WRITTEN SUMMARY OF THE STRATEGIC ENVIRONMENTAL ASSESSMENT RESULTS

AND JUSTIFICATION FOR THE SELECTION OF THE POLISH NUCLEAR POWER PROGRAMME

INDEX OF ACRONYMS

ExternE	External costs of Energy
NPP	Nuclear Power Plant
EIA	Environmental Impact Assessment
GeoSOP	deep storage of radioactive waste (in rock structures)
SWB	Surface Water Body
GWB	Ground Water Body
NRWR	National Radioactive Waste Repository
RES	Renewable Energy Sources
OBMP	Oder Basin Management Plan
VBMP	Vistula basin management plan
NPDP	Nuclear Power Development Programme
WFD	Directive 2000/60/EC (Water Framework Directive)
CSWB	Combined Surface Water Body
SEA	Strategic Environmental Assessment
SEIA	Strategic Environmental Impact Assessment
RWR	Radioactive Waste Repository
EIA ACT	The Act of October 3, 2008, on the Provision of Information on the Environment and its Protection, Public Participation in Environmental Protection and Environmental Impact Assessments (Dz. U. [Polish Journal of Laws] 2013 item 1235 with changes)
US NRC	United States Nuclear Regulatory Commission

1. SUMMARY OF THE STRATEGIC ENVIRONMENTAL ASSESSMENT

On January 13, 2009, by resolution no. 4/2009 of the Council of Ministers on nuclear power development activities, a decision on elaboration of the Polish Nuclear Power Programme (PNPP) was taken of the following wording:

"*In order to ensure national energy security and with a view to economic development, the Polish Nuclear Power Programme will be prepared and implemented. The Government Plenipotentiary for Nuclear Power will prepare and present to the Council of Minister a draft of this programme which shall determine the number, size and possible locations for nuclear power plants. Also, the Government obliges the Minister of the Treasury to ensure cooperation of the Polish Energy Group (Polska Grupa Energetyczna S.A.) in terms of preparation and implementation of the programme."*

On November 10, 2009, the Council of Ministers adopted the "Energy Policy of Poland until 2030". In the document, it was highlighted that one of the primary directions of Poland's energy policy is: "*diversification of the electricity generation portfolio by introducing nuclear energy*". Adoption of the policy followed the strategic environmental assessment of the implementation results of the Energy Policy of Poland until 2030, as part of which public consultations were conducted.

From the perspective of the procedure and this summary it should be emphasised that the Polish Nuclear Power Programme is not a document which introduces nuclear power to Poland or considers viability of such actions (since it has been already done in the Forecast for the Energy Policy of Poland until 2030). The Polish Nuclear Power Programme constitutes a framework and schedule of activities necessary to implement objectives and directions of the Energy Policy of Poland until 2030. The Polish Nuclear Power Programme depicts the scope and structure of organisation of the activities that should be undertaken in order to implement nuclear energy and ensure safe and effective operation of nuclear facilities.

Works on development of a draft Polish Nuclear Power Programme were in the course from July 2010 to September 2010. Development of the draft resulted in a necessity to conduct the procedure of strategic environmental assessment. Therefore, on **August 5, 2010**, the Ministry of Economy submitted a letter to statutory bodies: General Director for Environmental Protection and Chief Sanitary Inspector – with a request to present the scope and the level of detail of the information required in the Forecast of the Environmental Impact Assessment.

The Chief Sanitary Inspector and the General Director for Environmental Protection specified the scope of the Forecast accordingly **on September 2 and 20, 2010**.

Based on the scope specified by the two bodies, the Ministry of Economy, by means of an open tender, appointed the contractor which under the agreement no. IV/640/15004/4390/DEJ/10 of … developed the Forecast of the Environmental Impact Assessment for the draft Polish Nuclear Power Programme. Works on the Forecast were completed on **December 27, 2010**.

Opinions of competent bodies

On June 10, 2011, the Ministry of Economy imparted, pursuant to Article 54 section 1 of the Act of October 3, 2008, on the Provision of Information on the Environment and its Protection, Public Participation in Environmental Protection and Environmental Impact Assessments [Dz. U. (Polish

Journal of Laws) 2013, item 1265 with changes], the draft Programme along with the Forecast to the General Director for Environmental Protection and the Chief Sanitary Inspector. The bodies issued their opinions on the following dates:

- The General Director for Environmental Protection on September 15, 2011.
- The Chief Sanitary Inspector on February 1, 2011.

Public participation procedure

On December 30, 2010, the Ministry of Economy commenced the procedure with public participation. Initially, the time limit for submission of comments was 21 days. After numerous comments received from interested entities, the time limit was extended to 3 months, i.e. until March 31, 2011.

16 different entities took part in the national public consultation. Remarks were submitted in relation to both the Polish Nuclear Power Programme and the Forecast of the Environmental Impact Assessment drawn up for the Programme. All remarks were catalogued in a table and divided into 232 themes. Written responses, which contained information about adoption or rejection of the comment, were prepared for each of the themes. The table was published on May 16, 2011.

On November 25, 2011, a potential Investor for the first Polish nuclear power plant – Polska Grupa Energetyczna S.A. disclosed the list of three locations of nuclear power plants to the public, which would be interested. One of the locations was not included in the draft Programme and is not subject to assessment in the developed forecasts. Because of it, Ministry of Economy has prepared the appropriate changes of the draft Polish Nuclear Power Programme and of the Forecast of the Environmental Impact Assessment. Therefore, the Ministry of Economy prepared appropriate changes to the Forecast of the Environmental Impact Assessment for the PNPP and to the Programme. The changes took into account both the opinion of the General Director for Environmental Protection as well as of the Chief Sanitary Inspector, issued pursuant to the Article 54, section 1 of the Act of October 3, 2008, on the Provision of Information on the Environment and its Protection, Public Participation in Environmental Protection and Environmental Impact Assessments [Dz. U. (Polish Journal of Laws) 2013, item 1235 with changes.

On January 12, 2012, the Ministry of Economy commenced the public participation procedure for the amended draft of the Polish Nuclear Power Programme and the Forecast for the Programme. The documents were published in the Public Information Bulletin of the Ministry of Economy. Comments and proposals could be submitted within 21 days, i.e. until February 2, 2012.

Cross-border proceedings

On July 18, 2011, the General Director for Environmental Protection sent an official notification pursuant to the Article 10 section 1 of the Strategic Protocol, with the information that the Ministry of Economy of the Republic of Poland was developing the Polish Nuclear Power Programme, to 10 European countries directly bordering Poland, including countries bordering the Baltic Sea and countries which expressed their interest in participation in cross-border proceedings in advance (Austria).

There were 10 notifications sent on July 18, 2011. All countries confirmed their receipt and responded. Austria, Sweden, Finland, the Czech Republic, Slovakia, Germany and Denmark declared participation as Affected Parties. The countries requested an extension of the 21-day time limit for public participation until the end of October 2011.

On August 11, 2011, all of these 7 countries received the official information about extension of the time limit for submission of comments until October 31, 2011. Estonia, Latvia and Lithuania withdrew from the proceedings. However, they stressed that they wanted to be notified, as Parties potentially affected, at the stage of the proceedings concerning the environmental impact of the undertaking consisting in construction of a nuclear power plant (EIA).

Germany, Austria and Finland requested another extension of the time limit for public procedures, justifying their requests with equal treatment of the society of the Party of origin and the society of the Affected Party. In order to ensure equal treatment between all Affected Parties, the Ministry of Economy, consenting to the request of Germany, Austria and Finland, decided to extend the time limit for submission of public comments and objections until January 4, 2012, additionally extended by the time necessary to send them by post.

As on November 25, 2011, the Investor (PGE S.A.) disclosed the list of three possible locations of nuclear power plants to the public (one of which – Gąski – was not taken into consideration in PNPP) an update of the draft Polish Nuclear Power Programme and of the Forecast of the Environmental Impact Assessment was necessary. Therefore, an updated version of the PNPP draft and of the Forecast of the Environmental Impact Assessment was delivered to the Affected Parties in January 2012 along with the necessary translation into German and English, and with request to make it accessible for public participation for 21 days.

Then, all positions of the Affected Parties (from 7 countries) were received, and the public participation in all the affected countries was finalised. The Ministry of Economy prepared written answers which were served to the affected countries.

On July 23, 2012, cross-border consultations were held with Slovakia. On November 22, 2012, consultations were held with Austria, on November 27, 2012 – with Germany, and on December 4, 2012 – with Denmark. The other countries (Sweden, Finland, Czech Republic), submitted comments in writing and informed about no need to meet.

At the consultation meetings, discrepancies were clarified and questions submitted already during the meeting were answered. The necessary supplementations to be sent to the affected countries were agreed upon, and initial consents to sign protocols were expressed. After the supplementations were sent, the following protocols were accordingly singed:

Affected country	Protocol signature date
Austria	**6 May 2013**
Slovakia	**20 September 2012**
Germany	**4 April 2013**
Denmark	**10 February 2013**

Description of works on the final version of the Polish Nuclear Power Programme

On June 18, 2013, on the basis of the national and cross-border consultations, a draft of the written summary referred to in art. 55 of the Act of October 3, 2008, on the Provision of Information on the Environment and its Protection, Public Participation in Environmental Protection and Environmental Impact Assessments (Dz. U. [Polish Journal of Laws of 2013, item 1235, as amended) was prepared. It was decided, however, that in result of the national and cross-border consultations conducted as well as changes in the conditions and framework of the Programme, resulting from the passage of time, there was a need to update the Programme. The works on the update were commenced in July 2013 and ended, respectively, in September 2013 (Stage I) and December 2013 (Stage II).

In the meantime, the Management meeting on July 3, 2013, decided to include the Programme in the meeting agenda of the *Interdepartmental Team for the Implementation of Energy Policy* in Poland to 2030, and then to the ME Management for re-examination.

On July 9, 2013, the PNPP Programme was disputed by the Interdepartmental Team. The Team recommended to consult the contents of the PNPP Programme with its members. The consultations were held between July 15 and August 20, 2013. Comments to the Programme were submitted by:

- Chancellery of the Prime Minister
- Minister of State Treasury
- Minister of Transport, Construction, and Maritime Economy,
- Minister of Finance

The Programme was also included in the agenda of the meeting of the Interdepartmental Team for Polish Nuclear Energy, which on August 29, 2013 approved that interdepartmental arrangements should be conducted.

On September 25, 2013, the Programme was finally accepted by the Management of the Ministry of Economy and referred for interdepartmental arrangements. The arrangements lasted until December 15, 2013.

On December 19, 2013, the Programme was referred for examination to the Standing Committee of the Council of Ministers. On January 2014, the Committee of the Council of Ministers accepted the Polish Nuclear Power Programme and recommended it to the Council of Ministers for approval. The Council of Ministers approved the document on the meeting on January 28, 2014.

The updated Programme takes into account the comments of individual departments as well as current legal status and economic conditions. In section 2.3.3., this written summary takes into account also the results of the current economic analyses.

The Programme was published in the Polish Monitor MP / 2014/502 on 24 June 2014.

2. JUSTIFICATION FOR THE ADOPTION OF THE PROGRAMME IN THE CONTEXT OF THE MOST IMPORTANT COMMENTS, CONCLUSIONS AND FINDINGS STEMMING FROM THE STRATEGIC ENVIRONMENTAL ASSESSMENT

As part of the strategic environmental assessment, the public participation procedure and the cross-border environmental assessment procedure were conducted. Opinions on the documents were expressed also by relevant bodies. Comments and proposals concerned, both in the case of the national as well cross-border public participation procedure, the following aspects:

- Objections and concerns of a part of the Polish society about the introduction of nuclear power in Poland
- The conduct of proceedings of the strategic environmental assessment and the environmental impact assessment for the project
- Economic assumptions and results of the analyses of the electricity generation subsector, contained in the Programme and the Forecast
- Alternatives for PNPP
- The decreasing impact of nuclear power plants on the usage of fossil fuels and CO_2 emissions
- Impact resulting from the operation of nuclear power plants
- Impact resulting from the fuel cycle
- Impact of nuclear emergency conditions.
- External threats to the security of nuclear power plants
- Possibilities in the scope of ensuring the appropriate nuclear supervision in Poland
- Rendering available and discussing detailed data of technological solutions and criteria adopted for the selection of locations
- Issues related to the possibility of ensuring and training relevant staff for the nuclear power sector
- Need for an accurate reference to causes and consequences of accidents in Three Mile Island, Fukushima, and Chernobyl nuclear power plants

The Ministry of Economy provided answers first of all to the comments and proposals stemming from the national public participation procedure, and then the comments submitted during the cross-border environmental assessment. In this summary, the comments and answers given by the Ministry of Economy were compiled. Both comments and answers were each time published in the course of the procedure, so they are nothing new.

Thanks to the comments, doubts, and proposals submitted, a number of additional analyses were conducted, and some information contained in the Forecast and the Polish Nuclear Power Programme was specified .

It should be also taken into account that this chapter contains information which are mostly answers to the criticism of the Polish Nuclear Power Programme and to concerns of a part of the Polish society about this form of energy generation. **Thus, the following chapter constitutes the substantiation for the adoption of the Programme.**

2.1. OBJECTIONS AND CONCERNS OF A PART OF THE POLISH SOCIETY ABOUT THE INTRODUCTION OF NUCLEAR POWER IN POLAND

The Ministry of Economy understands and takes into account the concerns of the Polish society and the Affected Countries relating to the nuclear power. However, it does not share the opinion that the assessment of risk connected with the nuclear power in Poland is unacceptably high, indicating in particular:

- non-representativeness of accidents in Chernobyl and Fukushima for the assessment of risk connected with the development of nuclear power in view of the fact that in Poland, only most advanced and safe NPP technologies currently available commercially are planned to be used,
- lack of significant external threats in location areas of possible nuclear plants in Poland.

The decision to diversify the electricity generation portfolio by introducing nuclear energy was adopted on the basis of analyses of various alternatives and is a sovereign decision of Poland. The Polish Government adopted the "Energy Policy of Poland until 2030" (PEP 2030) which assumes the optimal strategy for power industry development – meeting the anticipated growth in demand for electricity (with ambitious goals to increase the energy efficiency taken into account[1]), at rational costs and in compliance with environmental protection requirements (including those relating to the reduction of CO_2 emission).

The Ministry of Economy points out that apart from nuclear power industry, Poland also plans to develop and use to a wider extend renewable energy sources (RES), whose share in 2030 is to reach 18.8%. In no way the adoption of the Polish Nuclear Power Programme (PNPP) has a decreasing impact on the share of RES or the extent of energy efficiency implementation.

The Ministry of Economy would also like to underline that in recognition of the importance of safety, decisions were taken to build only 3rd (or 3rd+) generation reactors in Poland which fulfil the most strict safety requirements so that even the results of a severe accident shall be limited to the direct vicinity of the plant.

Security measures taken and their efficiency are described in the SEA Forecast. The correctness of this decision (the choice of reactor generation) is confirmed by the Radiation and Nuclear Safety Authority (STUK), and also associations and objective authorities of countries bordering Poland. The reactor which will be selected by Poland shall not be a prototype, but a proven solutions examined by nuclear safety authorities in other countries, and used outside Poland.

[1] When planning the energy policy of Poland until 2030, a drop in GDP energy intensity by as much as approx. 45% was assumed.

2.2. COMMENTS ON THE PROCEEDINGS OF THE STRATEGIC ENVIRONMENTAL ASSESSMENT AND THE ENVIRONMENTAL IMPACT ASSESSMENT FOR THE PROJECT

2.2.1. Doubts about the possibility of participation in further stages of the environmental impact assessment

Poland is at the stage of implementation of the Polish Nuclear Power Programme, which is a strategic implementing document including legal, organisational, and formal measures necessary to introduce nuclear energy in Poland. At this stage, no technology, site, cooling system, capacity etc. to be applied have been specified so far (apart from the fact that it shall be a 3rd or 3rd+ generation reactor). The SEA Forecast, in order to assess the environmental impact as precisely as possible, used data obtained from other facilities – the so-called reference facility methodology. Only at the stage of EIA investment procedure it will be possible to provide more precise answers.

The interested entities shall have full right to take part in the future environmental impact assessment (EIA) procedures for the first Polish nuclear power plant and supporting facilities. To confirm the above, below you shall find facts important for the future EIA process which were already accounted for in Polish legislation:

Main legal instruments that regulate the environmental impact assessment procedure for nuclear energy facilities include:

- **EIA Act** - The Act of October 3, 2008, on the Provision of Information on the Environment and its Protection, Public Participation in Environmental Protection and Environmental Impact Assessments (Dz. U. [Polish Journal of Laws] of 2013, item 1235 with changes);
- **"Special" Nuclear Law** - The Act of June 29, 2011 on the Preparation and Implementation of Investments in the scope of Nuclear Facilities and Accompanying Infrastructure (Dz. U. [Polish Journal of Laws] No. 135, item 789);
- **EIA Regulation** - Regulation of the Council of Ministers of November 9, 2010, on undertakings materially affecting the environment (EIA regulation) (Dz. U. [Polish Journal of Laws] of 2010, no. 213 item 1397);

In Poland, the body competent for EIA procedure for nuclear facilities is obligatorily the **General Director for Environmental Protection (Art. 61. 3a. of the EIA Act).** It is a central government body for environment protection and conservation, pursuing its tasks with the help of the General Directorate for Environment Protection. The General Director for Environmental Protection reports to the minister competent for environmental matters. Therefore, in order to conduct the EIA procedure for nuclear facilities, a body was selected which has the widest competence in matters relating to the environmental impact assessment for the project.

Another fact which indicates the high quality and compliance with international legal requirements for EIA procedure is that the environmental impact assessment accompanying investments are also subject to the construction of the nuclear power facilities. These are investments in the scope of construction or extension of transmission grids within the meaning of art. 3 item 11a of the Act of April 10, 1997 – Energy Law (Dz. U. [Polish Journal of Laws] of 2006, No. 89, item 625, as amended), necessary to evacuate power from a nuclear plant, or another investment necessary to build or ensure proper operation of a nuclear facility.

Considering the above, one can be sure of high quality of future EIA procedures for a nuclear facility and that environmental impact connected with the construction, operation, and future decommissioning will be taken into account. Moreover, all interested entities, may participate in EIA procedures as part of the environmental impact assessment for investment process. In that way, they will be able to present their views before the related decisions are taken.

2.2.2. Compliance EIA forecast and the proceedings of the Strategic Environmental Assessment of the SEA Directive

The Forecast, complying with all requirements of SEA Directive and Polish law, meets the requirements for the environmental impact assessment for PNPP implementation.

The work on the Forecast has been divided into two stages. The first version of the Forecast was issued on December 30, 2010, and it was subject to public consultation and opinion-giving process of the environmental authorities. On the basis of comments submitted, the second version was prepared which takes into account, to a significant extent, the comments. In 2011, another update of the Forecast was prepared in result of an additional possible location added for a future nuclear plant, in Gąski. The cross-border SEA proceedings was similar.

Time frames for national and cross-border public consultations are provided below:

- National public consultations were held between 30.12.2010 and 31.03.2012.
- National consultations of the annex resulting from the new location added, were held between 13.01.2012 and 03.02.2012.
- Cross-border public consultations held in affected countries took place between 18.07.2011 and 04.01.2012.
- Cross-border public consultations of the annex resulting from the new location alternative added, were held from 08.01.2012 until 27.02.2012.

The content of the SEA Forecast follows the requirements of art. 51 of the Act of October 3, 2008, on the Provision of Information on the Environment and its Protection, Public Participation in Environmental Protection and Environmental Impact Assessments (Dz. U. [Polish Journal of Laws] No. 199, item 1227). However the complexity of the matter under consideration and the diversification of environmental effects to be analysed forced some modifications of the layout of contents applied in the SEA Forecast documents. This stems mainly from the fact that the Nuclear Power Development Programme under analysis covers a number of actions aimed at the placement of first nuclear power plants in Poland. These actions include not only the implementation of a specific investments in the form of construction of (two) nuclear power plants, but also a number of formal, legal, and organisational measures, as well as implementation of accompanying investments necessary to use nuclear energy in a country (e.g. acquisition of raw material, transmission grid development, location of radioactive waste repository etc.). Description and analysis of individual factors of impact on the environment connected with the whole variety of actions undertaken have proven to be difficult and unclear when applying the layout of the Forecast stemming from the EIA Act directly.

The complexity of issues under consideration required an individual approach to the preparation of the study. Therefore, an extended description model for environmental impact was developed on the basis of a multi-dimensional analysis of impact factors connected with the operation of nuclear power plants. Then, a summary chapter was produced, compiling radiological and non-radiological impact factors identified earlier, and assigning them to relevant statutory elements.

Below, the influence of the methodology used on the structure of the Forecast is presented.

In the initial part of the Forecast, connections between the Polish Nuclear Power Programme and other strategic documents are examined **(chapter 3)**. Further on, in accordance with the legal requirements with respect to the EIA forecasts, the current state of environment is described **(chapter 4)**. As the Programme under evaluation concerns in a way the whole area of the country and the final locations of specific investments have not yet been finally determined, the chapter addresses the state of environment in Poland in sufficient detail for further analyses contained in the Forecast. The chapter also discusses in detail possible natural hazards, including seismic and flood hazards (sections 4.2. *seismic conditions in Poland* and section 4.3.1 *flood hazards in Poland*, respectively). Moreover, chapter 4.9 of the Forecast describes and evaluates all biotic elements of the environment and areas subject to protection pursuant to the Act of April 16, 2004 on Nature Conservation, that may be endangered in result of implementation of the PNPP.

In accordance with requirements to the SEA procedure, the assessment of results of cancellation of the programme, the so-called **zero alternative**, was subject to analysis in **chapter 5**.

Following parts of the study contain a chapter aimed at acquainting the reader with technical aspects of nuclear power, including nuclear safety and possible accidents **(chapter 6)**. Such approach enables to understand complex analyses conducted in further chapters more easily. At the same time, the chapter under consideration fulfils the requirements for indicating possible technological alternatives for various reactor types which can be considered by Poland.

Next chapters of the SEA Forecast discuss in detail individual impact factors of nuclear industry. Radioactive emissions resulting from the operation of a nuclear power plant are analysed here in the first place. Since it is an impact specific for nuclear industry and one causing the greatest social controversy, a separate chapter **(chapter 7)** was devoted to it. All data in this chapter was accounted for in quantitative, precise manner, as objective values only.

Chapter 8 contains discussion of all other impact factors connected with the operation of nuclear power plants. A separate section (8.5) discusses the impact on biotic elements of the environment, with Nature 2000 areas included.

In order to meet the statutory requirements for the Forecast of the Environmental Impact Assessment, **chapter 9** presents identification and characteristics of impact factors **(already described in detail in previous chapters)** in terms of their influence on the individual elements of the environment. For legibility purposes, the analyses are presented in tabular form. Section 9.1 presents all impacts identified in **chapter 7 and 8**, with their influence divided in accordance with individual environmental elements they affect (biodiversity, people, animals, plants, water, air, earth surface, landscape, climate, natural resources, historical monuments, material goods). Section (9.2) presents characteristics of these impacts in terms of the range of influence, nature, duration, continuity, and possibility of occurrence. Section (9.3) in turn presents a summary account of both positive and negative impact factors. In further sections the assessment of cumulated impact is presented (9.4), and in (9.5) – the analysis of cross-border impact. The final section (9.5) contains an analysis of the possibility of occurrence of public controversies.

