the regulatory authority and government administration whose public services are not in a position to deliver, on their own, the tasks in the fields of:

- nuclear safety and security,
- radiological protection,
- radiological monitoring,
- research of materials and equipment for nuclear installations,
- operation of nuclear installations
- nuclear fuel cycle,
- education and training of human resources,
- public information and education.

The IAEA guidelines admit various organisational solutions, conditional upon the country's historical conditions and its scientific and research potential.

The Polish Atomic Law provides for an option to use laboratories and expert organisations authorised by the NAEA Chairman, in the course of evaluation of the request for a permit for operation consisting in construction of nuclear facility, control of the contractors and suppliers of systems and NPP construction and equipment elements, as well as contractors of the work carried out in construction, furnishing and decommissioning of NPP as well as during a control of the plant's operation. Authorisation to this end can be granted to laboratories and expert organisations:

1) other than the designers, producers, suppliers, installers or representatives of any of the entity involved in designing, construction, or operation of NPP;
2) having at their disposal the necessary staff and adequate equipment enabling proper delivery of technical tasks related to the control;
3) whose employees responsible for control have the necessary knowledge and experience in carrying out such controls or inspections;
4) ensuring that the control be carried out in an unbiased fashion.

Owing to the nuclear power programme carried out in Poland in the 1970s/1980s, in spite of its discontinuance in the subsequent two decades, there are teams of scientists, scholars and technicians, in a dozen-or-so scientific and research institutes across the country, displaying the relevant qualifications. This is especially true for radiological protection and radiological monitoring, the latter being systematically developed since the early eighties. The aforesaid also concerns, though to a lesser extent, the other fields of atomic eneregy, as a broad concept. Thus, the existing potential should be taken care of, to a maximum extent, along with development of the domestically available competencies, taking advantage of specialised foreign organisations.

In order for the collaboration with such organisations to give the expected results, it is indispensable that relevant competencies be developed for the state nuclear regulatory function as a specialised, professional contracting party and consumer of third-party professional services. Hence, it is indispensable that development of HR within the NAEA be adequately planned in this respect.

With a view to reinforce those entities at home which may ensure support for the nuclear regulator (and-inspector) and government administration in implementation of nuclear power and, at a later stage, operation and decommissioning of nuclear-power facilities, 2012 saw the launch of an NCBiR strategic research project '**Technologies supporting the development of safe nuclear power**', encompassing the delivery of ten research tasks totalling PLN 50 million in value. The said tasks extend to analysis of the potential options and criteria for Polish industry's participation in development of nuclear power; development of NSRP assurance methods to meet the present and future needs of nuclear power; or, for instance, a far-reaching task described as 'developing high-temperature reactors for industrial uses'. With the evaluation of the aforementioned research tasks completed – the tasks being delivered as part of a strategic research scheme, in view of their usefulness for implementation of nuclear power in Poland – preparation of a subsequent edition of the project should be considered. At this stage, account should be taken of the expectations of the nuclear regulatory authority and the government administration, in the light of future demand for third-party professional (expert) services, among other things.

CHAPTER 13. SAFETY OF NUCLEAR FUEL SUPPLIES

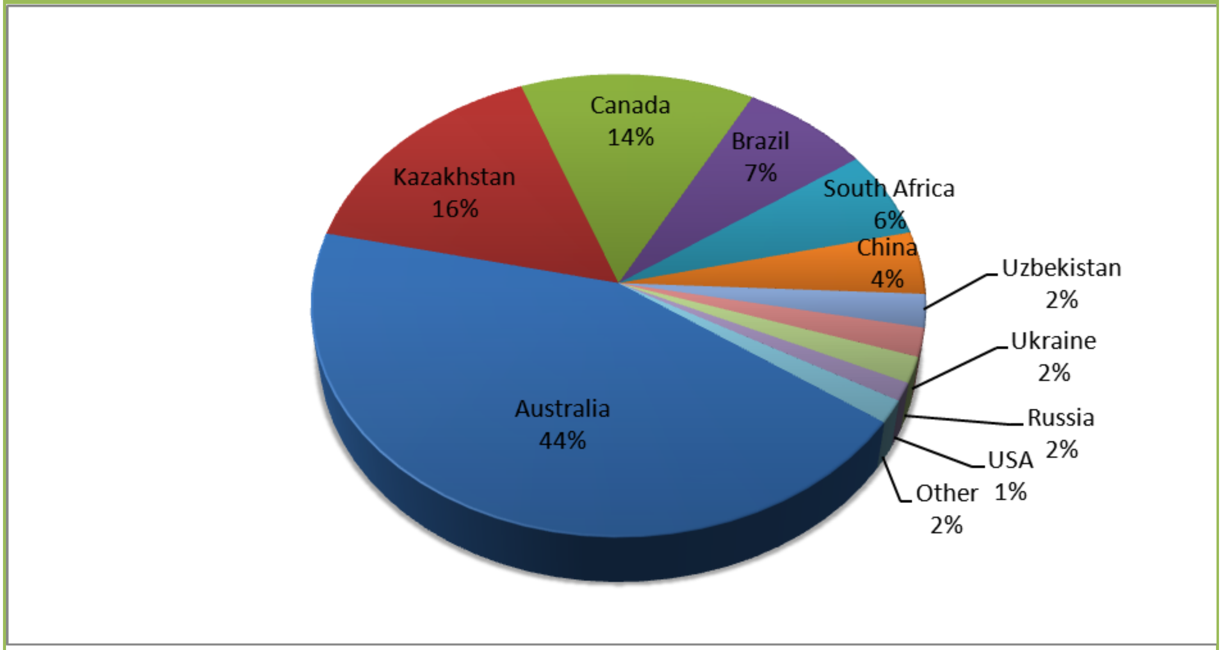
Production of nuclear fuel consists of four main stages:

1) mining of uranium, in the form of uranium ore;
2) conversion of uranium into a form enabling its enrichment;
3) enrichment of uranium, and,
4) fabrication of ready-to-use fuel cassettes.

13.1. AVAILABILITY OF URANIUM IN INTERNATIONAL MARKET

Figure 13.1 shows the distribution of international resources of uranium.

Fig. 13.1. Uranium resources, internationally (based on OECD data).



Source: *Uranium 2011: Resources, Production and Demand*, NEA/OECD, Paris, 2012.

As the attached chart shows, deposits of uranium ore are distributed across the world, but mainly concentrated in politically stable countries. In global terms, more than two-thirds of supplies of uranium, received in the form of uranium concentrate extracted from primary sources – that is, mines - comes from Russia, Canada, Australia, and Kazakhstan (69.00%, according to Euratom Supply Agency's Annual Report 2011). The use of uranium as a nuclear fuel is virtually the only peaceful large-scale application of this raw material.

Fluctuating prices of uranium ore do not quite affect the cost of electricity generation at NPPs, owing to a low share of uranium in the total cost of energy production. For instance, according to the AREVA data, a 100% increase in uranium price would have caused an increase of merely around 5% in the cost of NPP-based electricity production. According to a statement made by the British Government in order to give grounds for the decision to have new NPPs built within the UK, the impact of increases in uranium prices on cost of electricity from NPPs is even lower (cf. *Energy Challenge 2006*[79]). This causes that NPPs provide electricity generated at a stable cost, almost independently of the fluctuations in the international uranium market. This helps maintain stable prices of electricity in the market, which is advantageous to balanced and sustainable development.

The economic legitimacy of exploitation of uranium deposits is mainly dependent on the market price of uranium. For a number of years, uranium remained relatively inexpensive, which hampered exploration, development and management of new deposits. In the recent years, the price of uranium began showing an increase trend, which has translated into intensified search of uranium as well as enabled to open and operate some formerly-unprofitable mines. With prices of uranium further going up, an increase in the number of newly-discovered resources may be expected. Such developments are typical to all the minerals, and are not unique to uranium. The number of recognised uranium deposits with which the excavation of ore is, or can be, remunerative, given the expected pace of nuclear power development, has been growing year by year.

The progress in the uranium ore mining and purification technologies has caused that uranium mines excavating lean (low-grade or very-low-grade) ores are operational, proving highly profitable. For instance, the Rössing mine in Namibia, the ore with 0,0276% U_30_8 uranium content is exploited.[80]

The technological refinements under development meant, for instance, to bring about increased burn-up of fuel, increase the efficiency of uranium use. Some reactors (specifically, 15% of those presently in operation worldwide) recycle plutonium and uranium generated through reprocessing of spent fuel. This increases the energy obtained per weight unit of primary uranium obtained from the ore by up to 25%. Apart from the oxide uranium fuel, these reactors apply MOX – i.e. mixed oxide, a fuel generated from a mixture of uranium and plutonium oxides. Introduction in the nuclear fuel cycle of thorium, whose deposits in the Earth's crust threefold exceed those of uranium, may reduce the consumption of uranium worldwide. India, for instance, possessing considerable deposits of this particular raw material, has introduced such fuel cycle. Over following forty to fifty years, the launch of fast-neutron breeder reactors, which are mastered nowadays as part of the Generation-IV reactors' development programme, will allow for using plutonium and uranium coming from spent fuel of presently operating reactors as a fuel. Depleted uranium, in turn, being a residue of the process of isotopic enrichment of uranium for light-water reactors, will be used as a breeding/fertile material in Generation-IV reactors. This will allow to extend the operating time of nuclear power by thousands of years, with use of the presently-documented uranium resource alone.