Chapter 10 includes analyses of possible alternatives. Due to the specificity of the assessment of a strategic document, in addition to statutorily required analyses of possible technical and location alternatives, also an additional analysis of possible strategic options of energy generation and energy security in Poland was performed. The analysis of alternative locations in the main text of the SEA Forecast describes seven most probable locations basing on impact matrices which are not discussed in the previous chapters. Other locations are presented in the appendix to the SEA Forecast.

The study ends with a summary chapter compiling conclusions and recommendations as well as methods envisaged for analysis of the implementation consequences for the programme (**chapter 11**).

The table below presents the adjustments of the Forecast contents to the requirements provided for in art. 51 of the Act of October 3, 2008, on the Provision of Information on the Environment and its Protection, Public Participation in Environmental Protection and Environmental Impact Assessments (Dz. U. [Polish Journal of Laws] No. 199, item 1227). **It should be noted here that the Polish Act fully transposes the requirements of SEA directives on SEA Forecasts and in many cases, significantly expands them.**

Table 1. Description of actions detailed in the Polish Nuclear Power Programme.

STATUTORY REQUIREMENT FOR THE FORECAST CONTENTS		**CHAPTER**
information about the content, main objectives of the proposed document and its connections with other documents		2, **3, 6.3, 6.6**
information about methods used in the preparation of the forecast		**2.3**, 7, 8, 10
proposals of envisaged methods of analysis for the implementation results of the provisions of the proposed document, and the frequency of analysis		7,8, 10.4, **11**
information about possible cross-border environmental impact		**9.5**, 10.3
non-technical abstract		**1**
ANALYSES AND ASSESSMENTS		**CHAPTER**
of the existing state of the environment and possible changes to it if the proposed document is not implemented		**4, 5**, 8.3.2, 10.3
condition of the environment in areas subject to anticipated material impact		**4, 10.3**
existing environment protection issues from the point of view of implementation of the proposed document, and in particular related to areas subject to protection pursuant to the Act of April 16, 2004 on Nature Conservation		**4**, 5, 7, 8, **10.3**
environment protection objectives set at the international, community, and national level, significant from the point of view of the document, and ways of taking account of them as well as other environmental issues during the preparation of the document,		**3, 6.3, 6.6**
expected significant impact factors, including direct, indirect, secondary, cumulated, short-term, medium-term, and long-term, permanent and transient, and positive and negative factors of impact on the objectives and the object of protection of the Nature 2000 area as well as the integrity of this area, and also on the environment, and in particular on:	biodiversity	4.9, **4.10, 8.5, 9.3, 10.3**
	people	5, 7, 8, **9.1.1, 9.6, 10.3**
	animals	4.9, **4.10, 8.3.2**, 8.3.5, 8.3.7, **8.5, 9.3, 10.3**
	plants	4.9, **4.10, 8.3.2**, 8.3.5, 8.3.7, **8.5, 9.3, 10.3**
	water	4.3, 4.4, **7.6, 8.2.1, 8.3.2, 8.3.3**, 8.4, **9.1.2, 9.1.3**, 10.3
	air	4.5, **5, 7.2, 8.2.2, 8.3.2, 8.3.4, 9.1.4, 10**
	earth surface	4.1, **8.3.6, 9.1.6, 10.3**
	landscape	4.1, **4.9, 8.3.8, 9.1.7, 10.3**
	climate	**5, 8.2.2, 9.1.5, 10**

	natural resources	**8.3.1, 9.1.8**, 10.3
	historical monuments	4.8, **9.1.9**, 10.3
	material goods	4.8, **9.1.10**, 10.3
accounting for the relationship between these environment elements and the impact factors affecting these elements		4, 5, 6, 7, 8, 9.1, 9.2, 9.3, 10, 11

THE EXTENT TO WHICH THE FOLLOWING ITEMS WERE CONSIDERED	CHAPTER
solutions intended for prevention, limitation, or environmental compensation of negative environmental impacts that may result from the implementation of the proposed document, in particular the impacts on the objectives and objects of protection of Nature 2000 areas and their integrity	6.3, 6.6, 10, **11**
the objectives and the geographic range of the document and the objectives and the object of protection of Nature 2000 areas and their integrity – solutions that are alternative to those presented in the proposed document, with justification for their selection and a description of the methods of evaluation resulting in the selection, or explanation of the reasons for the lack of alternative solutions, to include information on encountered difficulties resulting from shortcomings of the technology or inadequate knowledge.	**4.9**, 4.10, 6.4, 8.5, 10, **10.3**, 11

2.2.3. Discussion of the objection that not all affected countries were taken into account as part of the cross-border impact assessment

The will to participate was expressed by Czech Republic, Slovakia, Austria, Denmark, Sweden, Finland, and Germany. All these countries were participants of the SEA procedure. Therefore, there are no grounds to question correctness of the proceedings on transboundary environmental effects of the implementation of the Programme objectives.

2.3. ECONOMIC ASSUMPTIONS AND RESULTS OF THE ANALYSES OF THE ELECTRICITY GENERATION SUBSECTOR, CONTAINED IN THE PROGRAMME AND THE FORECAST

2.3.1. Discussion of the argument on the erroneous estimation of profitability for the Polish Nuclear Power Programme.

As part of the strategic environmental assessment for the Polish Nuclear Power Programme, the analyses of the economical profitability of nuclear industry in Poland were not examined. Instead, the subject of the Forecast included assessment and possible minimisation of the potential environmental impact resulting from the implementation of the Polish Nuclear Power Programme

The choice of an optimal energy strategy and electricity generation technology for Poland, compliant with economic and social goals and not contradicting the EU policy and objectives (also those of the climate and energy package) is a sovereign right and duty of Polish Government.

However, for the purposes of the strategic environmental assessment, assumptions used by the Ministry of Economy are presented. The chapter presents also results and conclusions ensuing from the update of "Forecast demand for fuels and electricity until 2030".

The Energy Policy of Poland (PEP2030)[2] and the Polish Nuclear Power Programme (PNPP) are based

[2] Ministry of Economy: The Energy Policy of Poland until 2030. Warsaw, November 10, 2009, the Document adopted by the Council of Ministers on November 10, 2009, (Appendix to the Resolution no. 202/2009 of the Council of Ministers of November

on results of multi-variant analyses of the development of the fuel and energy sector, and in particular:

- ARE S.A. November 2009 - Forecast demand for fuels and electricity until 2030[3]
- ARE S.A. December 2009 - Comparative analysis of electricity generation costs in nuclear, coal, and gas power plant as well as from renewable energy sources[4]
- McKinsey&Co. December 2009 - Assessment of Greenhouse Gas Emissions Abatement Potential in Poland by 2030[5].

The result of this analysis is a sustainable and optimised energy policy of Poland (PEP2030) whose aim is to satisfy the country's demand for fuels and energy (including electricity), **at the lowest costs possible, while at the same time observing the requirements of environment protection (which have been significantly tightened in the recent years).** It should be highlighted that when planning the energy policy of Poland until 2030, **very ambitious goals in terms of energy efficiency improvement were assumed**[6] – reduction of GDP energy intensity: from 110.4 kWh/PLN'07 in 2010 to 77.8 kWh/PLN'07 in 2020 (by 29.5% when compared to 2010 – which is fairly more than the 20% required by the EU) and to 60.6 kWh/PLN'07 in 2030 (by as much as 45.1% in comparison to 2010).

The analyses show clearly that it is not possible to satisfy the demand for electricity in Poland only by improving the energy consumption efficiency and developing the RES sector. The decision to diversify the electricity generation portfolio by introducing nuclear energy was adopted on the basis of analyses of various alternatives. Generation of electricity in NPP will enable to reduce the growth of electricity prices and avoid additional CO_2 emissions and emissions of other pollutants from plants fired with fossil fuels. In no way the adoption of PNPP has a decreasing impact on the share of RES or energy efficiency improvement.

The analyses also defined the competitiveness of nuclear power in relation to all other electricity generation technologies. One of the key parameters determining the competitiveness of various electricity generation technologies is the cost of CO_2 emission allowances. The sensitivity analyses conducted imply that nuclear power plants are competitive with respect to power plants using organic fuels already when it comes to the cost of CO_2 emission allowances above 15 €'05/tCO_2 (see figure below). This conclusion has been also confirmed in the update of the Forecast demand for fuels and electricity developed in 2011 and referred to below.

10, 2009).

[3]Ministry of Economy: Forecast demand for fuels and electric energy until 2030. Appendix no. 2 to the "Energy Policy of Poland until 2030" project. 15-03-2009.

[4]Comparative analysis of electricity generation costs in nuclear, coal, and gas power plant as well as renewable energy sources, study by the Energy Market Agency, November 2009.

[5] McKinsey & Company: Assessment of Greenhouse Gas Emissions Abatement Potential in Poland by 2030. Warsaw 2009.

[6] Ministry of Economy: Forecast demand for fuels and electric energy until 2030. Appendix no. 2 to "Energy Policy of Poland until 2030". 15-03-2009.

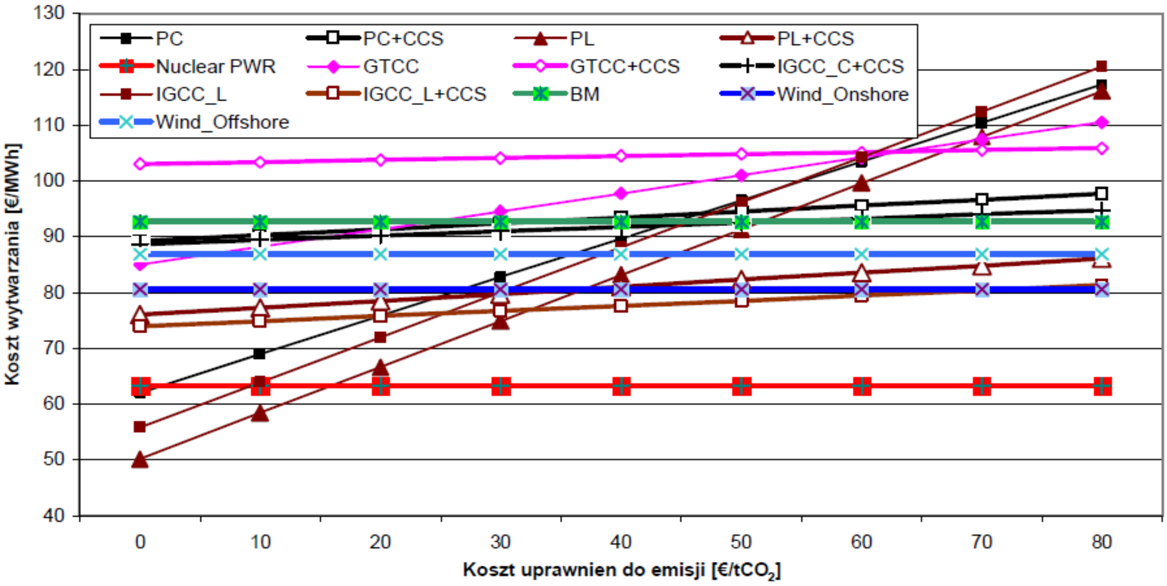


Figure 1. Impact of costs of CO_2 emission allowances on competitiveness of various electricity generation sources [source: ARE S.A.].

Koszt wytwarzania [€/MWh]	Koszt uprawnien do emisji [€/tCO_2]
Generation cost [€/MWh]	Emission allowance cost [€/tCO_2]

Coal technologies: hard coal – PC, PC+CCS, IGCC_C+CCS; lignite – PL, PL+CCS, IGCC_L, IGCC_L+CCS, Natural gas – CCGT, CCGT+CCS, Nuclear technology – Nuclear PWR, Biomass – BM, Wind – Wind_On-shore, Wind_Off-shore.

Moreover, the analyses carried out by McKinsey & Company indicate that in Polish conditions, the nuclear power has the greatest potential to reduce CO_2 emissions at the lowest costs, from among all electricity generation sources.

In order to ensure that PNPP is based on the national energy sector development forecast prepared on the basis of the current situation on the global, European, and domestic energy market, Ministry of Economy periodically updates the forecasts for the Polish Energy Policy. Updates include new data each prognostic external parameters, including the macroeconomic projections, fuel prices, of the efficiency of use of energy and renewable energy development.

The last updated Forecast demand for fuels and electricity until 2030 defines in particular:

- Forecast demand for end user electricity;
- Structure of capacity of generation sources, structure of electricity generation, and fuel structure of electricity generation—for baseline scenario and other scenarios examined as part of sensitivity analyses (including non-nuclear options);
- Costs of electricity generation—for baseline scenario and other scenarios included in the sensitivity analyses;
- CO_2 emissions—for baseline scenario and other scenarios included in the sensitivity analysis.

As part of sensitivity analyses in the updated forecast, the following scenarios were examined—in relation to the baseline scenario (with cost-optimal structure of generation sources):

- High price scenario for CO_2 emission allowances
- Reduced natural gas price scenario

- Implementation delay scenario for the nuclear power plants construction programme (first unit in 2025)
- Opt-out scenario—in conditions assumed for the baseline scenario
- Opt-out scenario—in the case of unavailable carbon capture and storage technologies (CCS)
- Opt-out scenario—in the case of unavailable CCS technologies, and high prices of CO_2 emission allowances
- Opt-out scenario for the construction of nuclear power plants and facilities equipped with CCS, given high prices of CO_2 emission allowances
- Scenario with the first nuclear power plant from 2020.

Selected results of analyses from the forecast update demand for fuels and energy until 2030 are presented below.

2.3.1.1. Updated baseline scenario

2.3.1.1.1. Assumptions made for analyses

- The updated macro-economic forecast (based on the forecast prepared by the Ministry of Finance) in which it was assumed that the average real GDP growth rate of Poland will gradually approach the long-term growth rate of the European Union in this category. It was assumed that in the period under consideration, Polish economy shall grow at the average GDP rate of 3.4%. It is a significantly slower pace than 5.1% adopted for "PEP Forecast 2030".
- Projections of fuel prices on European markets and prices of CO_2 emission allowances–in accordance with the study of International Energy Agency (IEA), "World Energy Outlook 2010". In particular the EIA projection according to which the price of CO_2 emission allowances shall reach in 2030 the level of 33 €'09/tCO_2
- The updated projection of results of energy consumption rationalisation.
- The projection of decommissioning of the exploited electricity generation capacities and assumptions concerning the units identified.
- Updated technical and economical specification parameters of new generation units. In particular, it was assumed that
  - carbon capture and storage technologies will not guarantee profitability before 2025. At the same time, it was assumed that in the period of forecast, one demonstration installation with CO_2 capture and storage (2016), integrated with a 858 MW unit shall be launched in Bełchatów II power plant (corresponding to the capacity of 250 MW of the unit);
  - exploitation of new lignite deposits (in the area of Legnica and Gubin) shall not commence before 2025;
  - IGCC technology shall be available in Poland as of 2025.

2.3.1.1.2. Forecast demand for end user electricity

Taking into account the horizon of 2030, there shall be a growth in end-user demand for electricity by approx. 43% – up to the level of 167 TWh (see table and figure below). It means the average annual growth rate at the level of 1.6%.

Table 2. Forecast demand for end user electricity [TWh].

2008	2010	2015	2020	2025	2030
117.6	119.5	129.4	139.4	151.9	167.6

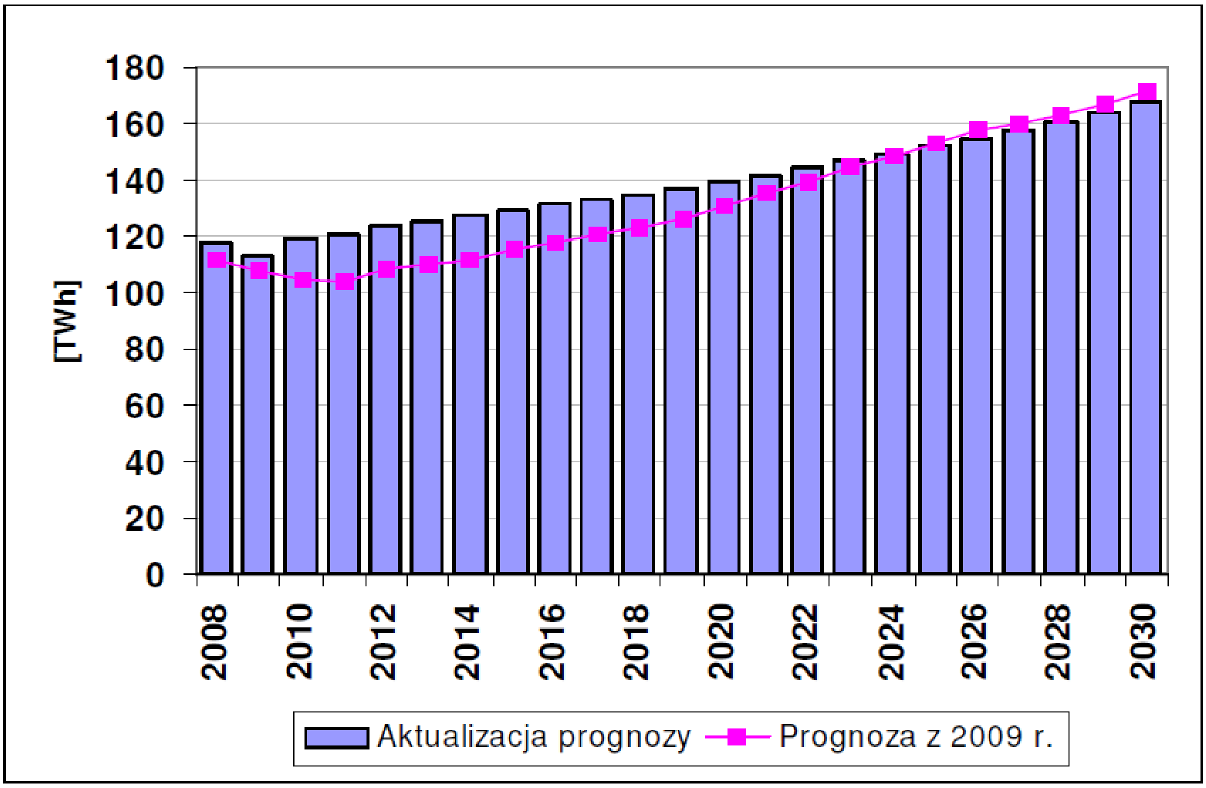


Figure 2. Forecast demand for end user electricity.

Aktualizacja prognozy	Prognoza z 2009r.
Forecast update 2011	Forecast for 2009.

As it can be seen on the diagram above, despite a significantly lower economic growth rate assumed in this forecast when compared to "Forecast for PEP2030", the demand for electricity shall remain at a similar level in relation to the forecast of 2009.

2.3.1.1.3. Forecast of optimal technological and fuel structure of electricity generation

On the basis of analyses carried out with the use of professional energy system development methodologies and tools, a cost-optimal structure of generation sources and electricity generation portfolio was defined, on the basis of the assumptions defined in item 2.3.1.1.1 (baseline scenario) with all environmental constraints observed.

The maximum net capacity of electricity generation sources in the National Power System shall grow, when compared to 2008, from 32.4 GW to **approx. 46.4 GW** (namely by **approx. 43%**) in 2030, which means an average annual growth rate at the level of 1.65%. At the same time, the demand for net peak capacity shall increase, when compared to 2008, from the level of 22.6 GW to approx. 33.3 GW in 2030.

The first nuclear power plant with 1,500 MW of capacity appears in 2022, and subsequent units are launched every three years, if the assumed maximal rate of construction is maintained (Figure 3 and 4).

The forecast po of generation sources is presented below (Table 3 and Figure 3).

Table 3. Technological structure of maximum net capacity of electricity generation sources (MW).

	2008	2010	2015	2020	2025	2030
Lignite power plants -	8326	8293	7728	6213	6213	6213
Lignite power plants -	0	0	795	1200	1223	1351
Lignite power plants CCS	0	0	0	0	0	4184
Hard coal power plants -	14536	14601	13033	10513	8322	2913
Hard coal power plants -	0	0	0	2520	2520	2520
Gas power plants GTCC	0	0	400	400	400	400
Nuclear power plants	0	0	0	0	3000	4500
Water power plants	929	944	981	1019	1056	1094
Pumping power plants	1405	1405	1405	1405	1405	1405
Industrial CHPs	1547	1509	1447	1411	1478	1737
Hard coal CHPs	4231	4267	3932	3930	4026	3993
Gas CHPs	797	797	1207	1807	2278	1935
Biomass power plants	39	41	827	1052	1052	1405
Biogas CHPs	51	76	211	37	514	631
On-shore wind farms	526	1059	2559	3759	4610	6081
Off-shore wind farms	0	0	0	750	2 000	2557
PV	1	1	2	4	10	24
Gas turbines	0	0	0	1584	2977	3500
In total	**32388**	**32992**	**34526**	**37938**	**43 083**	**46442**

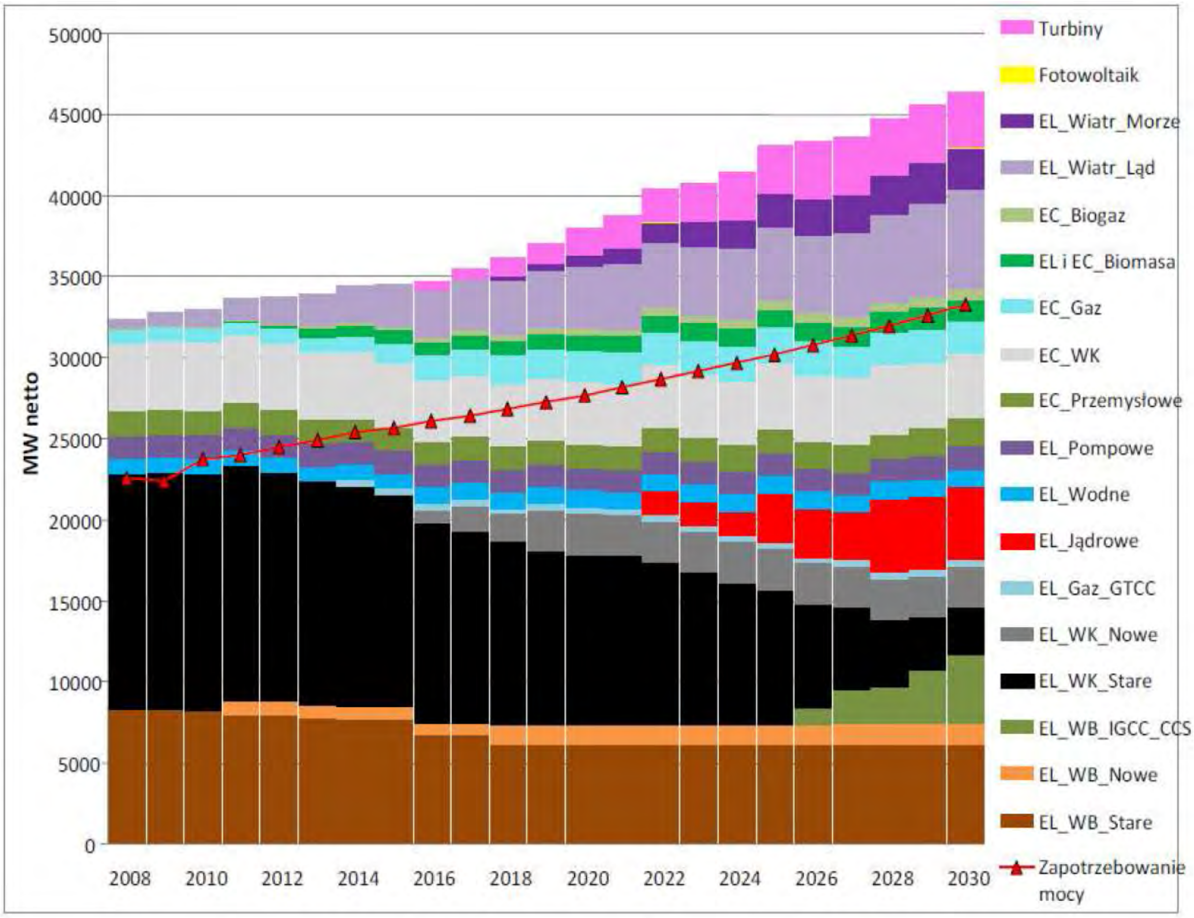


Figure 3. Technological structure of maximum net capacity of electricity generation sources).

MW netto	Net MW

Turbiny	Turbines
Fotowoltaik	PV
EL Wiatr Morze	Off-shore wind farms
EL Wiatr Ląs	On-shore wind farms
EC Biogaz	Biogas CHPs
EL i EC Biomasa	Biomass power plants and CHPs
EC Gaz	Gas CHPs
EC WK	Hard coal CHPs
EC Przemysłowe	Industrial CHPs
EL Pompowe	Pumping power plants
EL Wodne	Water power plants
EL Jądrowe	Nuclear power plants
EL Gaz GTCC	Gas power plants GTCC
EL WK Nowe	Hard coal power plants - New
EL WK Stare	Hard coal power plants - Old
EL WB IGCC CCS	Lignite power plants IGCC CCS
EL WB Nowe	Lignite power plants - New
EL WB Stare	Lignite power plants - Old
Zapotrzebowanie mocy	Demand for capacity

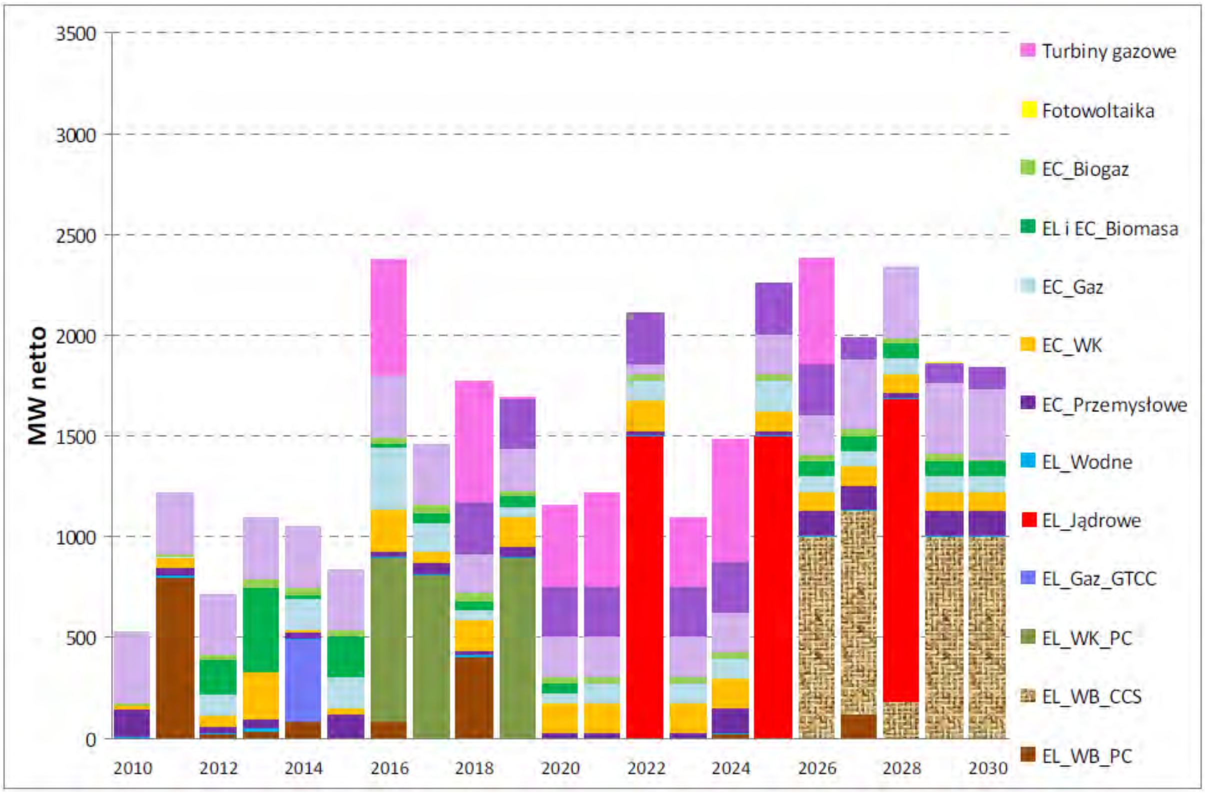


Figure 4. Structure of new and modernised generating capacities

MW netto	Net MW

Turbiny gazowe	**Gas turbines**
Fotowoltaik	**PV**
EC Biogaz	**Biogas CHPs**
EL i EC Biomasa	**Biomass power plants and CHPs**
EC Gaz	**Gas CHPs**
EC WK	**Hard coal CHPs**
EC Przemysłowe	**Industrial CHPs**
EL Wodne	**Water power plants**
EL Jądrowe	**Nuclear power plants**
EL Gaz GTCC	**Gas power plants GTCC**
EL WK PC	**Hard coal power plants PC**
EL WB CCS	**Lignite power plants CCS**
EL WB PC	**Lignite power plants PC**

Table 4 and Figure 5 present the forecast structure of net electricity generation per generation technology

Table 4. Electricity generation by technologies [TWh].

	2008	**2010**	**2015**	**2020**	**2025**	**2030**
Lignite power plants - Old	49.9	48.3	45.9	41.6	38.7	24.7
Lignite power plants - New	0.0	0.0	5.6	8.5	8.7	9.6
Lignite power plants CCS	0.0	0.0	0.0	0.0	0.0	29.6
Hard coal power plants - Old	60.9	60.2	52.8	36.3	23.0	6.5
Hard coal power plants - New	0.0	0.0	0.0	17.8	17.8	15.5
Hard coal power plants - Old	16.4	18.0	18.3	15.5	12.7	9.2
Hard coal power plants - New	0.0	0.0	0.6	4.0	7.5	10.0
Industrial CHPs	6.1	6.5	6.6	6.8	7.0	7.1
Gas power plants	0.0	0.0	2.8	2.2	2.9	3.1
Gas CHPs	4.2	4.5	7.0	10.8	13.7	12.1
Nuclear power plants	0.0	0.0	0.0	0.0	19.1	33.5
Water power plants	2.2	2.3	2.4	2.5	2.7	2.8
Biomass power plants and CHPs	0.2	0.2	4.5	5.6	5.1	6.6
Biogas CHPs	0.2	0.4	1.1	2.0	2.8	3.4
On-shore wind farms	0.8	1.5	4.6	7.0	8.8	11.9
Off-shore wind farms	0.0	0.0	0.0	2.3	6.0	7.7
PV	0.0	0.0	0.0	0.0	0.0	0.0
Net generation	**140.9**	**141.9**	**152.2**	**162.9**	**176.5**	**193.3**
Own consumption	14.4	14.4	14.3	14.1	13.7	16.3
Gross generation	**155.3**	**156.3**	**166.5**	**177.0**	**190.1**	**209.6**
Net export	1.2	1.4	0	0	0	0
Domestic supply, gross	**154.1**	**154.9**	**166.5**	**177.0**	**190.1**	**209.8**

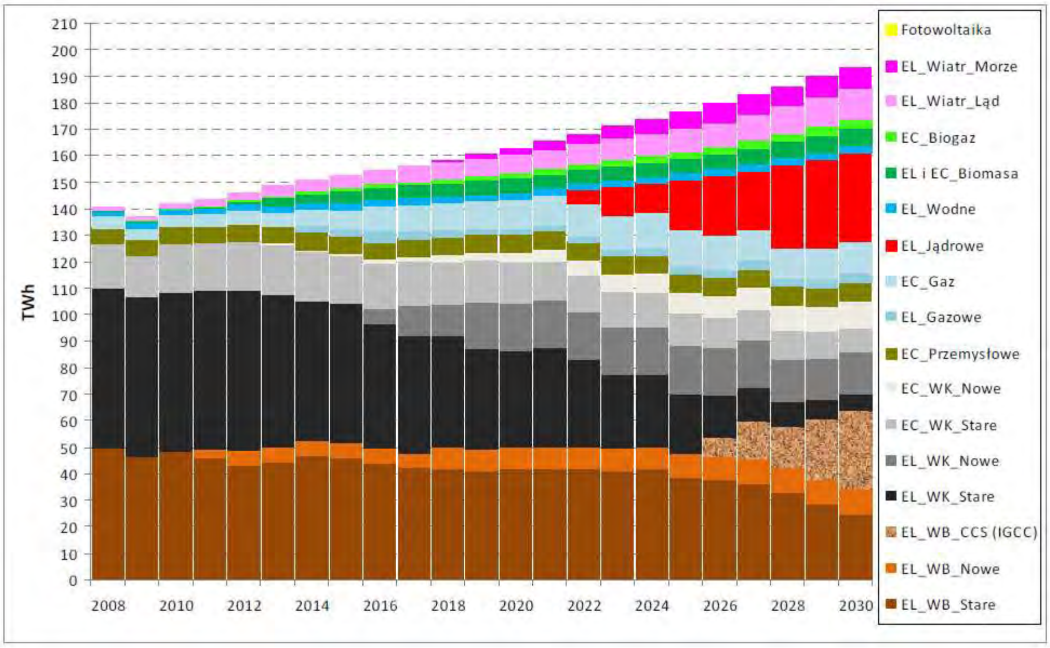


Figure 5. Forecast structure of net electricity generation.

Fotolowtaika	**PV**
EL Wiatr Morze	**Off-shore wind farms**
EL Wiatr Ląd	**On-shore wind farms**
EC Biogaz	**Biogas CHPs**
EL i EC Biomasa	**Biomass power plants and CHPs**
EL Wodne	**Water power plants**
EL Jądrowe	**Nuclear power plants**
EC Gaz	**Gas CHPs**
EL Gazowe	**Gas power plants**
EC Przemysłowe	**Industrial CHPs**
EC WK Nowe	**Hard coal CHPs - New**
EC WK Stare	**Hard coal CHPs - Old**
EL WK NOWE	**Hard coal power plants - NEW**
EL WK Stare	**Hard coal power plants - Old**
EL WB CSS (IGCC)	**Lignite power plants CSS (IGCC)**
EL WB Nowe	**Lignite power plants - New**
EL WB Stare	**Lignite power plants - Old**

The forecast structure of electricity generation per fuel type is presented below.

Table 5. Forecast structure of net electricity generation by fuels [TWh].

	2008	**2010**	**2015**	**2020**	**2025**	**2030**
Lignite	49.8	47.6	49.8	49.7	47.1	63.6
Hard coal	77.4	76.2	67.6	69.0	55.9	40.5
Natural gas	4.7	6.0	12.4	15.3	20.5	19.7
Fuel oil	2.3	2.2	2.2	2.1	2.0	2.0
Nuclear fuel	0	0.	0	0	19.1	33.5
Biomass	3.2	5.5	11.0	12.9	11.5	8.1

Biogas	0.2	0.4	1.1	2.0	2.8	3.4
Water energy	2.2	2.3	2.4	2.5	2.7	2.8
Wind energy	0.8	1.5	4.6	9.2	14.8	19.6
Solar energy	0	0	0	0	0.01	0.03
Other fuels	0.26	0.22	0.2	0.16	0.11	0.09
In total	**140.9**	**141.9**	**152.2**	**162.9**	**176.5**	**193.3**
Share %						
	2008	**2010**	**2015**	**2020**	**2025**	**2030**
Lignite	35%	34%	33%	31%	27%	33%
Hard coal	55%	54%	44%	42%	32%	21%
Natural gas	3%	4%	8%	9%	12%	10%
Fuel oil	2%	2%	1%	1%	1%	1%
Nuclear fuel	0%	0%	0%	0%	11%	17%
Biomass	2%	4%	7%	8%	7%	4%
Biogas	0%	0%	1%	1%	2%	2%
Water energy	2%	2%	2%	2%	2%	1%
Wind energy	1%	1%	3%	6%	8%	10%
Solar energy	0%	0%	0%	0%	0%	0%
Other fuels	0%	0%	0%	0%	0%	0%

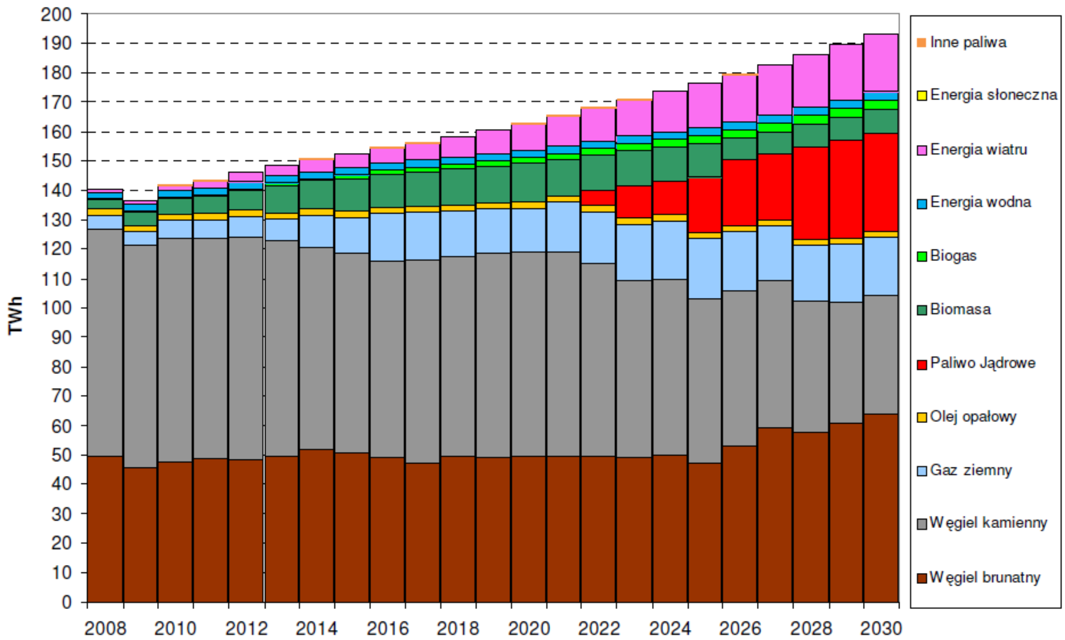


Figure 6. Net electricity generation by fuels.

Inne paliwa	**Other fuels**
Energia słoneczna	**Solar energy**
Energia wiatru	**Wind energy**
Energia wodna	**Water energy**
Biogas	**Biogas**
Biomasa	**Biomass**
Paliwo Jądrwowe	**Nuclear fuel**
Olej opałowy	**Fuel oil**
Gaz ziemny	**Natural gas**

Węgiel kamienny	**Hard coal**
Węgiel brunatny	**Lignite**

Figure 7 presents the share structure of individual fuels in electricity generation forecast for 2030. The share of nuclear fuels in the structure is expected at the level of 17%, which is slightly more than assumed in the previous version of the forecast (15.7%). Introduction of nuclear power shall make it possible to stabilise electricity prices on the wholesale market after 2025.

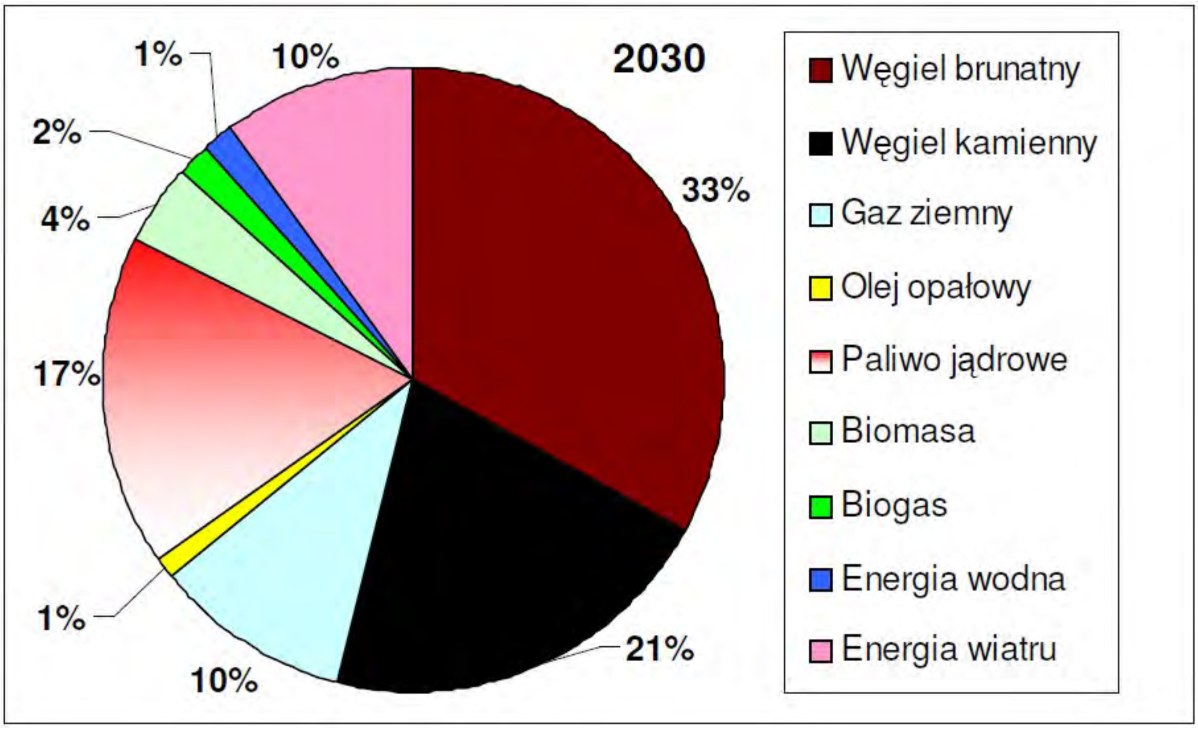


Figure 7. Share of individual fuels in net electricity generation - forecast for 2030.

Węgiel brunatny	**Lignite**
Węgiel kamienny	**Hard coal**
Gaz ziemny	**Natural gas**
Olej opałowy	**Fuel oil**
Paliwo jądrowe	**Nuclear fuel**
Biomasa	**Biomass**
Biogas	**Biogas**
Energia wodna	**Water energy**
Energia wiatru	**Wind energy**

2.3.1.1.4. Electricity generation cost forecast

Results of the analysis indicate the competitiveness of electricity generation with nuclear power plants (with conservative assumptions for NP) when compared to other technologies included in model calculations (Table 6, Figure 8), due to the expected growth in prices of organic fuels and fees for CO_2 emission allowances.

Table 6. Averaged generation costs in representative power plants [€'05/MWh].

Power Plants	Load factor	Investment costs	O&M costs	Fuel costs	CO_2 emission cost	Total
Hard coal power plants	0.70	23.26	7.80	23.79	29.20	84.74
Hard coal power plants + CCS	0.70	38.76	12.60	28.43	4.46	84.94
Lignite power plants	0.70	23.26	8.55	18.60	34.88	85.99
Lignite power plants + CCS	0.70	38.76	13.71	22.32	5.33	80.82
Nuclear power plants	0.80	48.75	12.11	8.29	0.00	69.95
Gas power plants GTCC	0.7	13.20	3.75	56.17	12.65	86.48
Hard coal power plants IGCC	0.7	31.01	10.20	23.31	28.62	93.83
Hard coal power plants IGCC + CSS	0.7	38.76	12.20	26.49	3.25	81.40
Lignite power plants IGCC	0.7	31.01	10.20	18.22	34.17	94.30
Lignite power plants IGCC + CCS	0.7	38.76	12.20	20.76	3.89	76.31

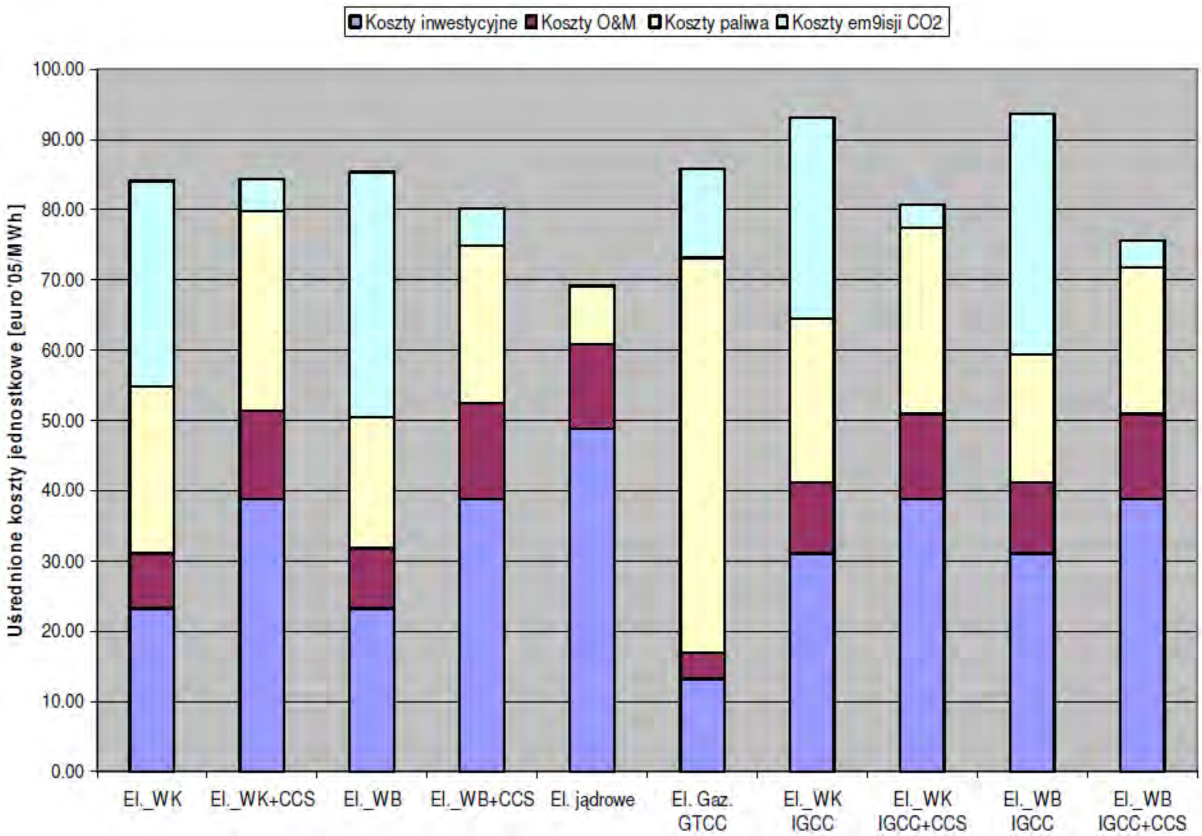


Figure 8. Structure of averaged electricity generation costs in representative power plants.