13.2. URANIUM RESOURCES IN POLAND

The deposits of uranium ore in Poland, as examined hitherto, contain 250 to 1100 ppm[81] of uranium; otherwise, there are mines using the ore whose content is approx. 300 ppm (Namibia's Rössing being one example). The uranium deposits exploited in Poland in the 1950s typically contained approx. 2000 ppm.

At present, the mining of uranium in Poland, owing, inter alia, to the mineral's uneven distribution in the deposits, and to the volume of the deposits, would be uneconomical, since uranium is purchasable from abroad at a lower cost. However, in the discussion on the strategic aspects, it is

[79] HM Government, BERR: *Meeting the Energy Challenge, a White Paper on Nuclear Power*, January 2008, Para. 3.23.
[80] Rössing, *Röossing working for Namibia*, *Report to Stakeholders*, 2004.
[81] 1 ppm = 1 part per million = 1 gram per tonne.

worth realising that Poland has its own deposits of uranium all the same, to potentially be used in a future. Below follows a breakdown of the volumes of uranium ore deposits as already recognised for Poland.

Table 13.1. Resources of uranium ore in Poland (based on forecast for depths over 1,000 m), as per NEA/OECD *Red Book*, 2011.

Region of Poland	Identified resource [tonnes $U_{nat.}$]	Uranium content in ore [ppm]	Forecast resource [tonnes $U_{nat.}$]
Rajsk (Podlachia [Podlasie])	5,320	250	88,850
Peri-Baltic Syneclise			10,000
Okrzeszyn (Wałbrzych Syncline/the Sudetes)	940	500–1,100	
Grzmiąca, Głuszyca-Dolna (the Sudetes)	790	500	
Wambierzyce (the Sudetes)	220	236	2,000

Source: *Uranium 2011: Resources, Production and Demand*, NEA/OECD, Paris, 2012.

Although the domestic deposits generally rank among lean ones, some of them (Wambierzyce, Grzmiąca, Okrzeszyn) have a particular advantage in that they form bedded, and pretty homogeneous, deposits; this enables their regular exploitation over dozens of years.

Uranium can moreover be obtained as a by-product while mining other minerals. The Olympic Dam mine in Australia is the world's largest uranium mine. Uranium appears there as an admixture in copper deposits, its content in the ore being 0.02%, i.e. 200 ppm. In Poland, recovery of uranium appearing as admixture in copper layers in the area of Lubin–Sieroszowice is also possible. The content of uranium in the ore locally is approx. 60 ppm, the copper content being 2%. The total ore resource is 2,400 million tonnes, including copper – 48 Mio. t and uranium – 144,000 t; this is an equivalent of approx. 900 GWe-years. Yet another advantage in exploitation of these deposits would be reduction or radioactivity in copper purification waste.

Today, the annual production in the Lubin–Sieroszowice basin is around 569,000 tonnes of copper, the quantity of uranium dumped on heaps being approx. 1,700 t/year. This is an annual equivalent of fuel for ten NPPs of a total capacity of 10,000 MWe.

Due to lack of reliable and comprehensive studies made with respect to resources of uranium in Poland, one of the purposes of the actions defined in the *Programme of executive actions for the years 2009–2012*, annexed (Appendix no. 3) to *PEP 2030*, was *Identification of resources of uranium in the territory of Poland*. On request of ME, the Ministry of the Environment has ordered that a relevant analysis be carried out. 2010 saw completion of one of the subject-matters planned for delivery, whereby preliminary prospects were shown for documenting the deposits of uranium in Poland based on the archival data. On commission of the Ministry of the Environment, an *Evaluation of the potential occurrence of uranium mineralisation in Poland, based on the results of geological and exploration works* was carried out. Co-funded by NFEPWM, it has confirmed that uranium deposits do appear in Poland, whilst their accurate estimate will call for further examination.

In July 2011, another subject-matter was opened: *A project for geological research in view of seismic research to be carried out in order to identify the geological construction of north-central part of the Polish Peri-Baltic Syneclise area*. This venture was completed by Polish Geological Institute (PIG) by December 2011. This undertaking and the research work designed in its course will form the basis for initiating the research for the possible occurrence and exploitation of uranium in the Peri-Baltic Syneclise area, together with elaboration of a methodology for evidencing the uranium deposits.

The actions taken to explore the volumes of the domestic resources of uranium will be continued, with ME focusing on examining the potential of future exploitation of unconventional deposits.

13.3. SUPPLY OF THE PLANNED POLISH NUCLEAR POWER PLANTS WITH NUCLEAR FUEL

The safety of nuclear fuel supplies depends on the certainty of supplies of uranium concentrate, access to fuel cycle services, as well as certainty and reliability of transportation of nuclear materials across the fuel cycle, as well as transports of ready nuclear fuel. The principles of supplies of uranium and the services related to nuclear fuel cycle within the EU are regulated by the EURATOM Treaty.

The Euratom Supply Agency (ESA), a special organisation affiliated to EC, holds the option right with respect to nuclear materials produced within the EU, and offers assistance, in parallel, in entering into contracts for deliveries of fuel cycle materials and services coming from inside and outside the Community. What ESA moreover does is monitor the markets of uranium and fuel cycle services, and prepare recommendations in this respect. In situations of uranium supply being put under threat (which has never occurred so far), it may also initiate the building of reserves of this element. The ESA Advisory Committee has determined, in 2005, the following recommendations for a common policy of safe uranium supplies: diversification of supply directions, maintenance of adequate level of own reserves of uranium, and optimal use of the uranium market potential in order to increase the same, striving for covering the need for uranium by way of multiyear contracts, and, satisfying the needs for fuel cycle services within the EU.

50% of the uranium concentrate imported to cover EU's purposes comes from Australia, Canada, and Kazakhstan. The other large suppliers to the EU are South Africa, Namibia, and Niger (approx. 15% altogether). Bulgaria, Czech Rep., Slovakia and Hungary are the only EU members that import fuel assemblies from other sources (mainly, from Russia); however, these countries mainly import ready-to-use fuel (fuel assemblies/cassettes) comprising enriched uranium and devised for use with VVER reactors built according to the Russian technology. The first two of the above-enumerated countries, as well as Romania, exploit also the small deposits situated within their territories to meet their own needs. In a more remote future, there is also a possibility to cover the demand for uranium using the newly-discovered deposits in Finland, Portugal, Slovakia, Spain, Sweden, and Hungary, albeit these countries will probably allocate them to satisfy their own needs. Poland may use supplies of uranium from the same sources as are presently utilised in the EU. It is not to be precluded that Poland in will also set about, in a remoter future, exploiting its own uranium deposits.

Apart from ensuring supplies of uranium concentrate, essential from the standpoint of safe supplies of nuclear fuel is the access to the services consisting in conversion and enrichment of isotopic uranium. Conversion of uranium concentrate into the UF_6 form, which enables isotopic enrichment, is provided in 63% internationally by conversion plants situated in France, the UK, Canada, and the USA. Russia ensures delivery of about 33% of these services. The isotopic enrichment service is rendered, in more than 50%, by specialised establishments located in France, UK, the Netherlands, Germany, and USA. Russia's output potential as far as enrichment equals 45%.

An extremely important matter with regard to energy security of Poland is the possibility of building multiyear reserves of nuclear fuel. Amassing a 12- or 24-month reserve of such fuel is technically simple, since the annual fuel demand for a 1,000 MW(e), Generation-III NPP, with an output of 8 TWh per annum, is about 20 tonnes – for the exemplary PWR or BWR reactors. To compare, with a coal-fired power station of an identical output, approx. 2.5 million tonnes of high-calorie hard coal (or, 4 Mio. t of medium-quality hard coal) would have to be amassed; for an oil-fired power station, approx. 2.5 Mio. t of its fuel, and for a gas-powered one, approx. 1.0bn cubic metres of natural gas would be equivalent. To stockpile such supplies would be extremely difficult and costly. Moreover, reserves of nuclear fuel can be amassed at different stages of the fuel cycle, with use of various forms of contracting – long-term through to spot contracts, the latter used e.g. in purchases of uranium ore.

Acquisition of fabrication services (manufacture of ready-to-use fuel cassettes) for NPPs in the first phase of the functioning of nuclear power in Poland (e.g., for the first and second fuel input) will be related to the purchase of a specified technology. The practice applied internationally is provision by the technology vendor of the fabrication service for the first few years of the reactor operation (and, potentially, in the course of subsequent years) and access to data for third-party fabrication of fuel (in order to avoid monopoly practices).