Uśrednione koszty jednostkowe [euro'05/MWh]	Averaged unit costs [euro'05/MWh]
Koszty inwestycyjne	Investment costs
Koszty O&M	O&M costs
Koszty Paliwa	Fuel costs
Koszty emisjii CO_2	CO_2 emission cost

Despite the fact that nuclear power plants are characterised by competitiveness in relation to other generation sources, it is planned to introduce them in the power source forecast structure baseline scenario only as of approx. 2022, as in earlier years, the existing power plants, power plants currently under construction, and planned for construction to fulfil the requirements of are sufficient to satisfy the updated demand for electricity, the EU energy and climate package.

2.3.1.1.5. Comparison of current investment costs for nuclear power plants with expected costs provided for in the Forecast

In the United Kingdom, the planned investment outlays for 2 EPR reactors are to amount GBP 14 billion, which is 14x1.167 = EUR 16.3 billion[7] (5.1 million EUR/MW), and the price of electricity from nuclear power plants, provided by EDF, shall amount to 97 GDP/MWh, which is 1.167 x 97 = 113 EUR/MWh. According to British assessment, the said figures are to be lower, although the final agreement has not yet been reached. However, it is necessary to point out here that this is an initial level of electricity **price** (for business negotiation) for a contract for differences, **and not the costs** of its generation.

According to estimates published by AREVA in January 2013, the cost of electricity from NPP Flamanville 3 with an EPR reactor, already after taking into account the costs of construction of this unit up to EUR 8.5 billion, shall amount to approx. 80 EUR/MWh[8].

According to estimates published by the US Nuclear Energy Institute in May 2013 (based on data from the US Energy Information Administration and from the Annual Energy Outlook 2013), the total, averaged over the life, costs of advanced nuclear power plants commissioned in 2018 in the USA shall reach 108.4 USD/MWh (in 2011 dollars), which is 81 EUR/MWh. The parameters adopted in the calculations are as follows: credit cost 5% annually, equity cost 15%, and the debt-to-equity ratio of 70/30. Investment outlays for EPC were assumed in the amount of 5 million USD/MW, which is 3.8 EUR/MW, load factor 90%, averaged investment costs 83.4 USD/MWh, constant operating costs 11.6 USD/MWh, variable operating costs together with fuel 12.3 USD/MWh, power transmission costs 1.1 USD/MWh.

In Finland, according to AREVA estimate, the total cost of NPP OL3 with capacity of 1600 MWe shall amount to EUR 8 billion, which is 5 million EUR/MW.

However the most recent data on investment outlays come from contracts concluded in the last two years in Turkey. They confirm the estimates presented in the Forecast in 2011. In Turkey, the value of contract for the first nuclear power plant with 4 WWER units with total capacity of 4800 MWe amounts to USD 20 billion, which corresponds to the unit costs of 3.2 million EUR/MW. The contract for the second nuclear plant with 4 ATMEA reactors with total capacity of 4800 MWe amounts to USD 22 billion[9], which corresponds to the unit costs of 3.5 million EUR/MW. In both cases, the prices under consideration are paid to suppliers of the nuclear unit for "turn-key" construction, so with all costs of engineering work, equipment procurement, construction and start-up (EPC- engineering, procurement, construction), but without investor's own costs such as the cost of plot or transmission

[7] http://m.foxbusiness.com/quickPage.html?page=19453&content=85055560&pageNum=-1
[8] http://www.ft.com/cms/s/0/5f270d2c-5660-11e2-aa70-00144feab49a.html#ixzz2UCgtQfpJ
[9] http://energetyka.wnp.pl/japonsko-francuskie-konsorcjum-zbuduje-atomowke-w-turcji,196606_1_0_0.html

lines and interest on principal during the construction. After adding these costs, total investment outlays for Turkish power plants total approx. 4.5 million EUR/MW.

As it can be seen, investment expenditures provided in the Forecast correspond to current data about prices in contracts concluded in the world for new nuclear power plants. In terms of the amount of energy supplied in a year they are significantly lower than investment expenditures on RES.

For example, a electricity generating facility based on PV cells requires investment outlays for a unit of peak capacity in the amount of 2 million EUR/MW. The actual average efficiency of such cells in 2012 was 0.095[10]. Taking the foregoing into account, the investment costs of energy from this source shall amount to:

2 million EUR/MW /0.095 = 21 million EUR/MW of average capacity.

At the same time it should be highlighted that the said investment outlays were calculated without taking into account the necessity of ensuring a permanent power supply of recipients in the system, so without energy storage costs.

2.3.1.1.6. Costs of cooperation of nuclear power plants and renewable energy sources (RES) with the power system.

When comparing the costs of nuclear power plants and intermittent RES-based energy sources such as wind farms and photovoltaic plants, it is necessary to allow for not only the cost of energy unit generated in the most favourable time for RES, namely sunny or windy conditions, but also the costs of ensuring a constant power supply in the power system, around the clock. It is obvious that both annually as well as daily, it is impossible to constantly generate electricity from solar energy due to the periodic absence of sunlight at night or its insufficient intensity caused by weather conditions. Individual year seasons differ in terms of the intensity of sunlight and its duration per day, hence even when substantial energy storage capacities are ensured, PV panels will generate significantly less in the winter than in the summer. In the case of energy generated by wind farms, the irregularity of wind occurrence and its strength during the year pose a significant problem. It means that the power system must be equipped with plants supporting part load operation—an operation significantly below the nominal load corresponding to the top efficiency, so as to absorb the load in periods when RES provide insufficient energy. Short-term energy storage, e.g. for 16 hours, can be ensured with vanadium batteries or with the use of water electrolysis to obtain an energy carrier in the form of hydrogen. A 1.5 MWh vanadium battery costs USD 0.5 million, occupies 70m$_2$ and weighs 107 tons It enables 10,000 charging and discharging cycles. The efficiency of the full cycle is 70-75%. The investment cost of 16h x 1000 MWe vanadium batteries would be:

16,000 MWh x USD 0.5 million/1.5 MWh = USD 5.32 billion, and the area 0.74 km$_2$.

It means that investment expenditures for the construction of power storage installation based on vanadium batteries would be higher than the cost of a nuclear power plant. Aside from the costs of installation of the PV panels, the costs of power reserve and the occupied area would constitute additional burden resulting from electricity generation from solar energy, while the limited capacity of batteries would not ensure a stable power supply in low generation capacity conditions in a period

[10] http://theenergycollective.com/willem-post/46142/impact-pv-solar-feed-tariffs-germany

longer than 16 hours.

To store the solar energy, the following system might be used: batteries + electrolysers + hydrogen + ammonia, which enables to store power for many weeks. Efficiency of such system would amount to approx. 70% for a few first hours of storage (batteries). Over time, it would diminish to approx. 35% for the full cycle (electrolysers 70% x generator in a combined cycle 60% x transmission 90% x 93% on the assumption that half of the hydrogen is converted into ammonia). It means that investment expenditures for a unit of power generated with the use of a PV system with storage in the full cycle shall amount, for Polish conditions:

EUR 21 million/MW/0.35 = EUR 60 mln/MW.

However, it should be remembered that PV cells can work only for 25-30 years, i.e. during the lifecycle of a NPP, which lasts 60 years, it will be necessary to replace them, incurring the investment costs once again.

The comparative analysis of nuclear and solar power costs indicated[11], that two units with EPR reactors with total capacity of 3200 MWe shall generate 450 TWh in the period of 20 years, which is more than all the PV panels built in Germany in 2000-2011—until 2031, the latter shall deliver approx. 400 TWh. Investment outlays on the unit in Olkiluoto 3 with all overheads and delays caused by prototypicality amount to EUR 8 billion, according to AREVY's declaration. The costs incurred by German electricity recipients for PV panels until 2031 shall amount to approx. EUR 130 billion. In consequence, the average cost of nuclear energy during 60 years of the lifecycle of an EPR reactor shall be many times lower than the cost of solar energy.

The lifecycle of PV cells is significantly shorter than NPP, and their efficiency decreases with age. When assuming the cell degradation rate of 0.5% a year, cells with capacity of 24700 MWe installed in Germany until 2011 shall enable production of slightly more than 604 TWh within the period of 30 years, which is little else than the production of one unit with EPR reactor.

Presently, there is no obligation imposed on photovoltaics—similarly as other RES generation sources—to feed a constant power to the grid. Stable supply is ensured by systemic (nuclear, coal, and gas) power plants. Photovoltaics supplies marginal amounts of energy, and the fluctuations are compensated by other power plants. As long as problems with power storage and long-distance transmission are not resolved, photovoltaics shall remain a source with insignificant contribution in operation of the power system. After 30 or 40 years, part of panels will be able to continue production, but most of them shall be removed or replaced, and the corresponding expenses shall be borne by the owners.

Power storage means that solar systems are not attractive any more, but without storage it will be necessary to maintain a substantial reserve in systemic power plants (spinning reserve and intervention reserve), which means significant costs and problems in planning the operation and adjustment of the power system.

It should be added that the cost of power storage with the use of hydro-pump plants are also very high—due to high investment expenditures (2000-3000 USD/kW[12]) and material energy loss in the pumping/generation cycle (its efficiency is usually at the level of 72-75%), and there are also very

[11] http://thebreakthrough.org/index.php/programs/energy-and-climate/cost-of-german-solar-is-four-times-finnish- nuclear/

[12] http://www.giz.de/Themen/en/dokumente/giz2012-en-hydropower-workshop-pump-storage-experiences.pdf

limited possibilities in terms of location of such facilities.

Additional costs incurred to maintain the stability of the power system are defined in the OECD Report for 2012. Results presented below concern Germany as the country which is most advanced in the implementation of RES within the power system.

Table 7. Systemic costs in Germany[13] (USD/MWh).

Technology	Nuclear power plants		On-shore wind farms		Off-shore wind farms		Solar photovoltaic plants	
Share in generation of electricity	10%	30%	10%	30%	10%	30%	10%	30%
Costs of reserve	0	0	7.96	8.84	7.96	8.84	19.22	19.71
Balancing costs	0.52	0.35	3.3	6.41	3.3	6.41	3.3	6.41
Connection	1.9	1.9	6.37	6.37	15.71	15.71	9.44	9.44
Grid reinforcement	0	0	1.73	22.23	0.92	11.89	3.69	47.4
Total costs at the system level	2.42	2.25	19.36	43.85	27.9	42.85	35.64	82.95

A review in OECD countries revealed that connection costs for RES are significantly higher than for nuclear plants. As the example of Germany demonstrates, the introduction of RES requires enormous subsidies paid by all power recipients, both for the installations themselves as well as for grid extension.

2.3.1.2. Results of the sensitivity analysis for the high price scenario for CO2 emission allowances

This scenario assumes a higher level of prices of CO_2 emission allowances, with a level of 60 €'09/t CO_2 to be achieved in 2030 (in baseline scenario: 33 €'09/tCO_2), with other assumptions adopted for the baseline scenario maintained. Figures below present the results of analyses of this scenario.

[13] Nuclear energy and renewable systems in low carbon electricity systems, OECD 2012, page 127

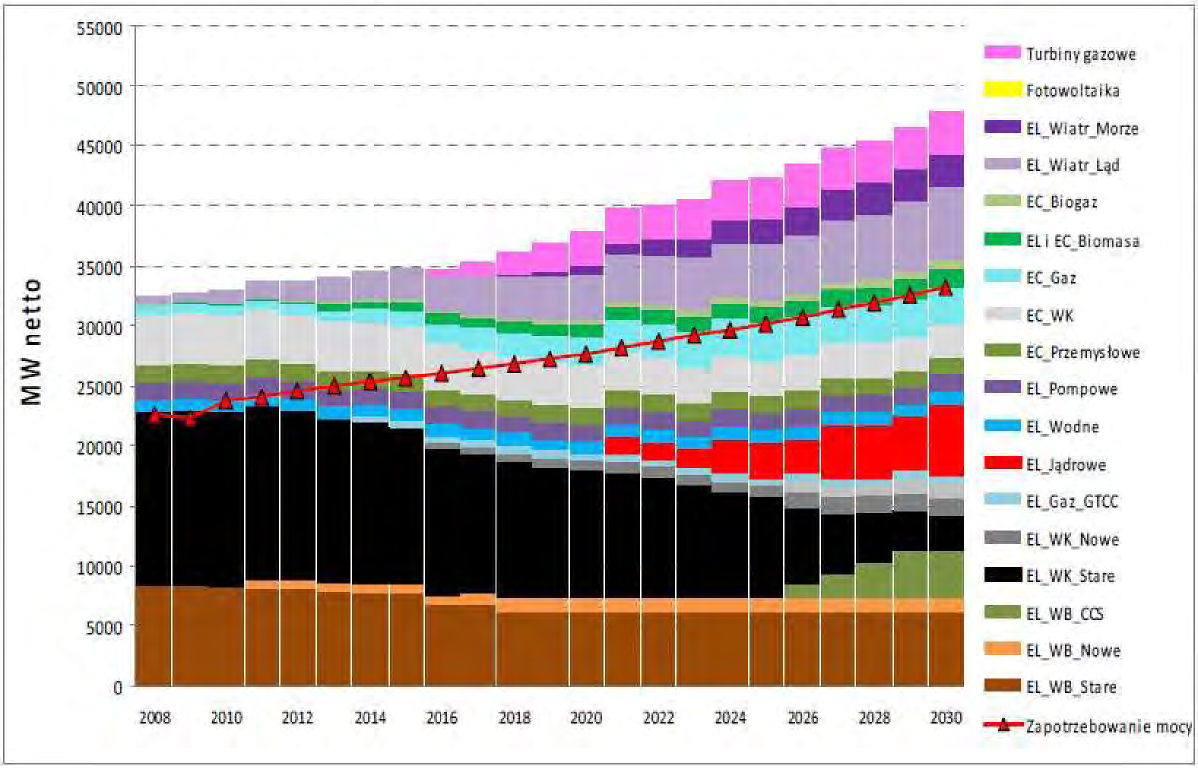


Figure 9. Electricity source capacity structure for the high price scenario for CO_2 emission allowances

MW netto	Net MW
Turbiny gazowe	Gas turbines
Fotowoltaika	PV
EL Wiatr Morze	Off-shore wind farms
EL Wiatr Ląd	On-shore wind farms
EC Biogaz	Biogas CHPs
EL i EC Biomasa	Biomass power plants and CHPs
EC Gaz	Gas CHPs
EC WK	Hard coal CHPs
EC Przemysłowe	Industrial CHPs
EL Wodne	Water power plants
EL Jądrowe	Nuclear power plants
EL Gaz GTCC	Gas power plants GTCC
EL WK Nowe	Hard coal power plants - New
EL WK Stare	Hard coal power plants - Old
EL WB CCS	Lignite power plants CCS
EL WB Nowe	Lignite power plants - New
EL WB Stare	Lignite power plants - Old
Zapotrzebowanie mocy	Demand for capacity

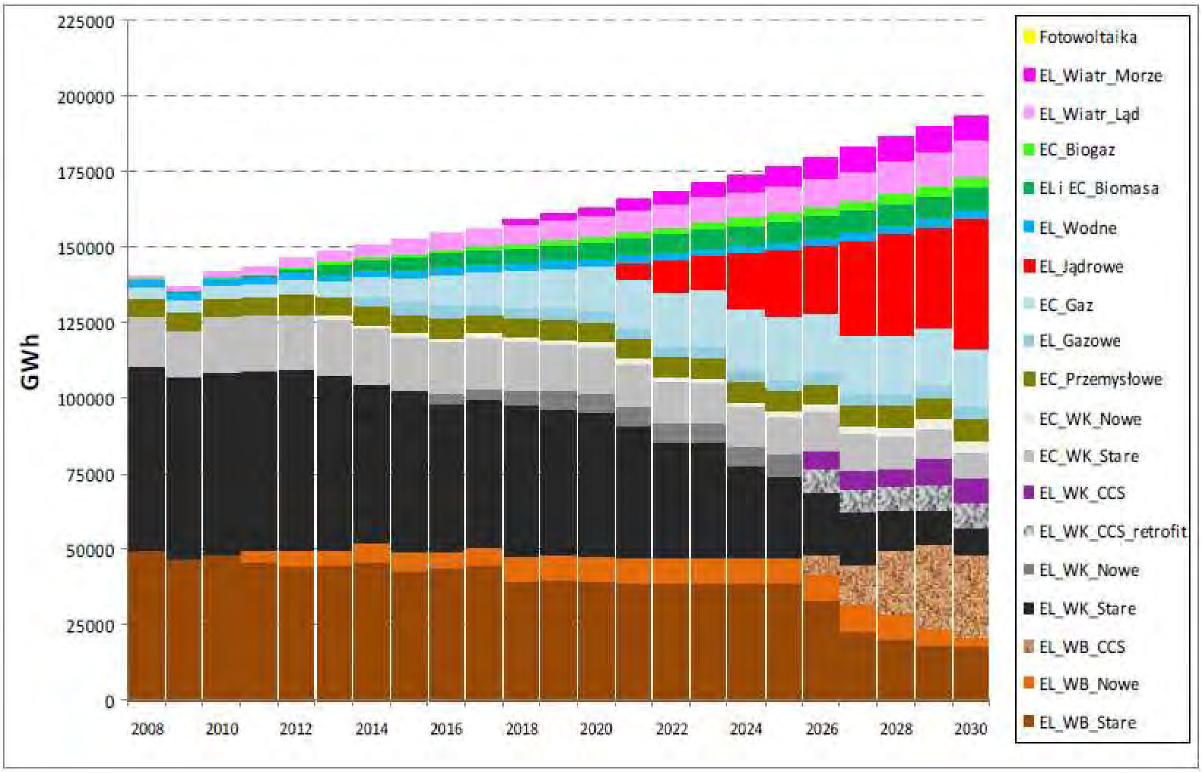


Figure 10. Net electricity generation portfolio for the high price scenario for CO_2 emission allowances

Fotowoltaika	PV
EL Wiatr Morze	Off-shore wind farms
EL Wiatr Ląd	On-shore wind farms
EC Biogaz	Biogas CHPs
EL i EC Biomasa	Biomass power plants and CHPs
EL Wodne	Water power plants
EL Jądrowe	Nuclear power plants
EC Gaz	Gas CHPs
EL Gazowe	Gas power plants
EC Przemysłowe	Industrial CHPs
EC WK Nowe	Hard coal CHPs - New
EC WK Stare	Hard coal CHPs - Old
EL WK CCS	Hard coal power plants CCS
EL WK CCS retrofit	Hard coal power plants CCS retrofit
EL WK Nowe	Hard coal power plants - New
EL WK Stare	Hard coal power plants - Old
EL WB CCS	Lignite power plants CCS
EL WB Nowe	Lignite power plants - New
WL WB Stare	Lignite power plants - Old

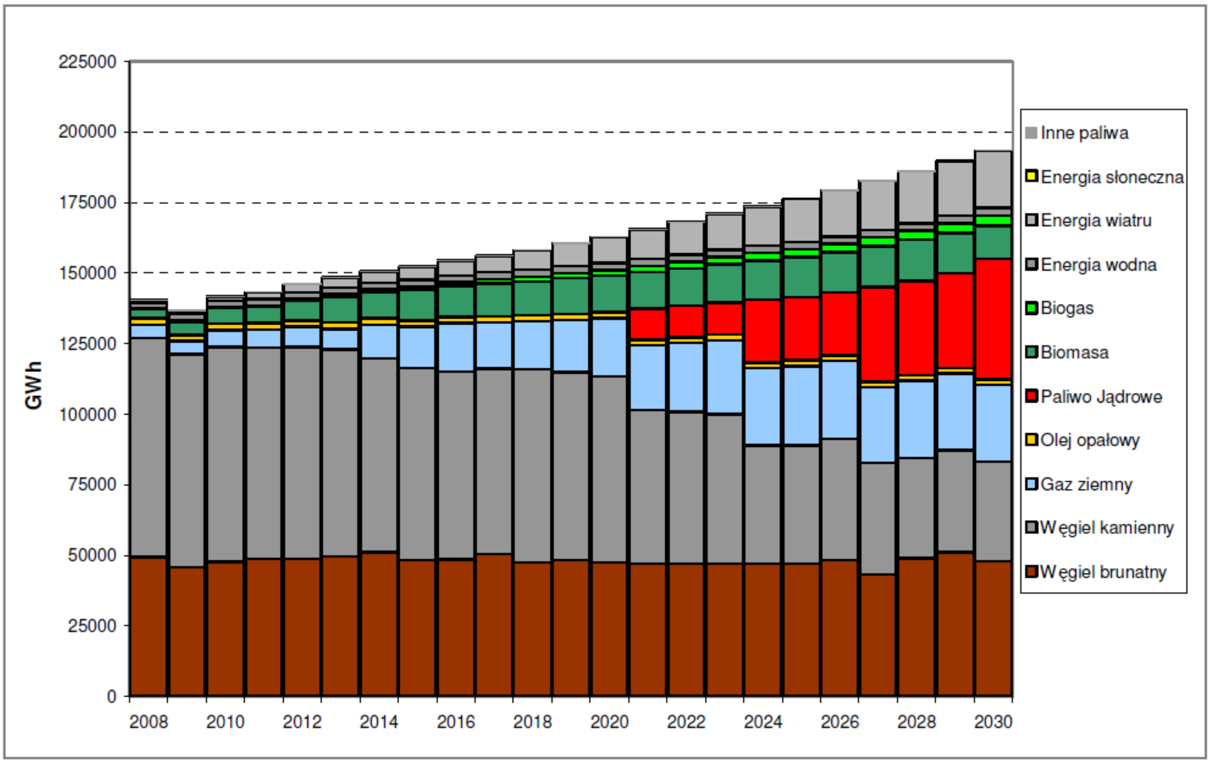


Figure 11. Electricity generation fuel structure for the high price scenario for CO_2 emission allowances

Inne paliwa	**Other fuels**
Energia słoneczna	**Solar energy**
Energia wiatru	**Wind energy**
Energia wodna	**Water energy**
Biogas	**Biogas**
Biomasa	**Biomass**
Paliwo Jądrwowe	**Nuclear fuel**
Olej opałowy	**Fuel oil**
Gaz ziemny	**Natural gas**
Węgiel kamienny	**Hard coal**
Węgiel brunatny	**Lignite**

The most important result of high price dynamics for CO_2 emission allowances is **the increased use of gas sources.** It concerns mostly natural gas CHPs which support to a significant degree old CHPs and limit the development of new coal CHPs. Combined cycle power plants have a slightly more share in electricity generation than in the baseline scenario, but they are little competitive when compared to coal sources equipped with CCS installations.

In this alternative, the competitiveness of nuclear power plants is very important (compare Figure 1), whose first unit with capacity of 1500 MW net appears in **2021**, and **next** are built **every three years,** which results in **4 nuclear units with total net capacity of 6000 MW** until 2030. **Nuclear power plants have a strong stabilising impact on electricity prices, especially after 2025**. A significant growth of coal CCS sources after 2025, especially lignite sources, is another important effect.

2.3.1.3. Impact of nuclear power industry on electricity generation costs in the National Power System

In the baseline scenario, the first 1500 MW nuclear plant with the lowest discounted costs appears in

2022, and subsequent units should be launched every three years—until 2030, **4500 MW** in nuclear units should be commissioned in total. While in the **high cost scenario for CO_2 emission allowances**, the first unit with capacity of 1500 MW net appears in 2021, and next are built **every three years**, which results in **6000 MW** of capacity in nuclear units until 2030.

After 2025, the baseline scenario provides for the stabilisation of generation costs in result of growing share of nuclear power plants and plants equipped with CCS in the generation portfolio.

Given low prices of CO_2 emission allowances, nuclear power plants virtually do not change the average generation costs, while enabling **significant CO_2 emission reduction.**

On the other hand, given **high prices of CO_2 emission allowances**, nuclear power plants **have a stabilising effect on the level of electricity prices**, and absence of nuclear plants among generation sources results in significant growth of generation costs. To some extent, an alternative to nuclear plants might be conventional sources with CCS installations. However, when taking into account the current, early stage of development of this technology, estimates of future technical parameters and costs connected with its exploitation should be approached with prudence. The analogical costs of operation of nuclear power plants are fairly more reliable.

2.3.2. Discussion of the argument on erroneous uranium price estimates in PNPP and SEA Forecast

The analysis of power generation costs include a growth forecast for uranium prices. Long-term forecast – until 2050. (Figure 12) shows a forecast that the growth of uranium prices shall still be the lowest among all energy carriers.

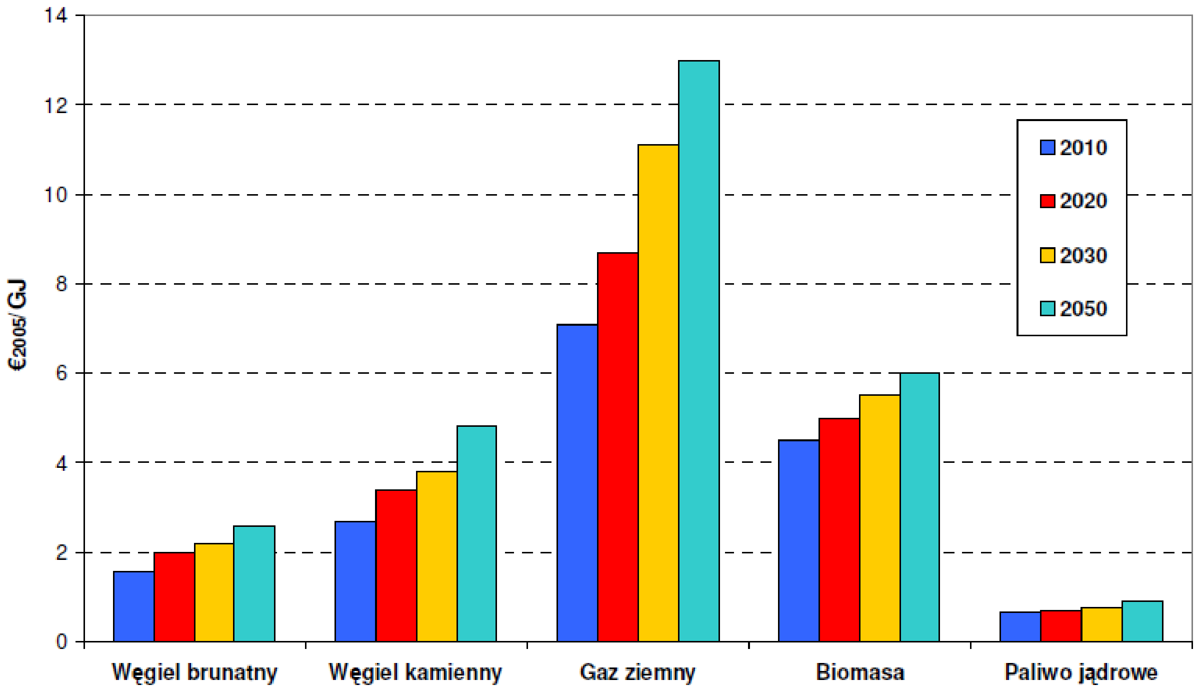


Figure 12. Forecast of fuel prices until 2050 (per GJ of heat generated) [PNPP, ARE].

Węgiel brunatny	**Lignite**
Węgiel kamienny	**Hard coal**
Gaz ziemny	**Natural gas**
Biomasa	**Biomass**

Biogas	**Biogas**
Paliwo Jądrwowe	**Nuclear fuel**

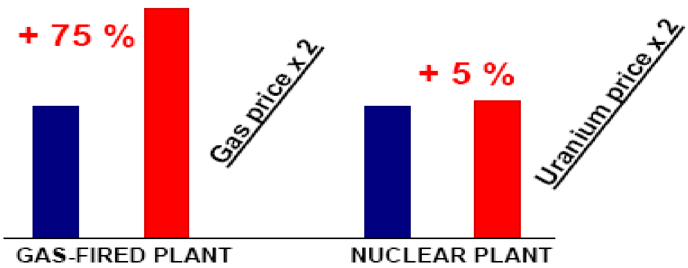


Figure 13. Impact of doubling of the natural gas and uranium prices on the costs of power generated in a gas power plant and nuclear power plant [AREVA].

At present, fuel costs in relation to the amount of generated heat (€/GJ) are approx. 4 times lower for the nuclear fuel than for hard coal, and approx. 10 times lower than for the natural gas. Moreover, costs electricity generation in nuclear power plants are little sensitive to the growth of uranium prices, because the cost of fuel constitutes only about 10% of generation costs, of which uranium costs correspond to 30-50% of nuclear fuel (which mostly depends on the reactor type). Therefore, even doubled fuel cost would result in a growth of generation costs for NPP only by about 5%, while e.g. in a gas power plant (where the share of fuel costs in total generation costs is approx. 80%) it would be a growth of approx. 75% (Figure 14).

2.3.3. Additional analyses of electricity generation subsector stemming from the update of the Polish Nuclear Power Programme

In order to ensure that PNPP is based on the national energy sector development forecast prepared on the basis of the current situation on the global, European, and domestic energy market, subsequent, additional updates for earlier analyses were prepared in 2013. They take into account new prognostic data for external parameters, including those relating to macroeconomic projections, fuel prices, actions in the scope of energy consumption efficiency and development of a renewable power industry. The following updates were released in 2013:

- ARE S.A. April 2013 - Update of the comparative analysis of electricity generation costs in nuclear, coal, and gas power plant as well as renewable energy sources[14],
- ARE S.A., June 2013 - Update of the forecast for fuels and electricity demand until 2030[15][16],

The analyses confirmed that it is not possible to satisfy the demand for electricity in Poland only by improving the energy consumption efficiency and development of the RES sector and that the decision to diversify the electricity generation portfolio through inclusion of nuclear power is reasonable.

[14] Update of the comparative analysis of electricity generation costs in nuclear, coal, and gas power plant as well as renewable energy sources ARE S.A., April 2013.
[15] Update of the forecast for fuels and electric energy demand until 2030, study by Agencja Rynku Energii S.A., June 2013,

The updated Forecast demand for fuels and electricity until 2030 defines in particular:

- Forecast demand for end user electricity;
- Structure of capacity of generation sources, structure of electricity generation, and fuel structure of electricity generation—for baseline scenario and other scenarios examined as part of sensitivity analyses (including non-nuclear alternatives);
- Costs of electricity generation—for baseline scenario and other scenarios included in the sensitivity analysis;
- CO_2 emissions—for baseline scenario and other scenarios included in the sensitivity analysis.

As part of sensitivity analyses in the updated forecast, the following scenarios have been examined—in relation to the baseline scenario (with cost-optimal structure of generation sources):

- High price scenario for CO_2 emission allowances,
- Low price scenario for CO_2 emission allowances,
- Low prices scenario for natural gas,
- Opt-out scenario for nuclear power plant construction,
- Scenario with determined coal units.

2.3.3.1. Forecast demand for end user electricity

2.3.3.1.1. Assumptions made for analysis

- The updated macro-economic forecast (based on the forecast prepared by the Ministry of Finance) in which it was assumed that the average real GDP growth rate of Poland will gradually approach the long-term growth rate of the European Union in this category. It was assumed that in the period under consideration, the Polish economy shall grow at the average GDP rate of 3.1%. It is a significantly slower pace than 5.1% adopted for "PEP Forecast 2030".
- Projections of fuel prices on European markets and CO_2 emission permit prices–in accordance with the study of International Energy Agency (IEA), "World Energy Outlook 2012". In particular the IEA projection according to which the price of CO_2 emission permits shall reach in 2030 the level of € 30/tCO_2.
- The updated projection of results of energy consumption rationalisation.
- The projection of decommissioning of the exploited electricity generation capacities and assumptions concerning units determined.
- Updated technical and economical parameters of specification of new generation units. In particular it was assumed that
    - carbon capture and storage technologies will not guarantee profitability before 2025;
    - exploitation of new lignite deposits (in the area of Legnica and Gubin) shall not commence before 2025;
    - IGCC technology shall be available in Poland as of 2025.

- In the scenario with determined coal units, it was also assumed that coal units no. 5 and 6 (2 x 830 MW_{net}) shall be built in Opole, a 830 MW_{net} coal unit shall be built in Jaworzno, apart from the following units to be built: 436 MW_{net} in Stalowa Wola (2015 – gas CHP), 450 MW_{net} in Włocławek (2016 – gas CHP), 925 MW_{net} in Kozienice (2017 – hard coal power plant), and 440 MW $_{net}$ w Turów (2018 – lignite power plant). It was assumed that unit no. 5 in Opole will be commissioned in 2018, while unit no. 6—in 2019. The unit in Jaworzno is to be commissioned in 2018.

2.3.3.1.2. Results of demand forecast for end user electricity

Results of forecasts show that the demand for end user electricity shall grow in the time horizon under consideration from the level of 119.1 TWh in 2010 to 161.4 THw in 2030, which is 36% more (see table 8 and figure 14). The demand mentioned above shall grow by 1.5% on an annual average.

Table 8 forecast demand for end user electricity

2008	2010	2015	2020	2025	2030
117.6*	119.5*	129.4*	139.4*	151.9*	167.6*
117.6**	119.1**	124.4**	136.6**	147.8**	161.4**

*- Update of the forecast for fuels and electricity demand until 2030, ARE, September 2011,

**- Update of the forecast for fuels and electricity demand until 2030, ARE, June 2013,

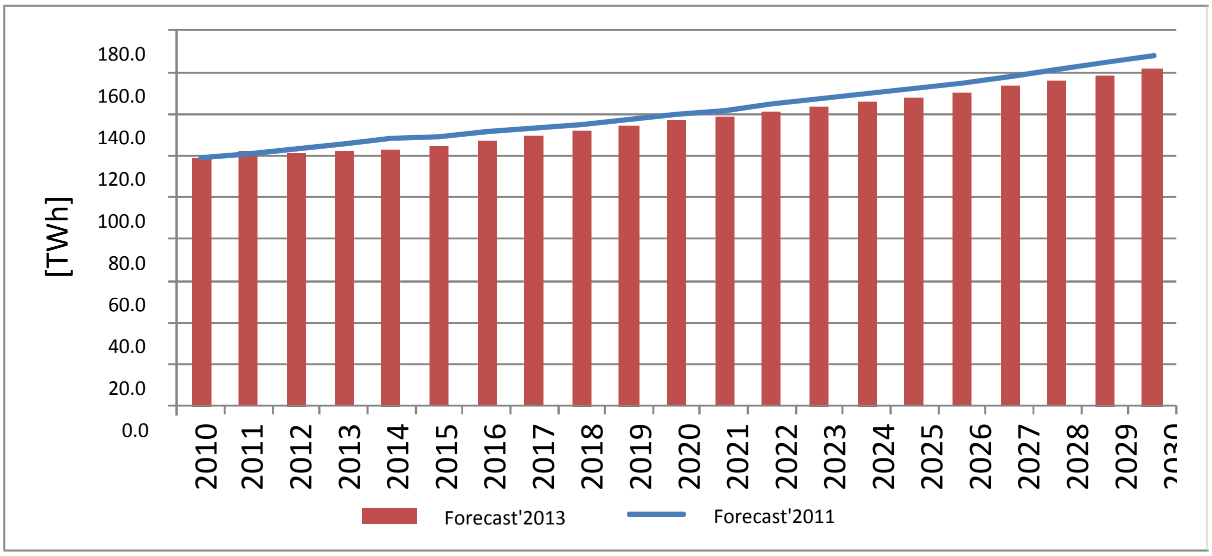


Figure 14 Forecast demand for end user electricity – Update from 2013

A comparison of the results of the end user electricity from the forecast of 2013 and the update made in 2011 results in slight differences. New assumptions caused a modest reduction of forecast demand, mainly due to the lower GDP growth rate than in forecast of 2011.

2.3.3.1.3. Forecast of optimal technological and fuel structure of electricity generation

To ensure a relevant volume of electricity generated, at reasonable costs and with environment protection requirements fulfilled, it will be necessary to build new, zero-emission and low-emission sources based on various power technologies, including high-efficiency coal, nuclear, gas, and renewable sources.

Due to the fact that when the work on PNPP were finalised, decisions were taken to erect new power plants, the baseline scenario within PNPP was assumed providing for determined coal units.

The maximum net capacity of electricity generation sources in the National Power System shall grow, when compared to 2010, from 33.5 GW to **approx. 44.5 GW** (namely by **approx. 33%**) in 2030, which means an average annual growth rate at the level of 1.45%. While the demand for net peak capacity shall increase, when compared to 2008, from the level of 22.6 GW to approx. 33.3 GW in 2030. The role of systemic power plants fired with coal fuels is being significantly reduced. The RES share (and on-shore wind farms in particular as well as the share of CHPs fired with natural gas, is growing.

The first nuclear power plant with capacity of 1,500 MW appears in 2025, another next unit shall be launched in 2030, and the next two until 2035 (Figure 15).

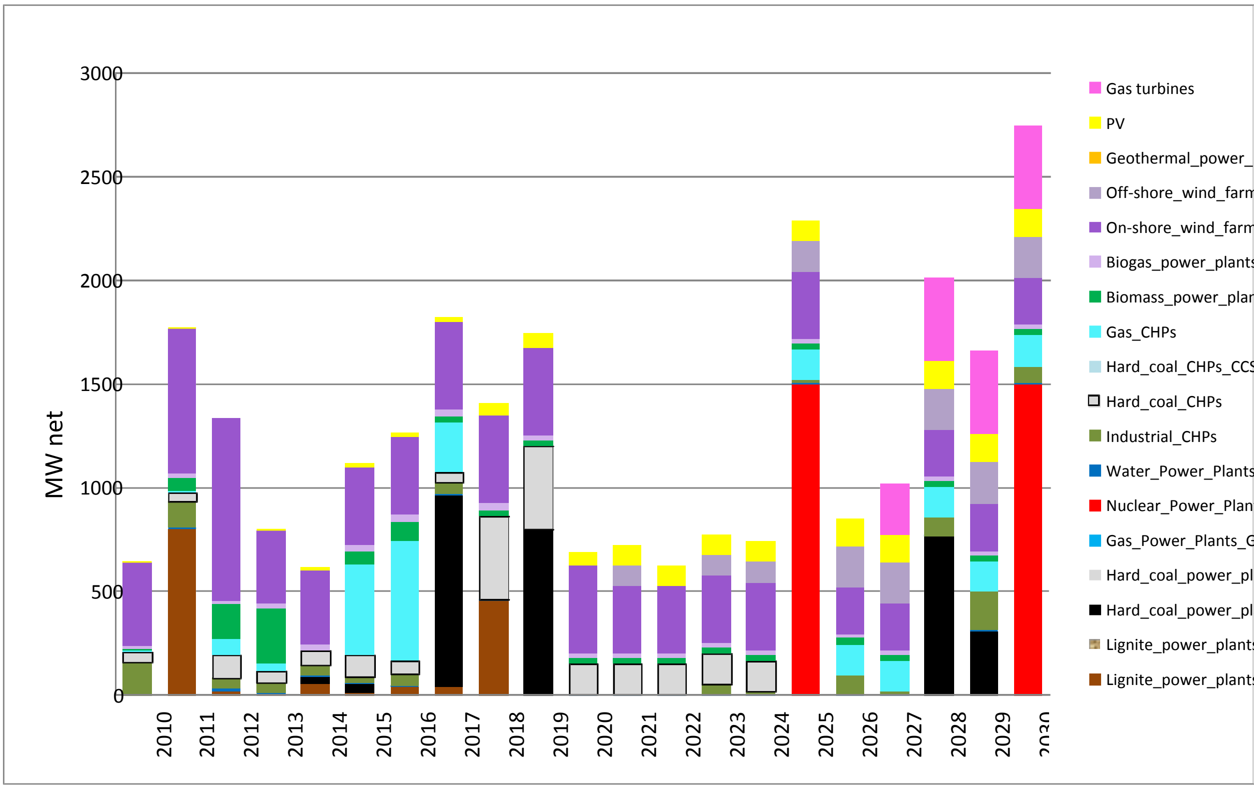


Figure 15 Structure of new and modernised generating capacities.

The forecast structure of generation sources is presented below (Table 9 and Figure 16, 17, and 18).

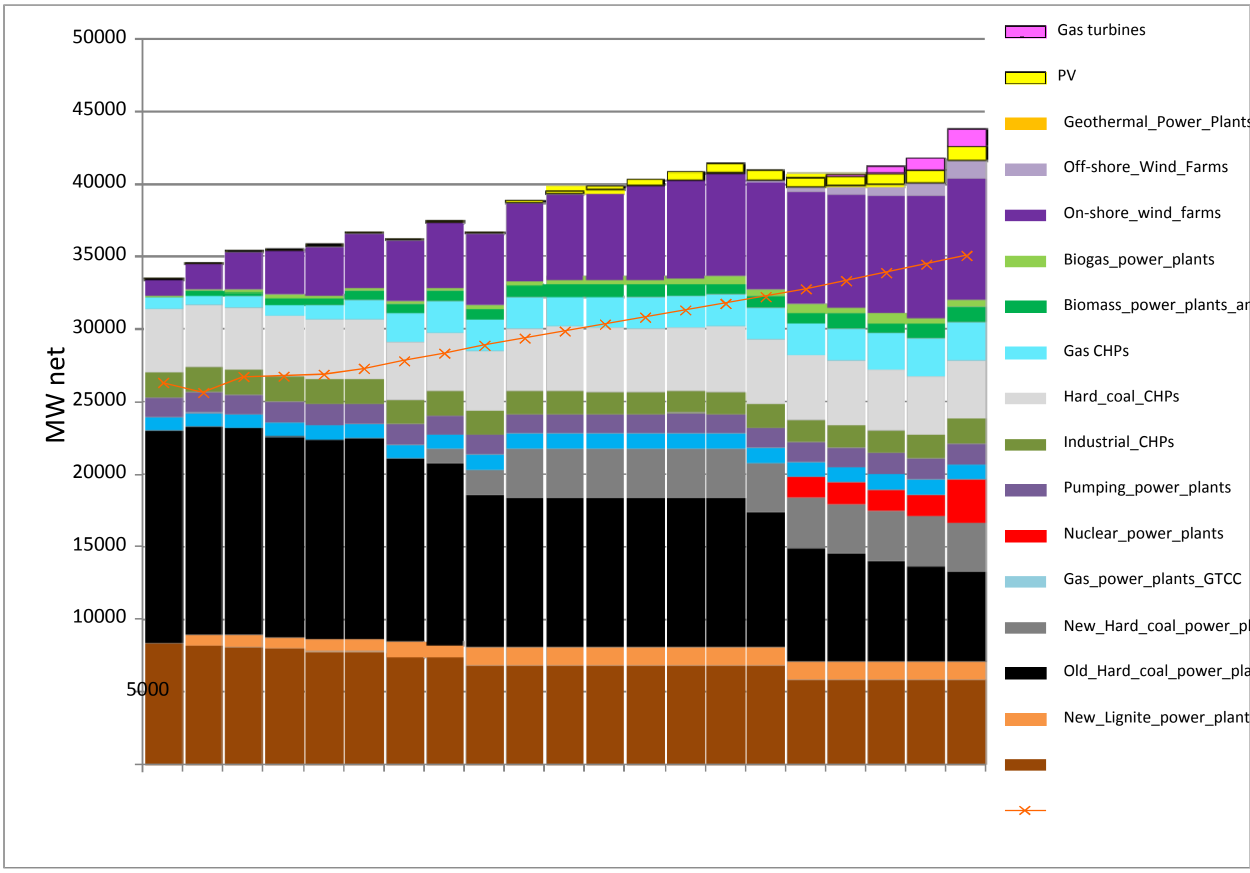
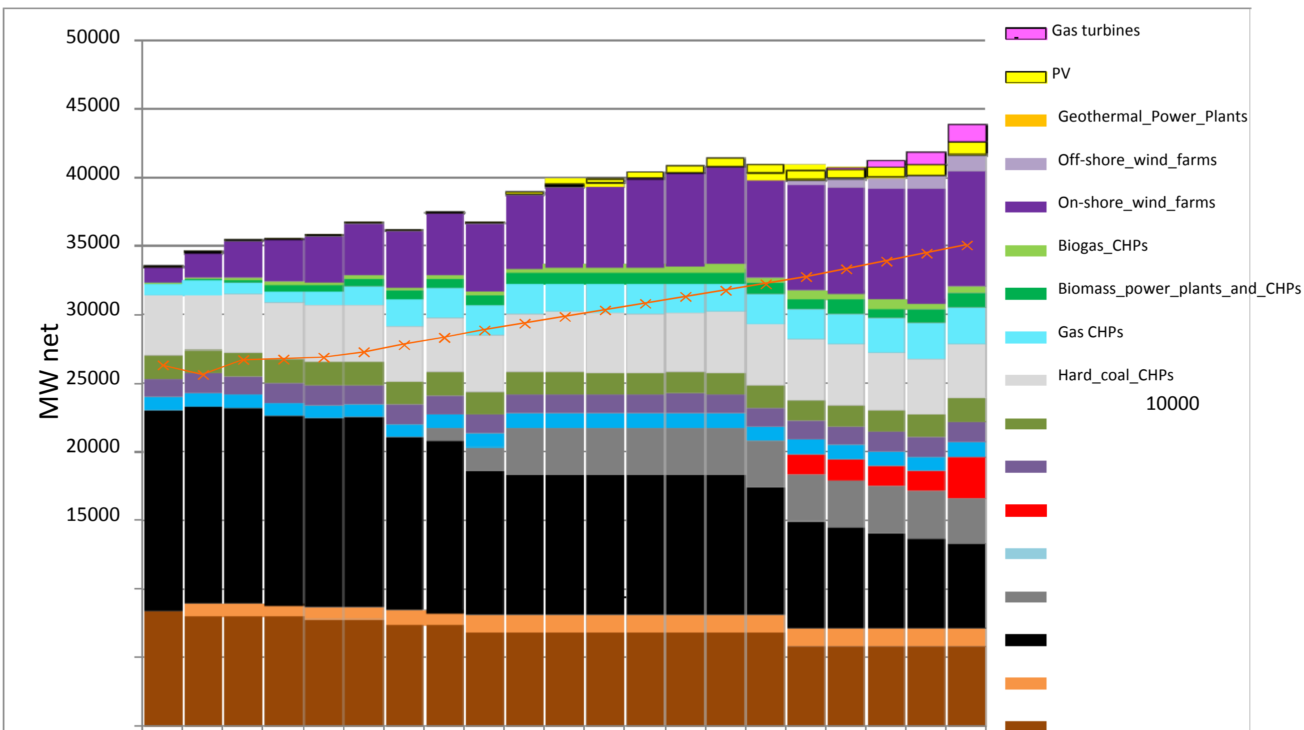


Figure 16 Maximum net capacity of electricity generation sources per technology in accordance with the scenario with determined coal units

Table 9 Technological structure of maximum net capacity of electricity generation sources [MW].