In a later period, the NPP operator selects the uranium concentrate supplier as well as suppliers of the subsequent fuel-cycle services, i.e. conversion, enrichment and fabrication – based on the relevant market analyses and the delivery conditions offered. In the EU, fuel fabrication plants are located in Germany, France, Belgium, UK, Sweden, and Spain. Reactor fuels are manufactured for the needs of EU countries also in the U.S. As has been said, Russia only provides fabrication services to EU for the needs of Russian-made reactors (VVER).

Taking into account the factors and drivers described in this chapter, it is clear that the launch of nuclear power would by no means imply rendering Poland dependent upon monopolistic or uncertain foreign suppliers. This is true for mining of uranium as well as for the fuel cycle services, that is, conversion, enrichment, and fabrication of ready-to-use fuel assemblies. Furthermore, Poland has its own resources of uranium which might be used in the future as well.

CHAPTER 14. ADMINISTRATION AND MANAGEMENT OF RADIOACTIVE MATERIALS ACROSS FUEL CYCLE

14.1. RADIOACTIVE WASTE MANAGEMENT WORLDWIDE

Any activity related to production or application of radioactive isotopes is accompanied by generation of radioactive waste. Due to its special nature, radioactive waste must be handled in a specific way – at its gathering, processing/treatment, transportation, temporary storage, and final storage/disposal. For this reason, to limit the number of sources and the quantities of waste produced is an extremely important task.

Radioactive waste must be appropriately processed, solidified, packaged and, thereafter, safely stored and/or disposed. The basic goal of these activities is to safeguard radioactive waste so that it should pose no threat to humans and the environment.

The nuclear fuel cycle extends to a system of industrial operations and technological processes whose task is to prepare fuel for use in the nuclear reactor, burn it the reactor, and thereafter, process the spent fuel and store the radioactive waste generated. The main elements of the fuel cycle include: mining of the uranium ore, production of uranium concentrates, U_3O_8 into UF_6, conversion, enrichment of the uranium with the U-235 isotope, production of fuel materials, manufacture of fuel elements/assemblies, burning the fuel in the reactor, storage of the spent nuclear fuel, reprocessing of the spent nuclear fuel, processing of the radioactive waste generated, and, storage/disposal of the radioactive waste. All the operations from the mining of the uranium ore through to manufacture of fuel assemblies are carried out at a low level of ionising radiation, and compose the initial part (front part) of the fuel cycle. The operations with the spent nuclear fuel, from discharge of the fuel from the reactor core to emplacement of radioactive waste at a storage facility, are performed at a high level of ionising radiation toward the cycle's end.

The nuclear fuel cycle can be open-ended, open-ended with treatment, or closed. In an open-ended cycle, the spent nuclear fuel is ultimately stored. Taking into account the present prices of uranium, and the cost of the presently applied spent fuel reprocessing technology, the open-ended cycle involves lower cost than the cycle including reprocessing. The fuel being stored may in future be recycled, along with the technological progress. In the open-ended fuel cycle with treatment, the spent nuclear fuel is subjected to reprocessing, with the resulting recovery of fissile materials therein contained. They can be thereafter reused in manufacture of fresh fuel elements. A closed fuel cycle with multiple recycling of nuclear materials requires that fast breeder reactors be used; industrial application of the cycle is a matter of future developments.

There are different methods of handling spent nuclear fuel. Some countries, e.g. Sweden, Finland, and the U.S., apply the open-ended cycle; some others use open-ended cycle with treatment (planning to develop a closed cycle) – as in France, UK, and Russia.

The method of handling radioactive waste depends on the type of waste. For low and medium level radioactive waste, all the countries store the waste (sorted and compressed beforehand). The appropriate storage facilities are operated across the EU, also in Poland.

For highly active waste, such as spent nuclear fuel, deep storage in geological strata is devised. As aforesaid, this is the final phase of the fuel cycle.

The Waste Isolation Pilot Plant in Carlsbad, New Mexico, USA, is today the only deep storage facility for highly active radioactive waste functioning in the world (in operation since 1999). There are more facilities to come, presently under construction. Finland and Sweden have the most advanced programmes for construction of such storage sites within the EU. The existing delays in the building of deep storage facilities have mainly been caused by a low cost of storage of nuclear waste in storage installations available at the power plant sites.

14.2. HANDLING RADIOACTIVE WASTE IN POLAND

Management of radioactive waste appeared as a large-scale issue in Poland in 1958, the moment the first nuclear research reactor, named 'EWA', was activated at the Nuclear Research Institute (IBJ) in Świerk. This, along with a significant development of isotopic technologies, with the related increase in applications of radioactive isotopes in various areas of economy, has made it necessary to build a storage facility for radioactive waste. The facility was opened in 1961 in the locality of Różan, approx. 90 km away of Warsaw.

Responsibility for appropriate handling of radioactive waste in Poland rests with the manager of the organisational unit within whose area the waste has been generated. The storage of waste and transporting of waste to the storage facility is dealt with by a specialised institution, called the Radioactive Waste Disposal Enterprise (RWDE [ZUOP]), a State-owned public benefit corporation. RWDE is responsible for proper handling of radioactive waste since the moment the waste is taken over from the producer.

RWDE collects solid and liquid low and medium level radioactive waste, used and closed radioactive sources, and decommissioned smoke detectors. The 'MARIA' reactor is the main source (approx. 90%) of liquid low level radioactive waste. Liquid medium level radioactive waste is generated in manufacture of radioactive sources and, in some cases, in the course of decontamination of contaminated surfaces. Such waste is stored, following a treatment. The Polish Atomic Law specifies that radioactive waste can only be stored in solid state, contained in packaging that ensures safety of humans and the environment, in terms of radiological protection, while ensuring abstraction of heat, preventing the occurrence of critical mass, and keeping these factors under permanent control during the storage period as well as after the closedown of the storage.

A significant portion of radioactive waste (approx. 40%) is generated at the Świerk nuclear centre, and thus comes from the 'MARIA' reactor and from the plant producing radioactive isotopes used in medicine. The reactor-generated radioactive waste includes, for instance: filters (from coolant purification system and ventilation system), decontamination waste, or worn-and-torn elements of reactor apparatuses and appliances. The remaining 60% of solid radioactive waste comes from hospitals, clinics and other institutions making use of isotopic techniques all over the country. The waste generated while using radioactive substances for medical purposes primarily include: radioactive preparation ampoules, syringes, lignin, foil, protective clothing, worn-and-torn equipment elements, and decontamination waste.

Table 14.1. shows the balance of waste collected for neutralisation in 2004–2012. What it shows is that due to new technologies of isotope production and appropriate operation of nuclear technology

appliances, coupled with decreased applications of radioactive isotopes, the quantities of solid and liquid wastes collected have been systematically decreasing.

RWDE is also the operator and user of the National Radioactive Waste Storage Facility (NRWSF). NRWSF is situated in the locality of Różan on the Narew River, approx. 90 km off Warsaw, within a former military fort site, occupying an area of 3.045 ha. In operation since 1961, the NRWSF is a surface storage facility, according to the IAEA classification.

The facility is devised for storage of short-lived low and medium level radioactive wastes and for temporary storage of long-lived low- and medium- level wastes.

Table 14.1. Balance of waste collected for neutralisation in 2004–2012.

Specification	2004		2005		2006		2007		2008		2009		2010		2011		2012	
	Solid	Liquid	Solid	Liquid	Solid	Liquid	Solid	Liquid	Solid	Solid	Liquid	Solid	Liquid	Solid	Liquid	Solid	Liquid	Solid
Sources of radioactive waste	Beta- and gamma-radioactive																	
MARIA reactor (m³)	6.00	98.21	5.03	21.00	12.92	152.09	5.50	84.00	6.76	6.00	98.21	5.03	21.00	12.92	152.09	5.50	84.00	6.76
EWA reactor (m³)																		
OR POLATOM IEA (m³)	8.03	0.13	8.60	0.02	7.75	0.03	6.20	0.02		8.03	0.13	8.60	0.02	7.75	0.03	6.20	0.02	
RWDE (m³)	7.06		2.56	4.00	0.33	0.00	1.51	0 -	3.35	7.06		2.56	4.00	0.33	0.00	1.51	0 -	3.35
Institutions other than Świerk centre (medicine, industry, science) (m³)	31.39-	2.88	26.13	1.66	21.17	0.96	17.27	0.48	12.68	31.39-	2.88	26.13	1.66	21.17	0.96	17.27	0.48	12.68
Total	**52.48**	**101.22**	**42.32**	**26.68**	**42.17**	**153.08**	**30.48**	**84.50**	**22.79**	**52.48**	**101.22**	**42.32**	**26.68**	**42.17**	**153.08**	**30.48**	**84.50**	**22.79**
Categories of radioactive waste																		
Low- level (m³)	51.13	28.19	41.67	26.68	41.57	153.06	29.82	84.48	22.38	51.13	28.19	41.67	26.68	41.57	153.06	29.82	84.48	22.38
Medium- level (m³)	1.35	73.03	0.65		0.60	0.02	0.60	0.02	0.40	1.35	73.03	0.65		0.60	0.02	0.60	0.02	0.40
Alpha-radioactive (m³)	0.79		1.90		2.46		0.45		0.08	0.79		1.90		2.46		0.45		0.08
Smoke detectors (no. of pieces)	12,211		14,101		19,394		16,425		25,053		17,180		17,546		14,780		28,748	
Closed sources (no. of pieces)	619		825		1,397		1,508		2,675		3,802		5,328		7,616		3,170	
Waste delivered for storage at NRWSF Różan																		
Volume (m³)	33.03		36.30		67.95		48.88		73.41		42.8		57.7		52.4		34.2	
Activity (decay status as at 31st Dec. of the year) (TBq)	0.52		1.87		1.74		1.37		1.26		5.6		9.5		15.6		28.2	

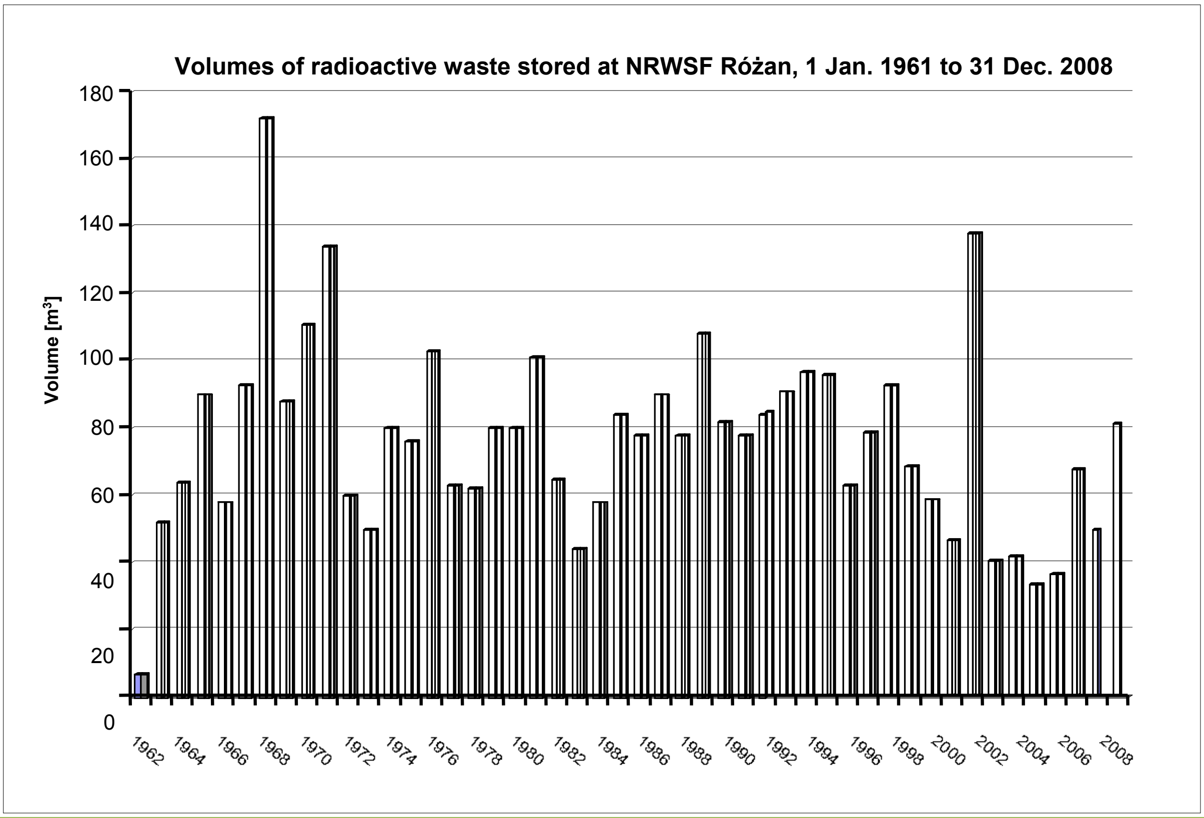
Source: RWDE

The quantity of processed radioactive wastes to be kept or stored is approx. 45 m³ per year. Once solidified, these wastes, in solid form, 70 tonnes in weight, occupy a space of 80 m³, of which 35 m³ is binding materials, mainly concrete. The solidified waste is transported to NRWSF in Różan.

As estimated by RWDE, the NRWSF will be filled up in as early as around 2024–5.

By instruction of the Minister of Economy o 27th August 2009[82], a team was established to develop a NPMRWSNF. The Team was joined by representatives of offices and institutions related to management of radioactive waste and spent nuclear fuel. Apart from determining the method of handling nuclear waste coming from various types of activity, the Team's basic task is also to propose a method of management of spent nuclear fuel as well as the assumptions and recommendations concerning further work in this area (recommendations on whether to apply in Poland an open-ended cycle or open-ended with treatment). The Team have analysed the cost of use of various methods for radioactive waste and spent nuclear fuel management. These analyses have become the basis for the recommendations regarding the method of handling spent nuclear fuel, taking into account the costs and benefits of each of the solutions considered.

Fig. 14.2. Volumes of radioactive waste delivered for storage between 1961 and 2008.



Source: RWDE.

In August 2012, the Minister of Economy approved the *Recommendations of the NPMRWSNF Elaboration Team* regarding management of radioactive waste and spent nuclear fuel.

[82] Instruction of the Minister of Economy of 27th August 2009 on the establishment of a team for development of a draft *National plan for the management of radioactive waste and spent nuclear fuel* (Minister of Economy's Journal of Laws, no. 3, item 30).

Based on the outcome of the Team's efforts and IAEA recommendations, a set of general rules of radioactive waste and spent nuclear fuel management have been determined:

- Design and build the system facilities, observing the most restrictive rules of nuclear safety;
- Minimise the amounts, volume, and toxicity of radioactive waste; sorting, processing/treatment, packing, and appropriate marking of packed radioactive waste for its content;
- Apply 'the pollutant pays' principle;
- Apply the open-ended fuel cycle, until there are conditions advantageous to the launch of a closed cycle;
- Monitor the storage, keeping, disposal and transportation of radioactive waste and spent nuclear fuel;
- Exports/imports of radioactive waste to be banned (save for spent nuclear fuel);
- Approach the threats, contingency procedures/emergency response and crisis management in an appropriate manner;
- Ensure transparency and public participation in making the relevant decisions;
- Carry out the indispensable public consultations, including trans-boundary consultations;
- Enter into extensive cooperation with international organisations and institutions dealing with radioactive waste and spent nuclear fuel management.

14.3. RADIOACTIVE WASTE MANAGEMENT IN POLAND: ACTIONS PLANNED FOR THE DEVELOPMENT OF NUCLEAR POWER

As far as financing of the management of radioactive waste and spent nuclear fuel is concerned, it has been envisioned to bring about the following solutions:

- Change in the legislation enabling the distribution of the amount defined in the Ordinance of the Council of Ministers of 10th October 2012 'on the amount of disbursement for coverage of the cost of handling spent nuclear fuel and radioactive waste and for coverage of the cost of decommissioning of nuclear power plant to be carried out by the organisational unit that has been permitted to operate such nuclear power plant'[83], into two portions, i.e.:
  - The write-off for the cost of handling radioactive waste and spent nuclear fuel will credit the Radioactive Waste and Spent Nuclear Fuel Storage Fund, such Fund to be supported by Nuclear Power Facilities' (NPF) operator(s). Further analysis needs being done for the method of managing such Fund.
  - The write-off for the cost of decommissioning will be made by the Nuclear Power Facility Decommissioning Fund, which will cover the expenditure necessary for the NPF(s) to be decommissioned. The Fund will lie in the hands of the NPP operator (the disbursement to be released following a positive opinion from the Chairman of NAEA). The funds amassed in the NPF Decommissioning Fund will come from payments made every year to the Fund by the NPF operator and from proceeds ensuing from investments of the Fund's monies made to the extent permitted by law. The funds gathered to be injected to the NPF Decommissioning Fund will be excluded from the operator's bankruptcy estate. These monies will be relieved from enforcement.

[83] I.e. JL 2012, item 2013.

Payments crediting the Fund are dependent on the quantity of electricity generated at the NPP. The amount of such write-offs will be cyclically updated, taking into account the costs of construction, operation, decommissioning, and monitoring of the facilities of the radioactive waste handling system, such costs/expenses to be changing in the following years.

The other processes of processing radioactive waste and treatment of spent fuel will be funded by the NPF operator.

Storage of radioactive waste and spent nuclear fuel will be performed by RWDE.

14.4. MAIN TASKS IN RADIOACTIVE WASTE AND SPENT NUCLEAR FUEL MANAGEMENT

The detailed tasks include:

A. For low- and medium-radioactive waste:

- prepare and carry out the close-down/decommissioning of the National Radioactive Waste Storage Facility in Różan (around 2024–5);
- select the location, construction, and commencement of operation of a new NRWSF for low- and medium level radioactive waste, with acquired public acceptance for these projects.