	2010	2015	2020	2025	2030
Old_Lignite_power_plants	8324	7818	6844	6797	5872
New_Lignite_power_plants	0	803	1243	1243	1243
Lignite_power_plants_CCS	0	0	0	0	0
Old_Hard_coal_power_plant	14687	13878	10298	9350	6151
New_Hard_coal_power_pla	0	0	3415	3415	3415
Hard_coal_power_plants_CC	0	0	0	0	0
Gas_power_plants_GTCC	0	0	0	0	0
Nuclear_power_plants	0	0	0	0	3000
Water_power_plants	935	968	996	1023	1051
Pumping_power_plants	1405	1405	1405	1405	1405
Industrial_CHPs	1741	1692	1626	1582	1695
Hard_coal_CHPs	4323	4164	4370	4426	3960
Hard_coal_CHPs_CCS	0	0	0	0	0
Gas_CHPs	821	1387	2204	2204	2737
Biomass_power_plants_and	53	555	766	916	1066
Biogas_power_plants	82	200	300	366	431
On-shore_wind_farms	1108	3770	5845	7470	8474
Off-shore_Wind_Farms	0	0	0	150	1150
Geothermal_Power_Plants	0	0	0	0	0
PV	1	41	275	665	940
Gas turbines	0	0	0	0	1267
In total	**33480**	**36680**	**39585**	**41011**	**43857**



Industrial_CHPs
Pumping_power_plants
Nuclear_power_plants
Gas_power_plants_GTCC
New_Hard_coal_power_plants
Old_Hard_coal_power_plants
New_Lignite_power_plants
Old_Lignite_power_plants
Net demand for capacity

5000
0

2010 2012 2014 2016 2018 2020 2022 2024 2026 2028 2030

Figure 17 Net electricity generation forecast per technology in accordance with the scenario with determined coal units

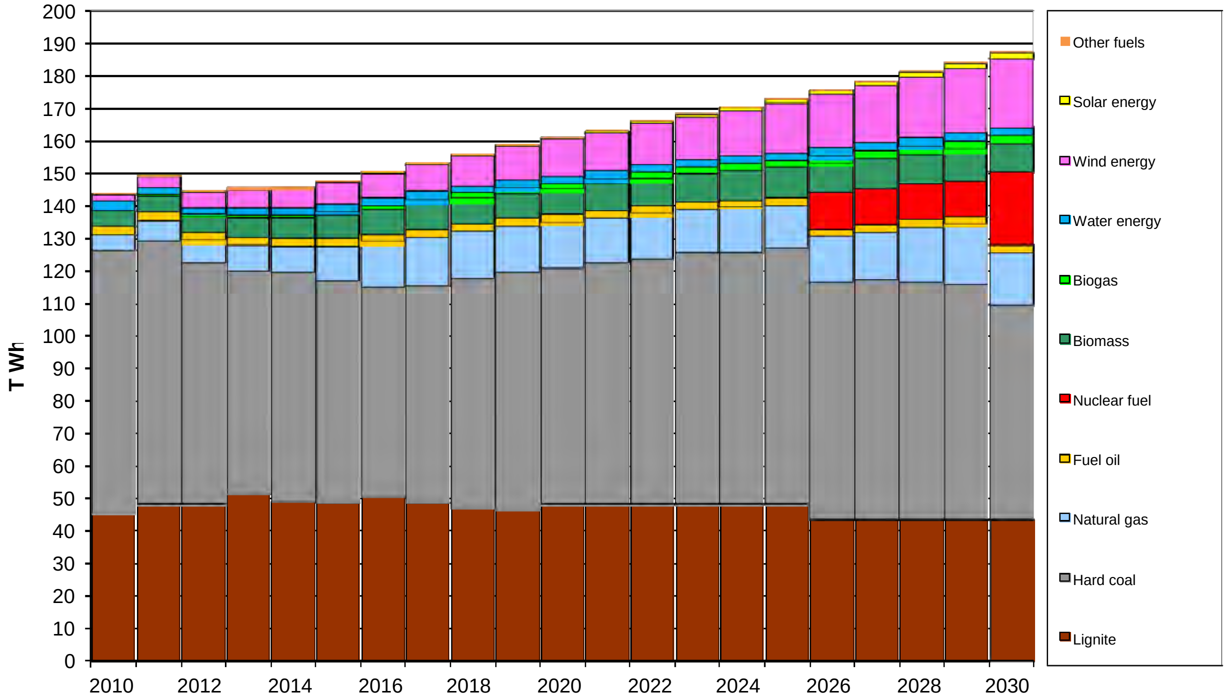


Figure 18 Net electricity generation per fuel type in accordance with the scenario with determined coal units

The table below presents the forecast structure of electricity generation per fuel type. **Table 10**

Forecast structure of net electricity generation by fuels [TWh].

	2010	2015	2020	2025	2030
Lignite	45.4	48.5	48.3	48.3	43.6
Hard coal	81.2	68.7	72.2	67.2	64.4
Natural gas	4.7	10.7	14.5	13.3	17.1
Fuel oil	2.7	2.3	2.2	2.2	2.1
Nuclear fuel	0.0	0.0	0.0	11.2	22.3
Biomass	4.6	7.3	8.1	9.0	9.0
Biogas	0.4	1.1	1.9	2.3	2.7
Biooil	0.0	0.0	0.0	0.0	0.0
Water energy	2.9	2.3	2.4	2.4	2.5
Wind energy	1.7	6.9	11.1	16.0	21.7
Solar energy	0.00	0.06	0.35	0.99	1.91
Other fuels	0.26	0.23	0.18	0.11	0.10
In total	**143.8**	**147.9**	**161.2**	**173.0**	**187.4**
			Share %		
	2010	**2015**	**2020**	**2025**	**2030**
Lignite	32%	33%	30%	28%	23%
Hard coal	57%	46%	45%	39%	35%
Natural gas	3%	7%	9%	8%	9%
Fuel oil	2%	2%	1%	1%	1%

Nuclear fuel	0%	0%	0%	6%	12%
Biomass	3%	5%	5%	5%	5%
Biogas	0%	1%	1%	1%	1%
Biooil	0%	0%	0%	0%	0%
Water energy	2%	2%	1%	1%	1%
Wind energy	1%	5%	7%	9%	12%
Solar energy	0%	0%	0%	1%	1%
Other fuels	0%	0%	0%	0%	0%

The share structure of individual fuels in electricity generation forecast for 2030 is presented in figure 19. The share of nuclear fuels in the structure is expected at the level of 12%, which is slightly less than assumed in the previous version of the forecast (15.7%).

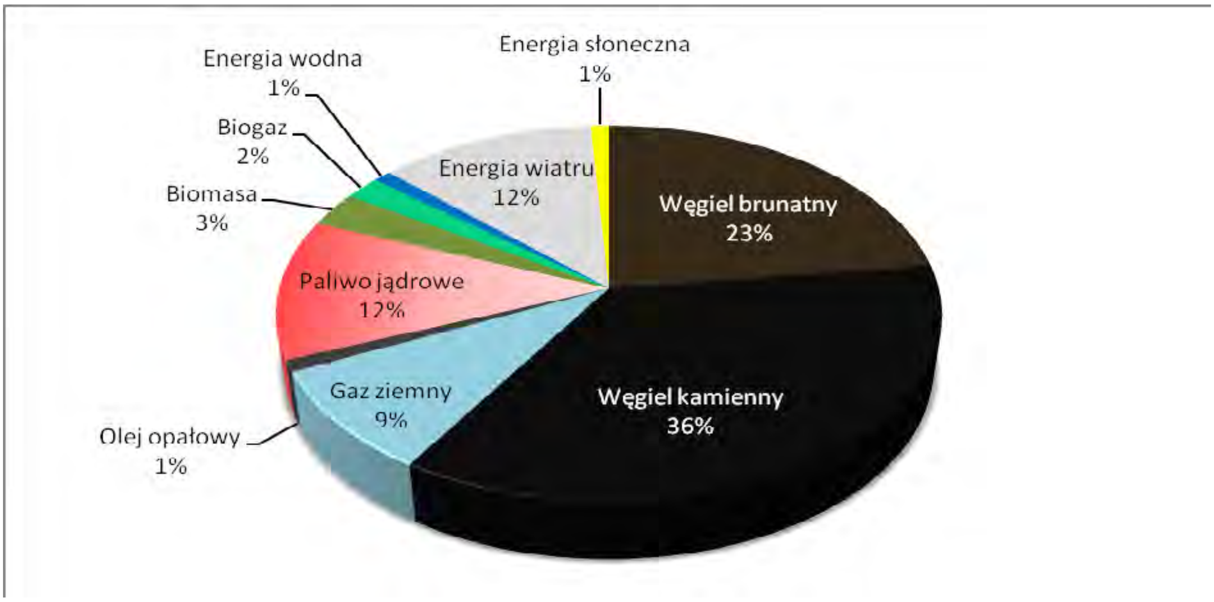


Figure 19 Share of individual fuels in net electricity generation - forecast for 2030.

Węgiel brunatny	**Lignite**
Węgiel kamienny	**Hard coal**
Gaz ziemny	**Natural gas**
Biomasa	**Biomass**
Biogas	**Biogas**
Olej Opałowy	**Fuel oil**
Paliwo jądrowe	**Nuclear fuel**
Energia wodna	**Water energy**
Energia wiatru	**Wind energy**
Energia słoneczna	**Solar energy**

2.3.3.1.4. High price scenario for CO2 emission allowances

This scenario assumes a faster rate of growth of CO_2 emission allowance prices than in the baseline scenario. It cannot be excluded that such a scenario will materialise (despite very low levels observed currently, which probably stem from the economic crisis in the course in Europe and oversupply of allowances on the market), if the ideas to drastically reduce the CO_2 emissions (85% reduction until

2050) proposed by the EU (Figure 20-23) are forced through.

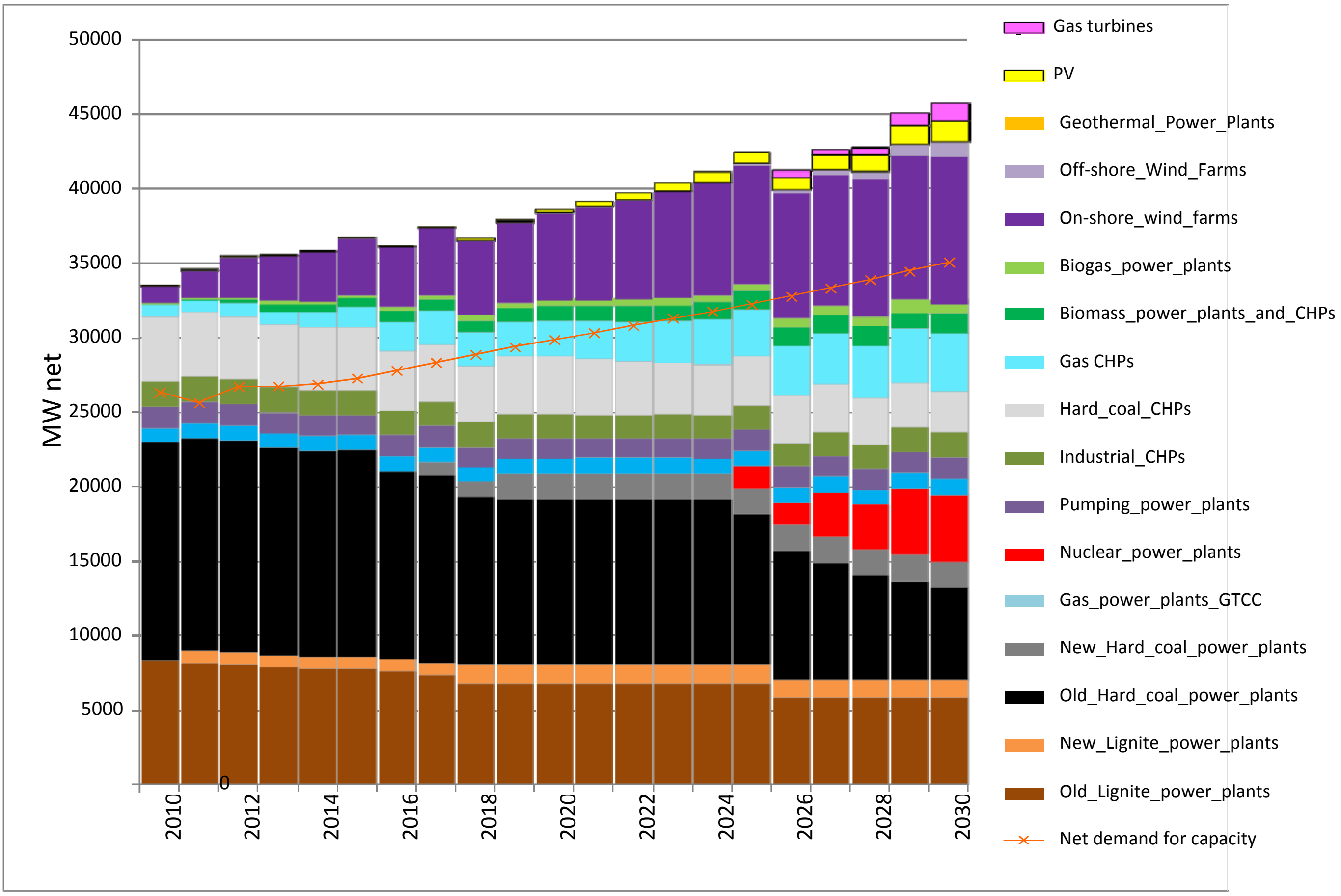


Figure 20 Maximum net capacity of electricity generation sources per technology in accordance with the high price scenario for CO_2 emission allowances

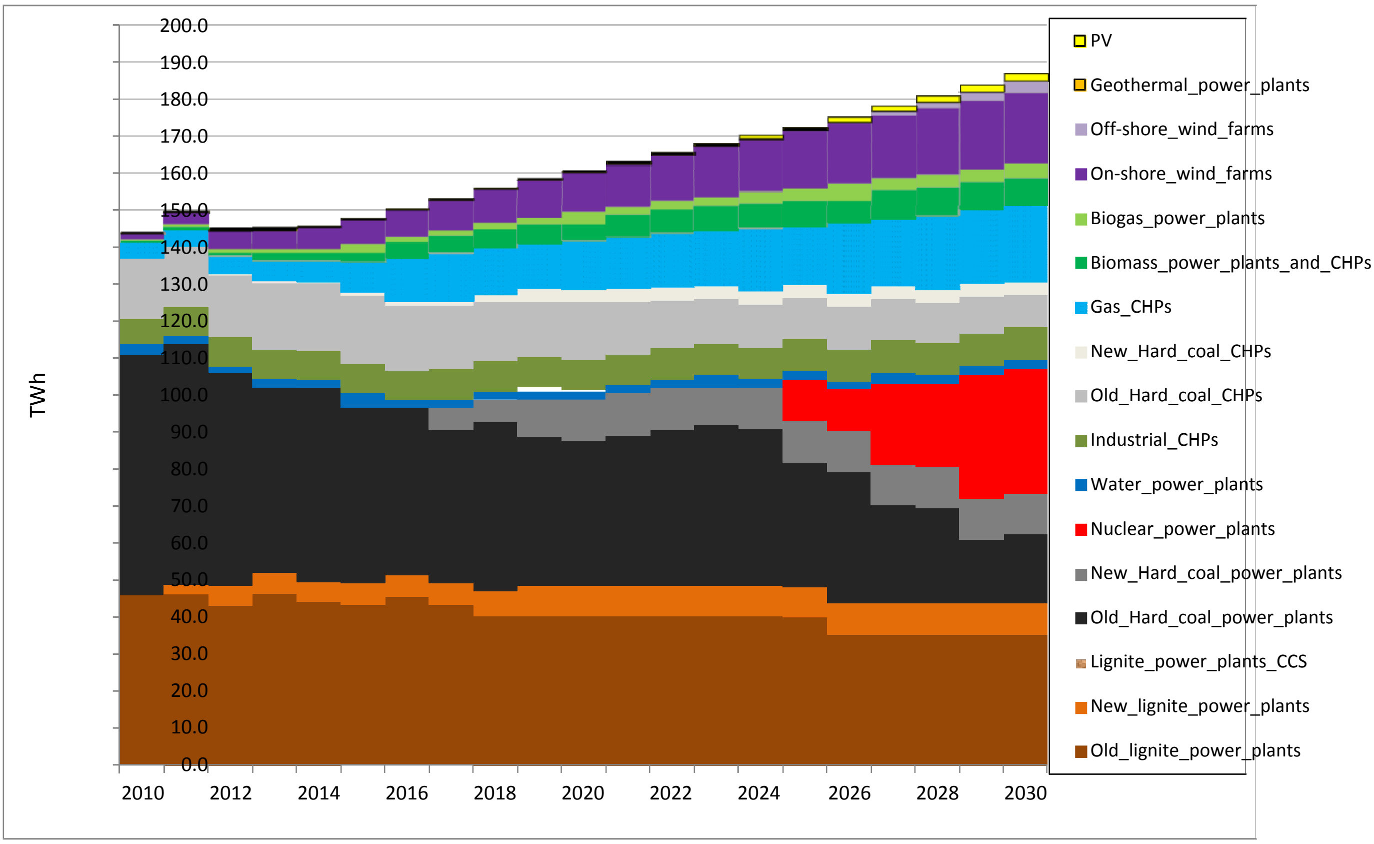


Figure 21 Net electricity generation forecast per technology in accordance with the high price scenario for CO_2 emission allowances

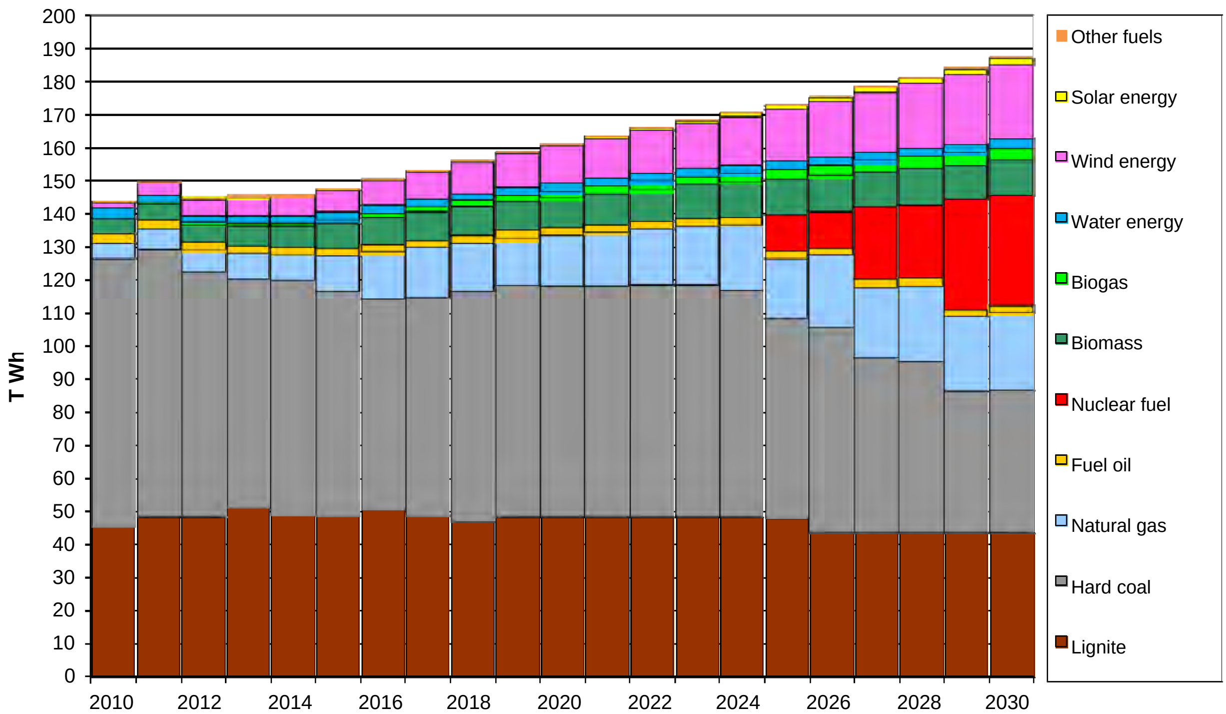


Figure 22 Net electricity generation portfolio for the high price scenario for CO_2 emission allowances

High CO_2 emission allowance prices introduced to model calculations resulted in a growth of share, in the capacity and electricity generation portfolio, of units characterised with low carbon dioxide emission. This is particularly the case for renewable energy sources and nuclear power plants (the latter shall have a 18% share in the electricity generation in 2013)

2.3.3.1.5. Low price scenario for CO2 emission allowances

Results for the scenario based on low prices of CO_2 emission allowances indicate that hard coal and lignite are uncontested as fuel for electricity and network heating generation. Low prices of allowances do not generate incentives to build low-emission units, i.e. they are unable to level the differences in operation costs and make the latter more competitive in relation to the coal units. Within this scenario, renewable energy sources are developed only because of the support system.