The most urgent task in management of radioactive waste, in connection with the fill-up of the NRWSF in Różan, is to build a new storage facility for low- and medium-level radioactive waste. As regards the selection of its site, ME has requested NFEPWM for the task to be made eligible for funding as from 2013. To this end, ME has selected, by open tender procedure, an entity to implement the task. The works will encompass analysis of the results of the existing studies. The archival geophysical material, for the locations now deemed archival, will be reinterpreted. Based on these analyses, three optimum site locations will be identified for the radioactive waste storage facility. For such chosen sites, detailed research is projected, which will finally lead to determining a single specified site for the storage facility for low- and medium- radioactive waste, which is envisaged for the year 2016. Once the site location is selected, design and construction work will be carried out, so that the new storage facility become fit for receiving radioactive waste by 2024 at the latest. This is a particularly important point, as the launch of nuclear power will entail enlarged scale of activities related to storage of low- and medium-active waste. In order to ensure adequate level of public support for the project, informative and consultative action will be necessary.

B. For highly radioactive waste and spent nuclear fuel:

- conduct works on implementation of an open-ended fuel cycle in Poland;
- perform the programme of research into deep storage of medium and high level radioactive waste: work and preparations for identifying the site for a deep storage facility of long-lived high level radioactive waste (GeoSOP – PURL).

Once the PNPP is approved, it is planned that ME, PIG, and the other interested institutions enter into an understanding for supporting the concept of deep geological storage of radioactive waste through constructing a Polish Underground Research Laboratory (PURL). The understanding is meant to:

1. Support scientific research aimed at mastering the technologies of deep geological storage and identification of geological conditions ensuring safe storage in deep geological structures whilst also fostering the development of scientific personnel and technologies indispensable for carrying out the future work.
2. Ensure coordination of these works in Poland.
3. Make the maximum use of international experiences in the field of geological storage of radioactive waste.
4. Provide the public with objective information on geological storage.
5. Support the formation of the Polish Underground Research Laboratory (PURL).
6. Support the operation of PURL, structurally forming part of PIG.
7. Make use of the PURL experience and transform PURL into an entity responsible for preparation and construction of a deep geological storage facility.

The purpose behind PURL is to:

- Coordinate the work in Poland and gather the results of the work done by various organisations;
- International cooperation;
- Scientific research;
- Enlarge knowledge on the geology of the potential storage facilities;
- Disseminate knowledge and render the actions transparent;
- Prepare the staff and organisational structures for making the storage facility operational.

In future, advantage will be taken of the gathered results of the research when it comes to identifying the site and to constructing a deep geological storage facility for spent nuclear fuel and highly active radioactive waste.

A solution was found to the issue of spent nuclear fuel from the research reactors as the agreements were concluded with the United States of America and the Russian Federation providing for exporting the fuel to Russia, the latter being the supplier of fresh fuel. Based on the experiences of some other countries, it will become necessary to have a spent nuclear fuel storage facility constructed approximately **thirty to forty years after** the first NPP is commissioned – i.e. around the year 2050, at the earliest. By the said time, the spent fuel will be stored within the NPP site, including in the storage facilities adjacent to the reactor. Although Poland has up to fifty years for commissioning such a storage facility (from the moment the first unit in the first NPP is delivered for commercial operation, i.e. 2024), the experiences of the other countries suggest that preparations in this respect ought to be initiated adequately beforehand. No option should be closed at the present-day stage of the work, in terms of the rock structures for construction of a spent nuclear fuel storage facility.

Along with the possibility to store the waste in a deep geological facility within Poland, there is an option to store such waste outside Poland. As per the Council Directive 2011/70/Euratom, this latter option is limited, and difficult to bring about. As a first variant, waste would be stored in one of the EU/Euratom Member States; in practice, however – in spite of no such ban in place on the EU/Euratom level – no Member State has accepted for storage within its territory any radioactive waste generated outside its boundaries. Storage in a third country is the other admitted variant.

However, the said Directive imposes certain restrictive requirements in this particular respect. First of all, in order to relocate the waste for storage in a third country, one has to make it certain that the following conditions have jointly been fulfilled:

(a) The country of destination has concluded an agreement with the Community covering spent fuel and radioactive waste management of, or is a party to the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management;

(b) The country of destination has radioactive waste management and disposal programmes with objectives representing a high level of safety equivalent to those established by the Directive; and,

(c) the disposal facility in the country of destination is authorised for the radioactive waste to be shipped, is operating prior to the shipment, and is managed in accordance with the requirements set down in the radioactive waste management and disposal programme of that country of destination.

The obligation to make sure that these conditions have been met rests with the Member State that has resolved to have its waste stored outside the EU.

The European Commission has, furthermore, to be notified of any agreement regarding storage of waste in a country not being member of the EU/Euratom.

In spite of such an option existing, presently, no country outside the EU has accepted radioactive waste from beyond its boundaries for storage within its territory[84]. While a potential change in this respect may be figured out, the current international conditions and the accepted standards of conduct virtually preclude the assumption of this option as a reference solution for PNPP, as at present. This remark also applies to the continuous technological progress in the radioactive waste and spent fuel handling technologies and techniques. Resulting from this progress, over the dozens of years when waste will be generated in Polish NPPs, new solutions may appear that will facilitate the procedure – for instance, by considerable reduction of the volume and/or activity of the spent fuel and radioactive waste. It has to be emphasised that the aforesaid changes and tendencies in dealing with radioactive waste and spent nuclear fuel, as coupled with the legal circumstances, will be strictly monitored; before the final decision is made as to the relevant solutions, all the options available at the time will be considered.

14.5. POSSIBILITIES OF BUILDING STORAGE FACILITIES FOR LOW- AND MEDIUM-LEVEL RADIOACTIVE WASTE AND DEEP REPOSITORY FOR HIGH LEVEL RADIOACTIVE WASTE AND SPENT NUCLEAR FUEL IN POLAND

These issues have already been considered for the purposes of the first nuclear programme in Poland (‘Żarnowiec’ NPP), with a series of examinations carried out to select the location for a deep storage facility for the spent fuel. The work was continued after the first nuclear programme was closed, in

[84] An exception in this respect is the programme for shipment of spent fuel from the research reactors to the country that supplies fresh fuel (which is Russian Federation, from the standpoint of Poland) as part of conversion of the research reactors from the highly enriched fuel to low-enriched fuel, as a result of non-proliferation activities under the Global Threat Reduction Initiative (GTRI). To this end, a series of agreements were concluded with countries having highly enriched fuel from their research reactors, on the one hand, and the U.S. and Russian Federation, on the other. This action is, however, single and unique, and has no relation with the operation of power reactors in NPPs. Poland’s participation is the project will have ended in 2014, the moment the whole of the spent nuclear fuel originating in Poland has been shipped to Russia. Since the ‘MARIA’ research reactor presently uses fuel from other suppliers, the question of handling the subsequent batches of spent fuel (including its potential storage within Poland) remains open.

1997–9, as part of NAEA's Governmental Strategic Programme 'Management of Radioactive Waste and Spent Nuclear Fuel in Poland'. One of the tasks in this Programme was to select the location and develop the concept of a radioactive waste storage facility in deep geological formations.

Resulting from the works conducted as part of the said Programme on selecting the location radioactive waste in deep geological formations, forty-four rock structures have been identified in the territory of Poland as potential locations of a deep storage facility for radioactive waste. These structures encompass igneous and metamorphic rocks, loamy formations, and salt deposits.

As part of the work conducted, the option to store radioactive waste in mining excavations or pits and surface geological formations, as well as in undeveloped deep geological formations, has been evaluated negatively. Also the areas of underground water reservoirs, of valuable minerals deposits, areas seismically active, areas located close to the sites of mining work or, at last, attractive in terms of nature and landscape have been assessed unfavourably.

In view of the above-listed results, it can be stated that Poland has both research capacity and knowledge which demonstrate a potential of management of spent fuel and radioactive waste within the country.

The information gained based on the research conducted so far will be used as a basis for further work. Since, however, the work being referred to was conducted more than ten years ago, it will not form the basis for making any specific decisions.

As part of the Programme, similar work was conducted also with regard to low- and medium-activity wastes; the potential for identification of a safe site for a new storage facility for such waste has been confirmed.

14.6. ESTIMATED COST OF HANDLING RADIOACTIVE WASTE AND SPENT NUCLEAR FUEL IN POLAND

PNPP is not decisive in the matter of the cost of handling radioactive waste and spent nuclear fuel. The amounts of spend on these activities will be defined at the stage of compilation and approval of NPMRWSNF. The present estimation of the cost, **totalling PLN 332,900,000**, is as follows[85]:

- Site location analyses for the storage facility: **PLN 6,000,000** – to be covered with NFEPWM funds.

The funds will be allocated for analyses and examinations, including geological surveys, which are meant to help select the best potential location for the new storage facility for low- and medium level radioactive wastes.

- Decommissioning/close-down of NRWSF in Różan:

[85] The estimate has been based on a justification to the Ordinance of the Council of Ministers of 10th October 2012 'on the amount of disbursement for coverage of the cost of handling spent nuclear fuel and radioactive waste and for coverage of the cost of decommissioning of nuclear power plant to be carried out by the organisational unit that has been permitted to operate such nuclear power plant' (JL 2012, item 1213).

- Preparation for the decommissioning (closing down) of NWSF in Różan: **PLN 8,900,000** – to be financed using the funds of the long-term programme *Construction of a new storage facility for low- and medium-active waste*, to be formed after the approval of NPMRWSNF;
- Safety evaluation for the decommissioning of NRWSF: **PLN 20,000,000**.

This action is to be funded using the NFEPWM monies. The analysis made as part of it will moreover enable to assess whether, and how, the closing of the storage facility in Różan would affect the safety of humans and the environment.

- Construction of a new storage facility for low- and medium level waste: **PLN 240,000,000**. This action is to be financed using the funds of the long-term programme *Construction of a new storage facility for low- and medium level radioactive waste*, to be formed after the approval of NPMRWSNF. This will be a modern facility, adapted for collection of radioactive waste also from NPPs. A possibility for processing a portion of the waste within the facility site has been envisioned, among other things.

- Delivery of NPMRWSNF: **PLN 4,000,000**. This task will be funded using MG's own monies, to be allocated for analyses, evaluations, and expert opinions/appraisals indispensable for compilation of reports on the delivery of NPMRWSNF and for keeping the Plan updated.

CHAPTER 15. PARTICIPATION OF THE POLISH INDUSTRY IN THE PNPP

Polish industry can, and indeed should, to the largest extent possible, participate in the tasks related to construction of Polish NPPs. The industry's involvement in the process means not only maintaining the existing jobs and creating new ones, but also a possibility to make a considerable technological leap. Such an approach is fully integrated with the long-term strategy of the country's development.

For many years, Polish industry has been rendering services or delivering products for nuclear power abroad, including for the needs of NPPs in France and Finland, whereas the number of companies involved in these projects encompasses several dozens of enterprises. The scope of the services provided or products delivered is quite broad: from performance of construction work, through assembly of wiring and cabling installations, instrumentation and automated control systems, up to the main elements of the reactor containment, or manufacture of appliances and machinery used in production of elements for NPP.

Hence, an essential element of PNPP is to make the most extensive use possible of the domestic industries. What it means is, on the one hand, an appropriately prepared technological offer, such that will include the participation of the Polish industry; on the other hand, it requires that Poland has enterprises capable of implementing the production and services tasks to the benefit of nuclear power, owing to their human, organisational, technological, and qualitative potential.

15.1. CONDITIONS OF DOMESTIC INDUSTRY'S PARTICIPATION

Participation of the domestic industry in construction of a Polish NPP will call for appropriate preparatory, training, and organisational actions to be taken mainly by Polish enterprises supported by the Minister in charge of economy and the investor, the latter being supported to this end by the technology offering enterprise.

The Minister in charge of economy will develop an efficient system for supporting the preparations of Polish enterprises for participation in construction of nuclear power facilities. Moreover, the Minister in charge of economy will be able to evaluate the system's operation, based on the data provided by the investor and by the Polish enterprises.

Provision of production and services for nuclear power purposes demands high technological competences from the participating enterprises, and calls for demonstration of the competence, adequate for nuclear power, with respect to personnel, organisation, and a quality assurance and control system.

PNPP concerns construction of NPPs of a high technological standard, in line with the statutory requirements as well as technological and quality standards as laid down in the relevant national and international regulations and provisions of law, and as required by the investor. All these requirements are classified depending on the component, product, appliance, or service provided. The quality management requirements, regardless of the class of safety, are set forth in the following documents and standards, inter alia:

- ISO 9001:2008 – Quality management;

- IAEA GS-R-3:2006 – The Management System for [Nuclear] Facilities and Activities – Safety Requirements;
- ASME NQA-1-2008 – Quality Assurance Requirements for Nuclear Facility Applications;
- RCCM A5000 – 2008 – Quality Assurance Principles.

The domestic subcontractors will also be obligated to observe the specific health-and-safety-at-work principles, e.g. those specified in OHSAS 18001, and the environmental rules, e.g. ISO 14001.

15.2. ACTIONS FAVOURING PARTICIPATION OF POLISH INDUSTRY

A. Assessment of the needs

The investor and/or its direct supplier of nuclear technology will determine a list of products and services whose delivery may be ordered to domestic enterprises. The list ensues from the awareness of objective factors and elements dependent on the local conditions (location, weather conditions, geology, standard represented by the contractors, etc.).

Orders for domestic companies will not be limited to technical or technological domains. They will also include legal and regulatory services, as well as organisational, design, transport, logistics, and the like services.

B. Evaluation of the potential of domestic industry and services

The investor and/or its direct technology supplier will announce the aforementioned list of products and services whose delivery may be ordered to the domestic enterprises in order to acquire the domestic enterprises' declarations of their participation in the construction of NPP. They will subsequently verify the received applications for technological and organisational status as well as competencies. The next step will analyse the enterprises that have displayed such interest, in order to determine their production or services potential. The selected enterprises may initiate their accreditation process through bringing about the necessary changes in their organisation, implementing quality control systems, adoption of new technologies, increase of production potential, reduction of their prime costs, etc. The analysis should also identify any costs or expenses indispensable for bringing about the changes.

C. Final analysis

A complete collection of data regarding the needs and the domestic enterprises will form the basis for a final analysis of the potential of using the national industry in PNPP. Resulting from such final analysis, the investor will receive the following information:

- a list of specified enterprises interested in the nuclear programme and capable of ensuring adequate quality of products and services delivered;
- a schedule of accreditation actions taken to make use of the specified providers of products and services;
- guidelines compiled to take advantage of selected domestic producers and service providers.

In order to arrive at a reliable assessment of the scale of Polish industry's participation for individual nuclear technologies, it would be helpful to develop a ratio of the use of Polish industry, which would determine the degree of involvement of domestic subcontractors in numerical terms. Such an indicator could take into account the global aggregated number of orders placed, headcount, improved competencies of the enterprises and improved skills of their employees, and the potential of using the enterprises in the subsequent nuclear power investment projects.

It has to be borne in mind that analysis of enterprises for their potential participation in the nuclear programme is carried out, likewise, by the prospective suppliers of products and services on their own, whilst their ‘accreditation’ for management and quality assurance systems is executed by the technology provider who is personally responsible for, and guarantees, the assurance of appropriate quality and standards of the services entrusted to it.

Of extreme importance will certainly be, moreover, the adaptation of Polish industry to the investment requirements characteristic of nuclear power, in order to deliver products and services for the nuclear power facility. Polish industry has to be aware of the challenges in this respect (apart from the elements such as quality assurance, technological standards, organisation, or competitiveness), and get prepared for development and reinforcement along these lines as well.

15.3. BENEFITS FROM PARTICIPATION OF POLISH INDUSTRY

One may expect positive effects, in macro-scale terms, in the sectors engaged in cooperation with the nuclear power sector. A maximised participation of Polish industries in the construction of PNPP should positively influence the Polish economy and industry. Polish economy will mainly benefit through increased employment related to the construction of NPP. The scope of this increase will be dependent on the scope of the nuclear programme itself. For each NPP, the subcontractors will be employing thousands of Polish workers associated, directly or indirectly, with the project under development. Increased employment translates into increased tax proceeds (direct and indirect), a growth in demand and supply, and other related benefits or advantages.

Attainment of higher competencies by an enterprise will enable it to deliver orders to the benefit of other nuclear power projects internationally, whilst also facilitating the winning-over of orders and commissions in the interest of industrial branches other than nuclear power.

Apart from technological, organisational or competency-related benefits, the enterprises taking part in the construction of NPP will also have a larger opportunity to enter into collaboration with similar enterprises having the required competencies and technologies, on a joint venture basis or by means of other measures, like equity links or organisational relations. This will ensure integration of Polish industry with the international nuclear power industry. Not only construction of NPPs could be the case: other fields, such as nuclear fuel cycle or radioactive waste management, could potentially be included. Especially the latter mentioned area is of interest to Poland, due to the necessity to build in this country a new storage facility for low- and medium level radioactive wastes.

The business operations of Polish enterprises related to construction of NPP ought to create an added value directly implying an increase in the GDP – an element to be taken into account in economic development forecasts for Poland, to be delivered by the Minister in charge of economy.

In June 2010, the Minister of Science and Higher Education commissioned the National Centre for Research and Development (NCBiR) to carry out a strategic research project on ‘Technologies supporting the development of safe nuclear power’.

On 30th September 2010, NCBiR announced competitions for performance of research tasks as part of the said strategic project, one of these tasks being 'Analysis of the potential and criteria of Polish industry's participation in the development of nuclear power'.

ME is getting prepared for choosing the contractor for the task consisting of stocktaking of the national industrial potential that could, or should, begin its preparations for applying for delivery of orders whose quality class is as required for the nuclear industry. The aforementioned study, the analyses performed as part of the NCBiR project, and the consultations with the Polish enterprise sector – particularly, with business self-government chambers, will provide the basis for ME to take further action in this respect.