2.3.3.1.6. Low prices scenario for natural gas

Energy prices assumed in the baseline scenario on the basis of forecasts of the International Energy Agency provide for the growth of natural gas prices in 2013-2020. However, current situation on the global gas market, resulting, *inter alia*, from the diminished demand for gas and the availability of cheap gas from the USE, indicates that there is a possibility of a scenario providing for a markedly lower growth rate of gas prices in the nearest years, and even for their temporary decrease. Therefore, it was deemed reasonable to analyse an alternative scenario with a lower forecast prices of natural gas. A comparison of gas prices for the reference scenario and the low price scenario is showed in fig. 23.

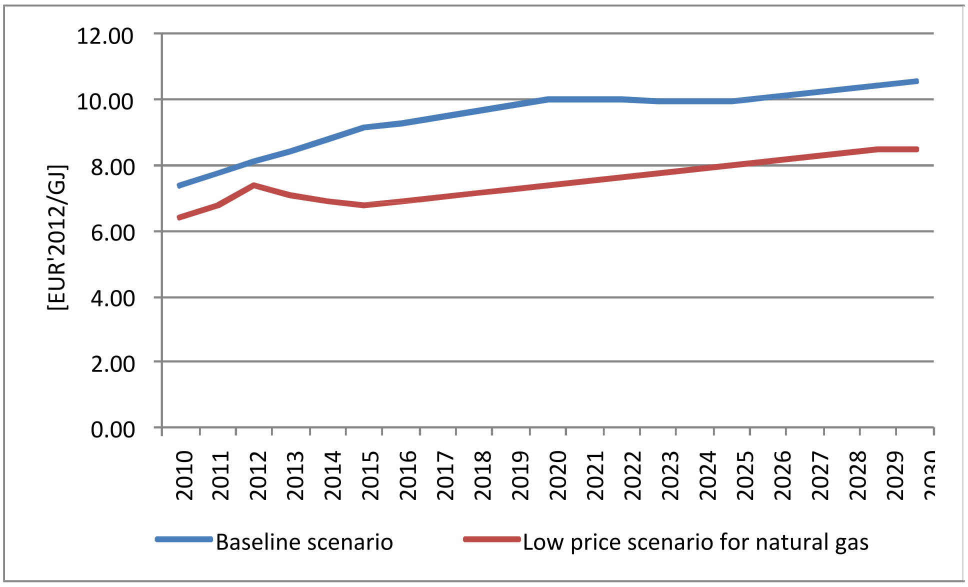


Figure 23 Comparison of natural gas prices in the baseline scenario and in the low price scenario [€'2012/GJ]

The structure of generation capacity for the low price scenario is markedly different from the structure of the baseline scenario. Significantly more sources fired with natural gas are built, including combined cycle plants with total capacity of approx. 3100 MW in 2030, which are not competitive in the baseline scenario. They supersede part of new hard coal units and postpone the construction of first nuclear units. Moreover, the low price scenario for natural gas provides for more gas cogeneration sources (by approx. 1000 MWe more than in the baseline scenario), which supersede coal CHPs (see Fig. 24-26)

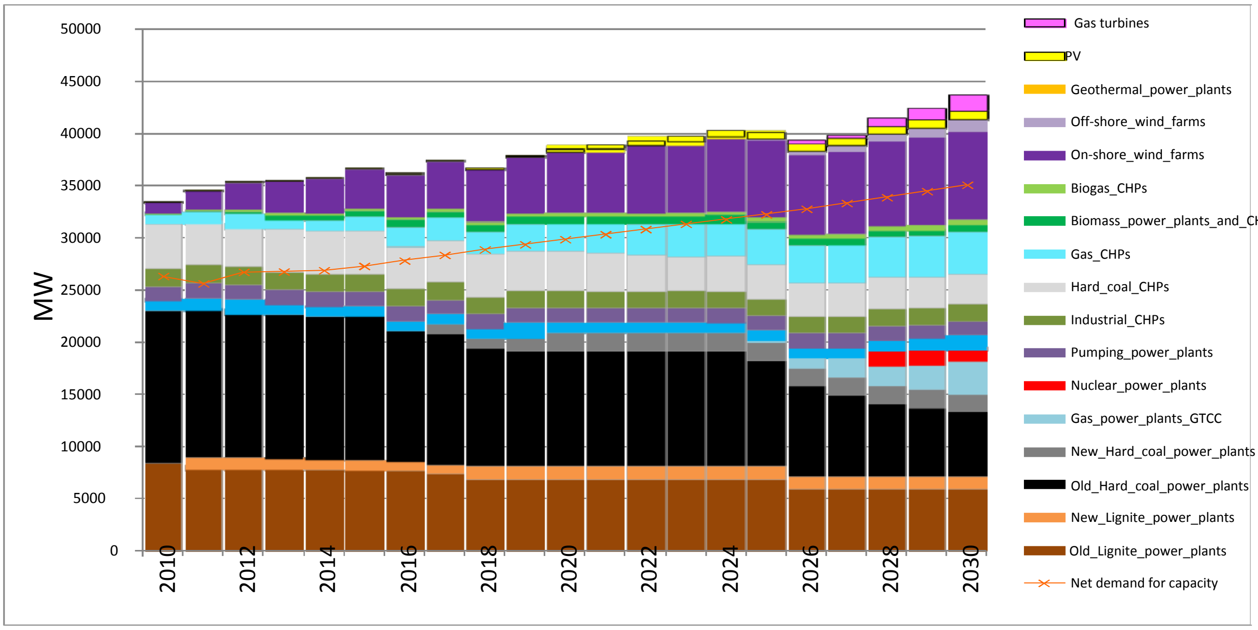


Figure 24 Maximum net capacity of electricity generation sources per technology in accordance with low price scenario for natural gas

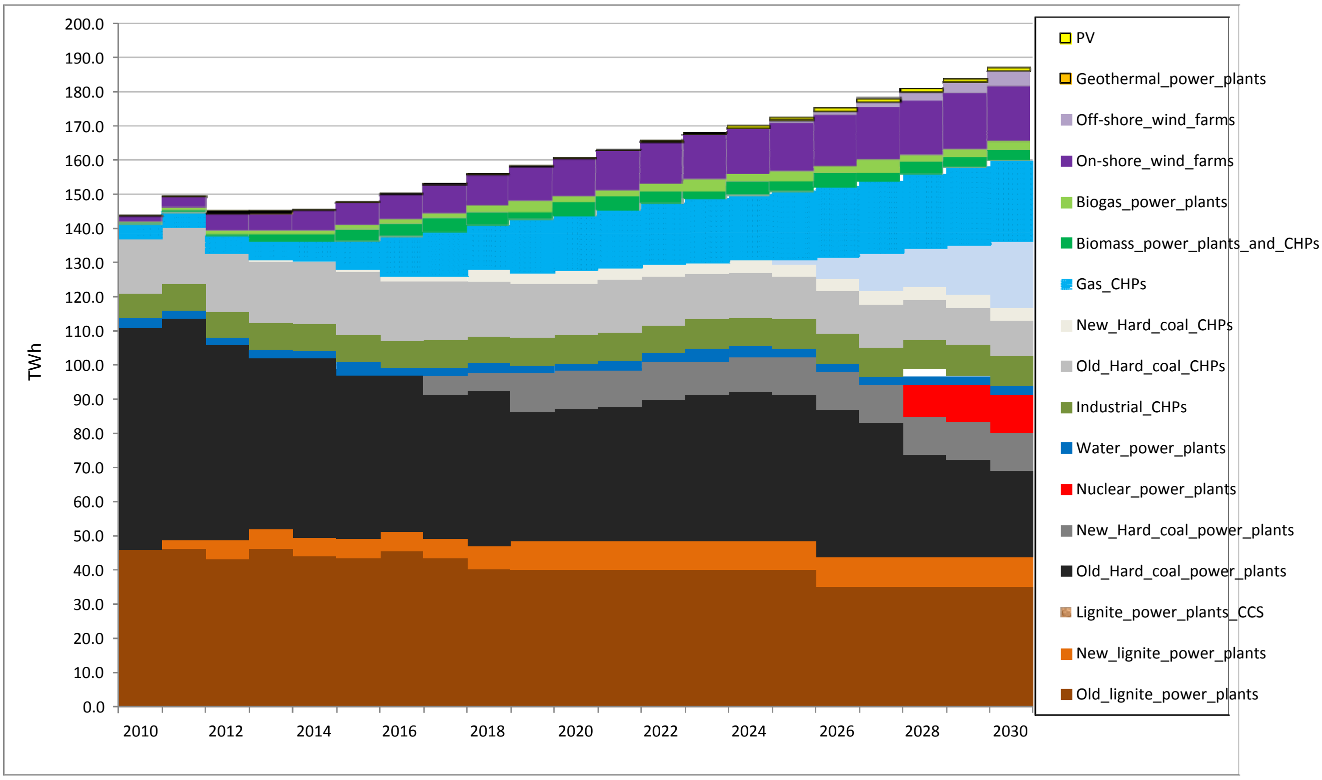


Figure 25 Net electricity generation forecast per technology in accordance with the low price scenario for natural gas

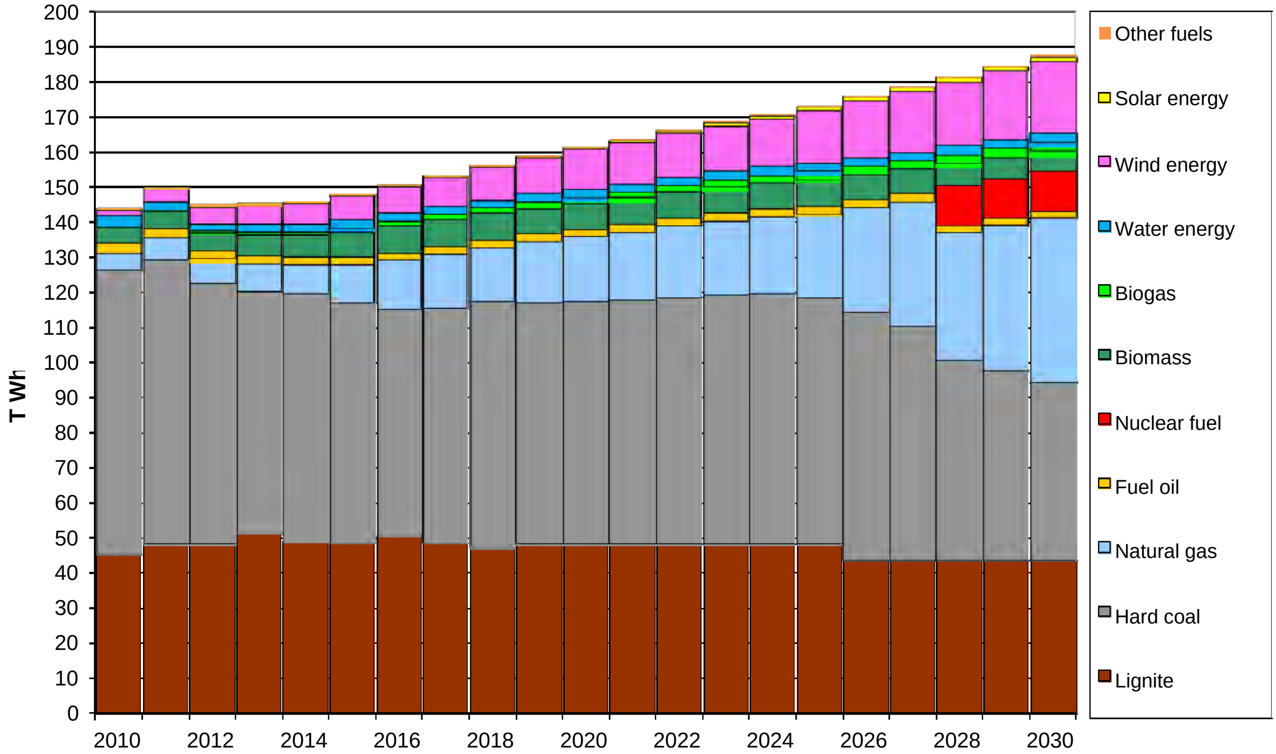


Figure 26 Net electricity generation per technology in accordance with the low price scenario for natural gas

The aggregate electricity generation with natural gas in the low price scenario totals approx. 47 TWh in 2030, which constitutes approx. 25% share in domestic generation (the reference scenario stipulates a share of 9%). On the other hand, the share of hard coal power plants and CHPs is reduced to approx. 27% (36% in the baseline scenario), and nuclear power plants as well—whereby in relation to the latter, the result should be interpreted rather as a postponement of the construction programme and not its limitation.

2.3.3.1.7. Opt-out scenario for nuclear power plant construction,

This scenario presents an electricity generation capacity and fuel portfolio forecast on the assumption that the nuclear power programme shall not be implemented in Poland. In such a case, the nuclear plants shall be replaced in the generation portfolio optimisation process with units fired with hard coal, and in this scenario, the share of electricity generation based on hard coal in 2030 is 46% (given 36% in the baseline scenario) In general, it is the only change when compared to the baseline scenario, but it results in a significant increase of CO_2 emissions. (See fig. 27-29)

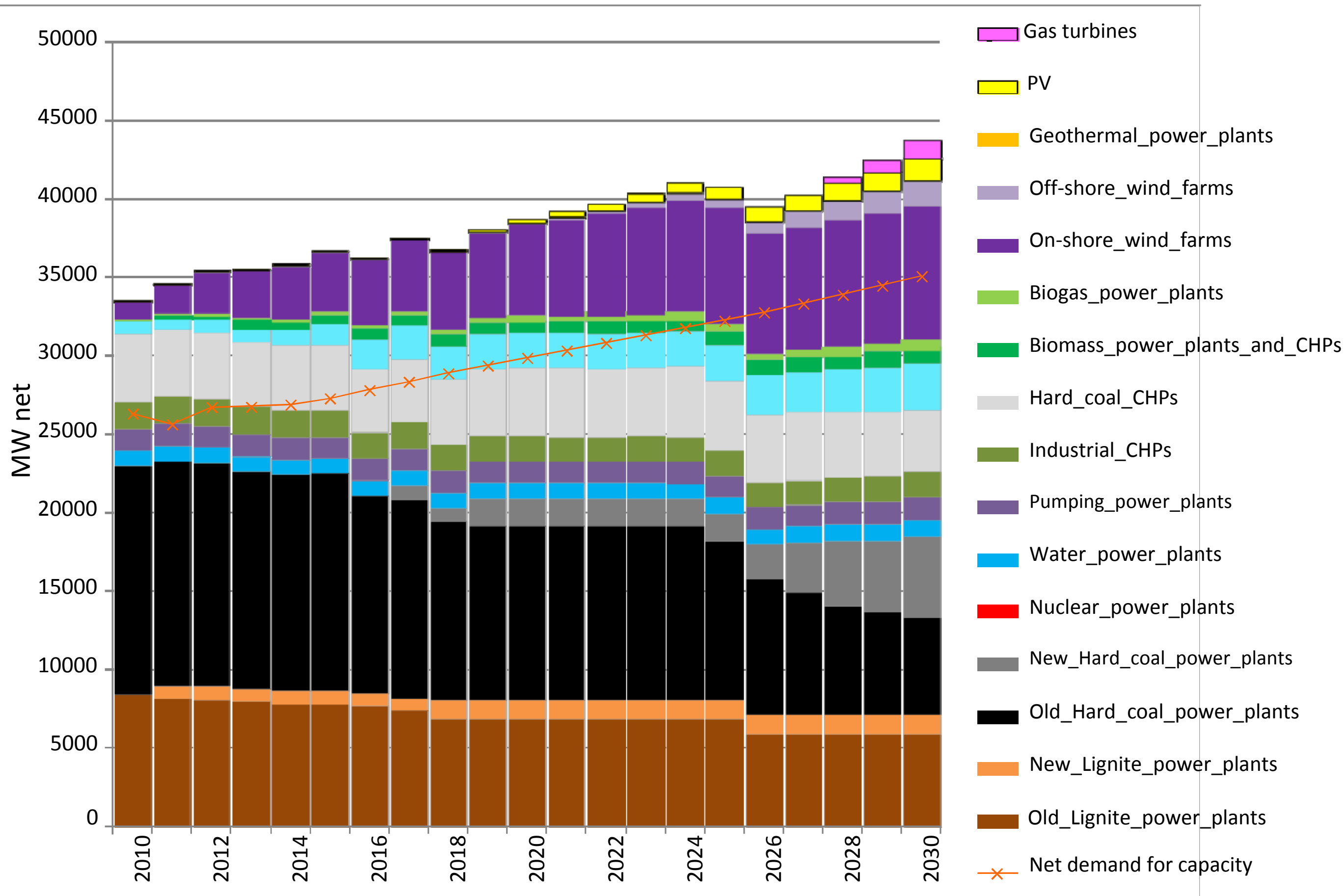


Figure 27 Maximum net capacity of electricity generation sources per technology in accordance with the scenario with no nuclear plants

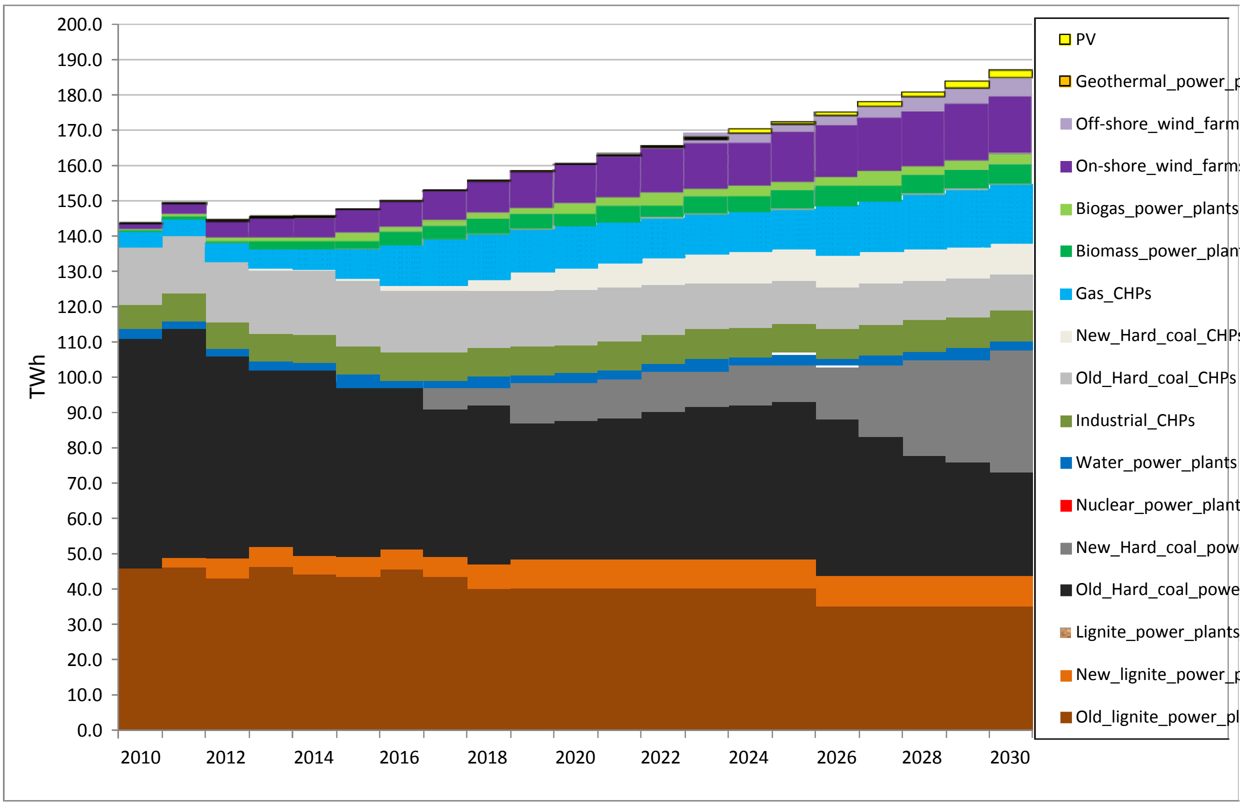


Figure 28 Net electricity generation forecast per technology in accordance with the scenario without nuclear plants

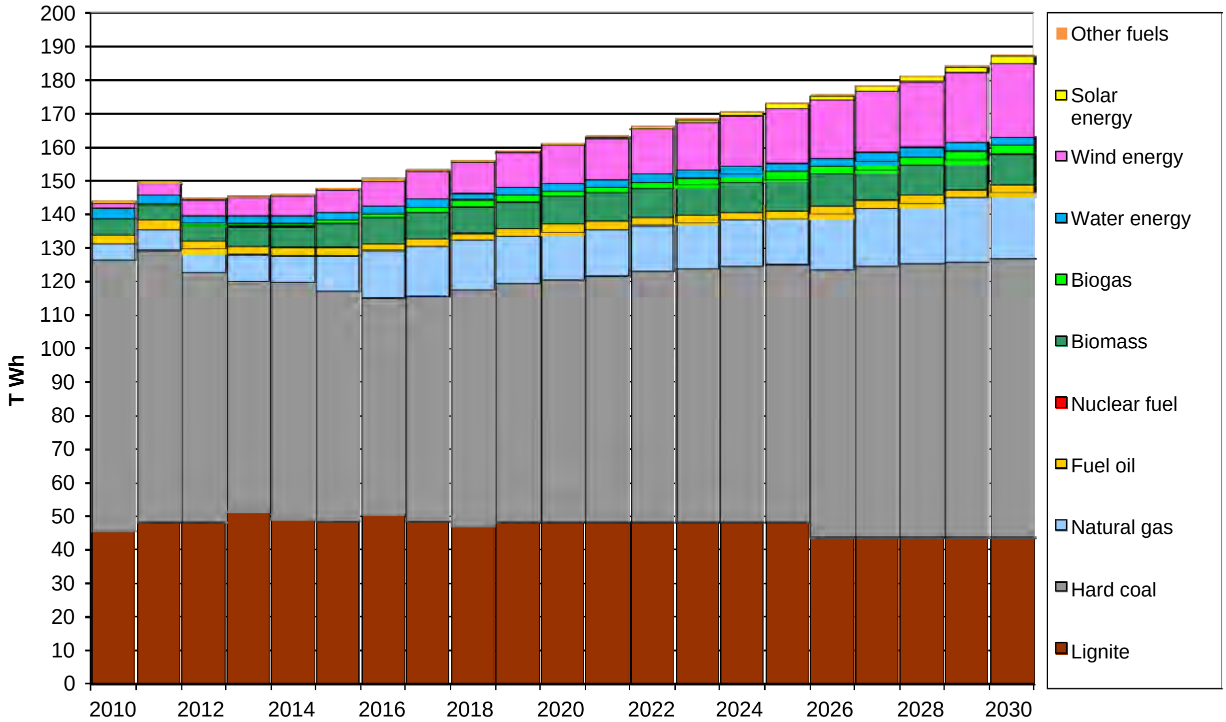


Figure 29 Net electricity generation per technology in accordance with the scenario without nuclear plants

2.3.3.2. Electricity generation cost forecast

The analysis compares electricity generation technologies to be launched in 2025, 2035, and 2050. The averaged electricity generation costs were estimated for a standard set of technologies in national conditions which are also present in analyses of renowned research institutions and centres in the world. The analysis is based on operational experiences of existing and designed facilities, and forecasts presented in the most recent literature.