CHAPTER 16. PUBLIC INFORMATION AND EDUCATION IN THE FIELDS OF NUCLEAR POWER AND DELIVERY OF PNPP

Stable and conscious public support for nuclear power is one of the major conditions for implementation of PNPP. It is based on public access to reliable and updated knowledge and information on nuclear power and the progress of PNPP. It moreover calls for a broad consensus and political consistence at the stage of preparation and implementation of PNPP, as well as appropriate regulations in this respect. It is also necessary to observe and take into account the opinions of the stakeholders and, in the first place, the opinion of local communities in the areas being the prospective locations for NPPs.

The process of public information and education must be a continuous action delivered at the preparatory and implementation stage of the PNPP. Knowledge on nuclear energy and nuclear power engineering is complex; moreover, these issues are burdened with numerous myths and negative associations.

16.1. STATE OF PLAY

At present, the support for nuclear energy in the Polish society fluctuates between 40% and 56%, according to various surveys. It ought to be observed, however, that the signalled lack of sufficient public knowledge in this respect remains a considerable issue. This is clearly indicated by the public opinion polls commissioned by various institutions.

Both ME and the Investor have been implementing an array of informative actions regarding nuclear power, including, as its part, the information campaign 'Learn more about the atom. Let's talk about Poland with energy', being an ME project, as well as within PGE's information campaign 'Knowingly about the atom'. The consulting and debating process has involved a number of various stakeholder groups, including local governments, business self-governments, economists, energy experts, sociologists, activists of organisations and institutions opposing nuclear power, exponents of public trust professions (teachers, fire brigade officers, police officers, doctors etc.).

The National Atomic Energy Agency pursues its information-related actions, as required by the law.

As far as dissemination of knowledge on nuclear power is concerned, the National Centre for Nuclear Research as well as the Institute of Nuclear Chemistry and Technology conduct intense activities; the same, albeit in a lesser degree, is true about some university-level schools.

16.2. REQUIRED ACTIONS

As provided by the Polish Atomic Law, the Minister in charge of economy is obliged to pursue actions in the fields of public information, education and popularisation, as well as scientific and technological and legal information regarding nuclear power. The Law also specifies the obligations of Chairman of NAEA as regards informing on NSRP.

In order to increase the reliable public knowledge on nuclear energy (and, as part of it, knowledge of nuclear power), it is necessary that educational and informational actions be conducted on a regular basis. Any such actions should be mutually correlated, coordinated, and pursued in parallel to one another, aiming at attaining a level of knowledge that enables understanding and realistic assessment of technologies, as well as the related benefits and risks – whilst also enabling to take a position in the matter, on a well-informed basis.

Educational activities ought to be conducted beginning with the lowest levels of the education system – i.e. from the primary and junior high school. The Investor should support these activities as part of its Business Social Responsibility policy as well as through cooperation with institutions educating the personnel for nuclear power purposes.

Informative activities in the area of nuclear power will be conducted by ME, PGE, RWDE, and NAEA. Such activities need to be carried on two levels:

- countrywide, and,
- local – in the considered and assigned locations for nuclear facilities. The Investor ought to be responsible for such actions, in the first place.

Informative actions and some educative activities on the local as well as countrywide level should be carried out and financed by the Investor, owing to their importance for efficient conduct of the project and, thereafter, functioning of the NPP.

The informative activity of the institutions responsible for it should be systematic, reliable, open, and transparent. The Polish society generally considers nuclear power an important topic; the social research has shown that over 90% of Poles expect information actions to be taken in this respect.

The public communication in the area of nuclear power ought to be enriched with dialogue with the citizens and with the interested social organisations and institutions (bidirectional flow of information). Such communication should take account of the use of feedback from the stakeholders. The experiences ME has gained so far indicate and confirm, moreover, that the direct dialogue and consultation with citizens and social organisations is legitimate. It may be delivered by organisation of workshops, meetings, or debates. Such initiatives reinforce public involvement in the implementation of the nuclear project, while also enhancing the stakeholders' sense that they are of importance in this process.

Encouraging the stakeholders to get involved in such activities remains some sort of a challenge. A clear communication policy of institutions responsible for communication activities in the area of nuclear power builds trust towards projects implemented by these institutions.

16.3. PROPOSED ACTIONS

16.3.1. INFORMATION ACTIONS

In the process of planning and implementation of nuclear power, a task of real importance will be to pursue reliable and professional informing and popularising actions, and such that will enable public participation in making decisions to be implemented under the principles and by the procedure of the Polish Atomic Law and the Act 'on disclosure of information on the environment and its protection, participation of the public in environmental protection and on environmental impact assessments'.

Communication actions will be carried out based on the best practices, with support from firms specialising in mass communication. The interested stakeholders will benefit from meetings, discussions, debates and workshops organised for the purpose, study visits to countries developing nuclear power, and a series of other actions or activities which may prove legitimate and justified.

The Local Information Centre (LIC) will be an important element of public communication. Every investor is obliged to form such a LIC within the commune being the prospective location of a nuclear power facility, by the date the permit for construction of the nuclear facility is requested, at the latest. The investor is thereafter bound to run the Centre's operations until the decommissioning of NPF is completed. The LIC will be the information desk where the investor and, subsequently, the operator will conduct the informational, educational and promotional actions in the domain of nuclear power. The Investor has alreadylaunched such local centres in Choczewo, Gniewino and Krokowa.

The local community of the commune(s) being the prospective NPF location may establish a Local Information Committee (LIC) whose role is that of a link between the local community, the investor, and the NPP operator. The LIC will be composed of the commune representatives appointed by the village heads or city mayors, along with representatives of the local community. The LIC's tasks will include ensuring public monitoring of the operations of the NPF, informing the local community on the NPF's operations, and representing the local community in contacts with representatives of the NPF. LIC will be allowed to enter the NFP area, access NPF's documents or records (save for those containing legally protected secret or sensitive information, including documents related to physical protection of NPF and safeguards of nuclear materials), appoint third-party experts, and demand upon the NPF investor/operator to share legitimate information in any matter of interest to the Committee.

The commune within which the construction project is planned, with the NPF to be constructed or to function there, may set up a Communal Information Point (CIP) where its communal information, education and promotion policy with respect to nuclear power will be conducted.

In parallel, regardless of the informative action taken locally, the operator of the NPP, the moment it is commissioned and started up, is obliged to reply in writing to any requested information – regardless of the requester's factual or legal interest – regarding the nuclear facility's condition with respect to NSRP, the facility's impact on human health and natural environment, and the volumes/quantities and isotopic composition of radioactive substances released to the environment. The operator is obliged, under the Polish Atomic Law, to publish such information on its official website, not less frequently than every twelve (12) months.

Moreover, the NPP operator is under obligation to forthwith notify the NAEA Chairman, the Province Governor (Voivode) and the authorities of the county (*poviat*) and commune (*gmina*) where the nuclear facility is located, and the authorities of the adjacent communes, of any occurrences or incidents within or related to the NPP that may cause, or have actually caused, a threat. Any unscheduled occurrence that implies a threat is notified by the NAEA Chairman in the Public Information Bulletin (on the publishing entity's official website).

The operator is also obliged to give access, on its official website, to information of any threat-causing occurrences or incidents having appeared within the last twelve (12) months.

16.3.2. EDUCATION ACTIONS

As shown by public opinion research, the knowledge on power industry, nuclear power, ionising radiation, and nuclear physics is still very poor in Poland. Hence, continual educative action, thanks to which nuclear power decisions – whether supportive or negative – will gain a stronger substantive foundation, is a must.

Educational actions related to nuclear power, targeted at the society as a whole, are carried out by the competent ME cell – for nuclear power, and NAEA – for NSRP, in line with the Polish Atomic Law. It is legitimate that the other institutions (RWDE, the Investor, …) conduct such actions as well. An important element of educational action will be the education offer targeted at primary, junior high, and upper-secondary students and teachers. Education-oriented actions will encompass: training the teachers and enriching their skills and tools (preparing scripts for classes, object lessons, preparation of interactive presentations and educational materials), organising conferences, seminars, lectures, exhibitions, competitions, excursions, and the like.

The public education will be carried out using all the available forms of communication (internet, television, radio, daily press, periodicals, trade press), including ‘Scholaris’ – the specialist knowledge portal for teachers.

APPENDIX NO. 1

A construction schedule of the first Polish NPP, as proposed by the Investor

Milestone	Final date
Adoption of Atomic Law and Investment Act	Q2 2011 (done)
Preparatory work to commence	Q1 2012 (done)
Selection of site location and environmental research contractor	Q1 2013 (done)
Selection of site location	End 2014
Acquisition of funds to commence	2014–2018
Selection of a consortium as part of integrated procedure, correlated with environmental decision	Until end 2016
Obtaining a complete set of permits, including site location decision, connection agreement, NAEA Chairman's permit for construction of the facility, Minister of Economy's decision-in-principle, building permit	Until end 2018
Work to be commenced by reactor technology provider and the main contractor; EPC – Final Investment Decision	2020
First NPP unit to commence operation	Q4 2024

The schedule provides that the first NPP unit may start operating in 2024. The possibility that the construction will have been completed within the assumed timeframe will have to be finally confirmed by the main contractor – such contractor to be selected resulting from an integrated tender procedure – and synchronised with the demand for electricity and the power consumption plan.

Sustaining of the timeline assumed for construction of NPP implies exposure to multiple risks. The project's key risks, in this respect, are connected with obtaining the required formal and legal decisions as well as with acquisition and assurance of the funding of the project, such funding being strictly depended upon implementation of the necessary mechanisms securing the project's balance-sheet risk.

Chapter 7 hereof – 'PNPP Implementation Costs and Sources of Funding' (see items 7.2. and 7.3.) deals with the costs/expenses and methods of funding of the investment project in question.

APPENDIX NO. 2

PNPP implementation expenditure envisioned for the years 2014–2024

No.	Task description	Expenditure until 2024	Thereof, expenditure as for2014–2017			
			2014	2015	2016	2017
	1	2	3	4	5	6
1.	Necessary expert evaluations and analyses concerning legal framework determining the functioning of nuclear power; thereof:	2,750*		400*	350*	300*
	• ME	2,000*		200*	200*	200*
	• NAEA	750*		200*	150*	100*
2.	Analyses related to implementation and update of Nuclear Power Programme (ME)	2,000*		200*	200*	200*
3.	Personnel education programme for institutions dealing with nuclear power	22,330		1.070	680	950
	• ME	2,340*		540*	150*	420*
	• NAEA	3,600*		400*	400*	400*
	• MSHE	16,000**				
	• National Fire Service	360*		120*	120*	120*
	• Border Guard	30*		10*	10*	10*
4.	Information and education campaign on nuclear power (ME)	22,850*		1,650*	6,350*	6,150*
5.	NAEA prepared for acting as nuclear and radiological regulatory authority, along with other services and institutions necessary to implement nuclear power; thereof:	8,913*		606*	721*	1,028*
	• NAEA expenditure on CEZAR	8,521*		606*	721*	1,028*
	• National Fire Service (purchase of apparatus)	392*				
6.	Adaptation of scientific and research infrastructure (MSHE budget)***	165,000	15,000	15,000	15,000	15,000
7.	Search of uranium resources in the territory of Poland, thereof:	24,000	2,000	2,200	2,200	2,200

	• NFEPWM funds	22,000	2,000	2,000	2,000	2,000
	• ME budget	2,000*		200*	200*	200*
8.	Polish industry prepared for participation in PNPP (ME)	4,000*		1,000*	400*	400*
9.	Cost of participation in international organisations and research programmes (ME budget)	13,200	1,200	1,200	1,200	1,200
	TOTAL	**265,043** **Thereof:** **48,843*** **16,000**** **(Personnel training conducted by MSHE as part of Human Capital Operational Programme)**	**18,200**	**23,326** **Thereof, long-term programme funds:** **5,126**	**27,101** **Thereof, long-term programme funds:** **8,901**	**27,428** **Thereof, long-term programme funds:** **9,228**

* State budgetary funds within the multi-year programme of PNPP implementation, incl. PLN 15,000 from the administrators' limits, without increasing the limit amounts.

** This task is to be delivered as part of an agreement for provision of financial support to the systemic project 'Development and implementation of a training and traineeship system in nuclear power and exploitation/operation technologies and identification of shale gas resources' as part of 'Human Capital' Operational Programme, co-funded using the monies of the European Social Fund, entered into by NCBiR (the intermediating institution) and MSHE (the beneficiary). The project is to be delivered in 2013–15, with a budget of PLN 32 million. The exact amount allocated to personnel education in nuclear power may be quoted only after competitions have been carried out for organisation of traineeship/training trips (the programme being a joint one for shale gas technologies and nuclear power). Moreover, due to the project's character, the amount is not distributable on an annual basis (it might happen that the monies, in their entirety, be expended within a year; the project is to be delivered till end 2015).

*** Pursuant to the Science Financing Principles Act of 30th April 2010 (JL No. 96, item 615, as amended).

The tasks listed as Nos. 6 and 9 are funded based on the expenditure incurred by individual administrators within the partial limits (without the right to increase the limits by inclusion of expenses due to implementation of new tasks under PNPP).

APPENDIX NO. 3

Conclusions of the draft PNPP evaluation report

	Recommended action(s)	Timeframe
Nuclear power is indispensable for the Polish economy, in economic as well as environmental terms.	The public ought to be made aware of the benefits stemming from nuclear power plants, once built and made operational.	The actions should be implemented systematically and in an urgent fashion, so that the public become aware of the benefits from nuclear power by 2020.
Government of Poland ought to look after the development of research infrastructure, in order for PNPP to be implemented efficiently.	It is recommended that power engineering experts have their research activities facilitated by access to new technologies, innovations, and support with extra funding.	Continuous process.
Research has shown that a concrete location should be selected for Poland's first NPP.	It is recommended that the location for the first NPP be selected, so that implementation of PNPP can be accelerated.	Ideally, completed by 2013, so that NPP can be in place by 2020.
Polish society's knowledge on nuclear energy proves unsatisfactory, which ultimately adversely affects the efficiency and effectiveness of PNPP.	It is recommended that an education programme on nuclear power be launched to encompass all the schooling levels, from junior secondary upwards.	This action ought to be commenced from the next school year onwards.
Through various means of mass communication, Poles tend to receive negative information on nuclear power.	Transmission of reliable and positive information on nuclear power needs being increased. Advertising and social campaigns are the means to be used to this end.	Advertising and social campaigns to be prepared at a possibly early stage, so that they can be implemented from 2012 onwards.
Research has shown that government organisations should recruit well-educated specialists who will be responsible before the Polish Government.	It is recommended that funds be allocated for creation in government organisations of new posts for nuclear power experts.	Continuous process.
Analysis of the research conducted and expert opinions has basically found that management of radioactive waste remains unclarified, which might adversely affect the efficiency of PNPP.	It is recommended that the issue of radioactive waste be clarified, and the technique/technology and location for storing such waste selected.	The location site for storage of nuclear waste should be selected together with the location site for the first NPP.

APPENDIX NO. 4

Conclusions of the *Strategic Environmental Impact Assessment of the Draft PNPP*

An assessment of the effects of implementation of PNPP is comprised in the *Forecast Environmental Impact of the Polish Nuclear Power Programme*. The conclusions of the strategic evaluation, specifying the justification of the approved Programme, are contained in 'A written summary comprising the results of the strategic environmental impact assessment and a justification of the selection of the Polish *Nuclear Power Programme*'. The following provisions have been added to PNPP, through this Appendix no. 11, resulting from the strategic EIA in question:

- The primary goal and a positive environmental effect of implementation of NPPP is to **minimise adverse impacts connected today with the operation of the power sector, especially through reduced social costs related to production of energy, and reduction of greenhouse gas emissions.**

- From the standpoint of environmental assessment, an aspect of extreme importance is to select the locations for the NPPs to be built. **In selecting the site location, the technological potential and economic effectiveness of cogeneration of heat and electricity in the NPP ought to be taken into account and analysed**. As demonstrated in the *Forecast Environmental Impact of PNPP*, this particular option enables to considerably minimise the adverse environmental effects of NPP. **The possibility to apply a cogeneration system should be one of the factors taken into consideration when it comes to selecting the site location for the first NPP in Poland.**

- **Actions limiting the possible scale of social conflicts:**
  The development of new directions of acquisition of electricity in Poland – the development of nuclear power in particular – must be based on public consent and acceptance. Nuclear power should be developed in a manner preventing escalation of potential social conflicts, ensuring complete transparency of the actions and dialogue with all the parties interested in the matter. Apart from application of the best practices and technologies ensuring safety and security of the NPP, it is important that the intended goals be delivered – which means to provide inexpensive and 'green' energy, caring for the condition of the environment and improving the quality of life of the country's inhabitants. NPPs must finally become an element diversifying the sources of energy, leading to satisfaction of the needs and ensuring the country's energy security. Each citizen must have the indispensable right to be informed about the functioning of the NPP and its influence on the surrounding environment (to the extent such information poses no threat to the facility's safety). To this end, introduction of an information and education programme is a must. Yet, **such a programme must not be a propagandist vehicle for nuclear power. It should, instead, provide the public with reliable information, pointing out to the assets and shortcomings of nuclear energy and defining its place amongst the other methods of energy acquisition.**

- **<u>Actions at the environmental impact assessment stage:</u>**

  – Taking into account, in a comprehensive manner, the indispensable infrastructure which must be built for the purposes of NPP site location; issuing one environmental conditions decision for the entire undertaking.

  – Following the indispensable research and analyses for a minimum of two equivalent site locations indicated by the Investor as part of EIA, the final site location for NPP will be selected (decision on environmental conditions for the accomplishment of the investment project). The EIA for the specified technology and site will be carried out at the stage of so-called environmental impact reassessment, within the process of requesting the building permit. The EIA process will be carried out with public participation. Such approach guarantees that environmental issues will be considered at the same level of significance as the social and economic issues.