Issues related with technology subsidising were not taken into account in the analysis of generation costs.

2.3.3.2.1. Fuel

Fuel prices significantly influence operating costs of power plants fired with hydrocarbon fuels, and play a crucial role in the selection process for electricity generation technology. Since anticipation of fuel prices on the international market is highly uncertain, this analysis, to define forecast prices of natural gas, use the most recent long-term forecasts of fuel prices on the European Market, from two renowned sources:

- OECD/IEA, Word Energy Outlook 2012, Paris, 2012,
- Capros P., PROMETHEUS WORLD ENERGY OUTLOOK - Price Scenario for Baseline 2012, National Technical University of Athens - NTUA, Presentation for Member State Consultation, Brussels 18/04/2012.

The analysis assumes the prices of hard coal and natural gas on the domestic market to be the average of the two abovementioned forecasts.

The two sources referred to above (IEA and NTUA) do not contain anticipated nuclear fuel prices, probably due to the fact that the cost of fuel does not influence the total costs of generation in a nuclear power plant in any significant manner. Indeed, one of the main advantages of nuclear power is relatively low cost of fuel, when compared to coal or gas. Nuclear fuel prices taken from a couple of available sources[17,18,19,20] range from 0.4 to 0.7 €/GJ. In this analysis, a nuclear fuel price of 0.8€'2012/GJ was assumed in 2010, and its average annual growth rate in 2011-2050 of 0.5%.

Biomass prices defined for Polish conditions on the basis of present levels of these prices (ARE S.A. database) and an expert opinion

Fuel price forecasts for Poland, prepared on that basis and adopted in this analysis, are presented in fig. 30.

[17] *Cost estimates for nuclear power in the UK, Imperial College Centre for Energy Policy and Technology-ICEPT, August 2012*

[18] *Rothwell G., New U.S. Nuclear Generation: 2010-2030, Stanford Institute for Economic Policy Research, June 2010.*

[19] *Du Y., Parsons J.E., Update on the Cost of Nuclear Power, MIT Center for Energy and Environmental Policy Research, May 2009.*

[20] *Tarjanne R., Kivisto A., Comparison of electricity generation cost, Lappeenranta University Technology, 2008*

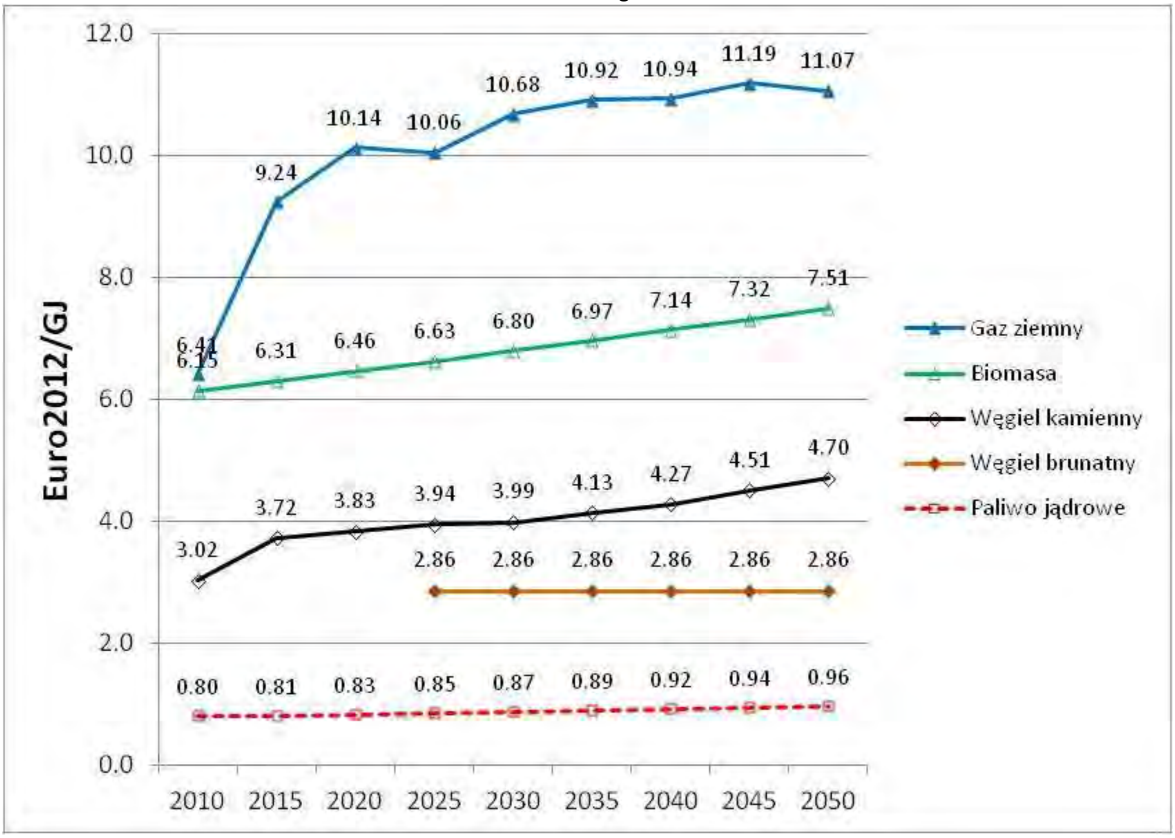


Figure 30 Assumed forecast fuel prices

Gaz ziemny	Natural gas
Biomasa	Biomass
Węgiel kamienny	Hard coal
Węgiel brunatny	Lignite
Paliwo jądrowe	Nuclear fuel

2.3.3.2.2. Technologies

For the year 2025, the analysis under consideration, apart from electricity generation technologies which are available commercially already today, also includes technologies which are being intensively developed currently and it is expected that until that year, they will reach a level of advancement enabling their commercial use. It concerns first of all carbon capture and storage (CCS) installations, associated with CO_2 repositories. These installations, which are currently being tested in laboratory-scale research, may be soon put into service in industry, and therefore they are included to the benchmark analysis in this period. For the same reasons, IGCC technology is also included. The same technology set was adopted for sources whose launch is expected around 2035. For the year 2050 in turn, due to the fact that all anticipations for new technologies in such a distant horizon are by their very nature highly uncertain, only those technologies are considered in the benchmark analysis which are presently developed, but they are still at the early stage of development (in addition to technologies already available). Within this horizon, a significant development of nuclear technologies is expected, with operation of nuclear power plants equipped with 4^{th} generation reactors included. Therefore, the same technology set was examined for 2050 as in the case of 2025 and 2035, taking into account the technological advancement leading to higher generation efficiency for these units in the future, with substantial differences in cost parameters and, in addition, 4^{th}

generation reactors which shall be used as links closing the nuclear fuel cycle, enlarging thereby fuel supplies for thermal reactors.

The following technologies are compared in the analysis:

- condensing power plants firing hard coal in **PC** (pulverised coal) boilers with flue gas desulphurisation ($DeSO_2$), and denitration ($DeNO_x$),
- power plants firing hard coal in PC boilers with carbon capture and storage installations (**PC +CCS**),
- condensing power plants firing lignite in **PL** (pulverised lignite) boilers with $DeSO_2$ and denitration $DeNO_x$ installations,
- power plants firing lignite in PL boilers with carbon capture and storage installations (**PL +CCS**),
- NPwith Light Water Reactors (3rd generation water reactors),
- NP with 4th generation reactors,
- power plants firing gas from the coal integrated gasification combined cycle installation (**IGCC_C**),
- power plants firing hard coal with the coal integrated gasification combined cycle and carbon capture and storage installations (**IGCC_C +CCS**),
- combined cycle power plants fired with natural gas (gas turbine combined cycle, **GTCC**)
- gas turbines (**GT**)
- biomass power plants (**BM**),
- **on-shore wind farms**,
- **off-shore wind farms**,
- photovoltaic plants (**PV**).

Results of the analysis indicate the competitiveness of electricity generation with nuclear power plants (with conservative assumptions for NP) when compared to other technologies included in model calculations (Figure 31), *inter alia* due to the expected growth in prices of organic fuels and fees for CO_2 emission allowances.

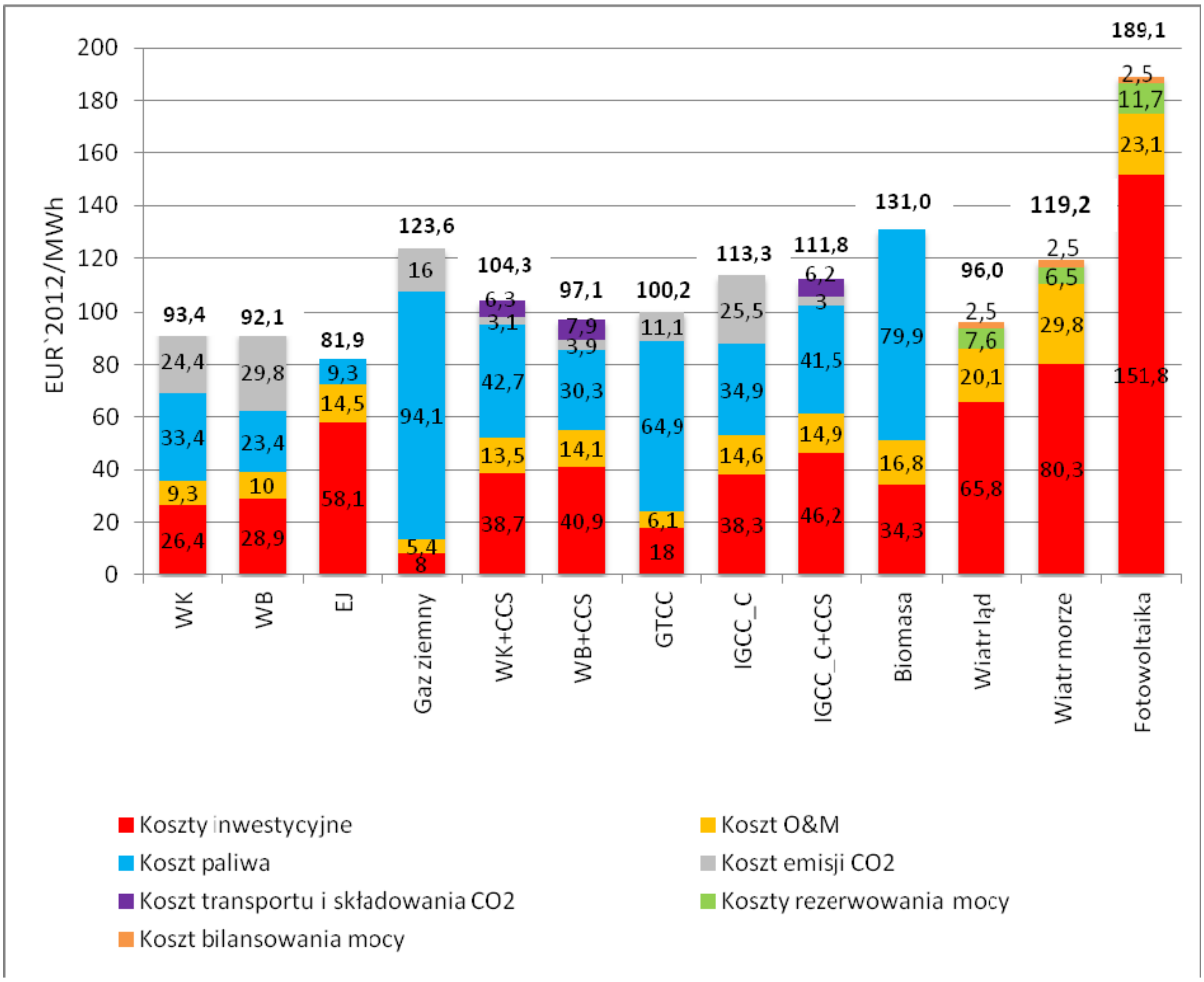


Figure 31 Structure of averaged electricity generation costs in representative power plants.

WK	Hard coal	IGCC C	IGCC C
WB	Lignite	IGCC C+CCS	IGCC C+CCS
EJ	NPP	Biomasa	Biomass
Gaz ziemny	Natural gas	Wiatr ląd	Wind on-shore
WK+CCS	Hard coal+CCS	Wiatr morze	Wind off-shore
WB+CCS	Lignite+CCS	Fotowoltaika	PV
GTCC	GTCC		

Koszty inwestycyjne	Investment costs
Koszt paliwa	Fuel costs
Koszt transport I składowania CO2	Carbon dioxide transport and storage costs
Koszt bilansowania mocy	Capacity balancing costs
Koszt O&M	O&M costs
Koszt emisji CO2	CO_2 emission cost
Koszty rezerwoania mocy	Capacity reservation costs

Results of the analysis for the year 2025 (tab. 11) show that already in the case of a consumption factor of 0.8, nuclear power is connected with the lowest generation costs per unit 86.3 EUR/MWh, and in the subsequent periods, that is up to 2035 and 2050, this trend shall strengthen and confirm the long-term efficiency of this technology. This is important even more so when consider that present reactor generations operate with at least 90% of power used. For example, French AREVA which offers a 3rd generation EPR reactor declares that its availability is at the level of 92%.

Table 11 Generation costs per unit [EUR/MWh] – estimates for 2025.

Generation Unit	Consumption factor (CF) for a source capacity					
	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: *Update of the comparative analysis of electricity generation costs in nuclear, coal, and gas power plant as well as renewable energy sources ARE S.A.*, April 2013.

To depict unit generation costs per technology and time periods adopted in the analysis more comprehensively (until 2025, 2035, and 2050), one standard value of consumption factor has been assumed - 0.8 (fig. 32). The data obtained confirms similar levels of unit costs in the individual time periods without indication of any unambiguous trend, whereby it was possible to observe a similar scale of cost reduction in the case of technologies equipped with CCS and nuclear power.

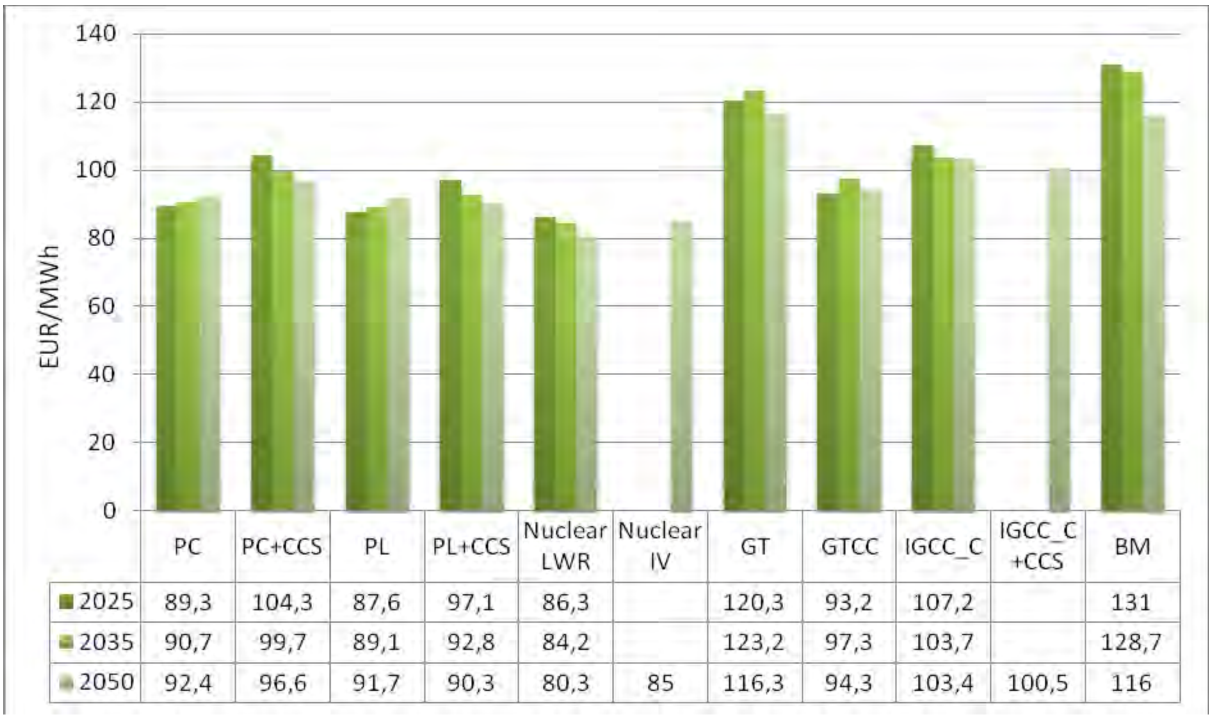


Figure 32 Averaged power generation costs per unit in sources to be launched in the years: 2025, 2035, 2050 given the source consumption factor of 0.8 [EUR/MWh]

source: Update of the comparative analysis of electricity generation costs in nuclear, coal, and gas power plant as well as renewable energy sources ARE S.A., April 2013.

2.3.3.2.3. Competitiveness of sources planned for launching approx. 2025

Competitiveness curves of sources to be launched approx. 2025, which is the period for which commissioning of the first nuclear power plant unit in Poland is planned (figures 33 and 34) show that nuclear power plants are competitive in the system in operating conditions corresponding to the average load factor above 0.8 (which is approx. 7000 hours), given the averaged discounted price of CO_2 emission allowances in the whole life cycle of the unit equal to approx. 33 €/ton. Averaged costs of generation in NPP with LWRs for a load factor of 0.9 typical for this technology (approx. 8000 h/a) totals approx. 80 €/MWh.

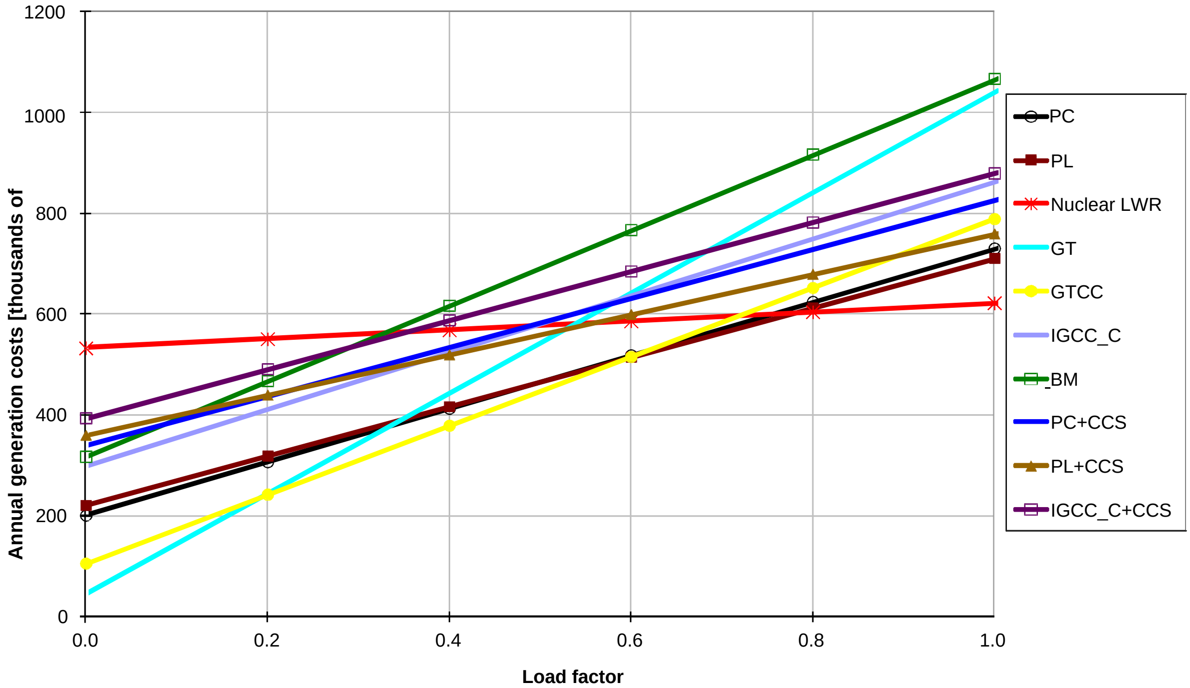
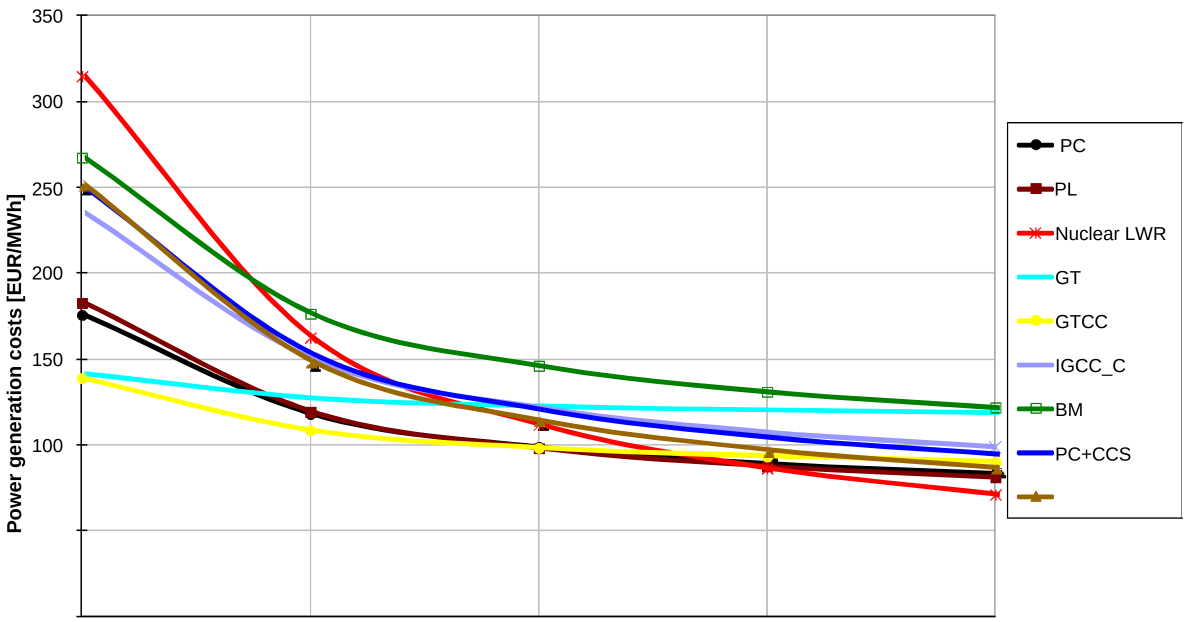


Figure 33 Averaged annual generation costs [thousands of €/MW-year] for sources to be launched around 2025.



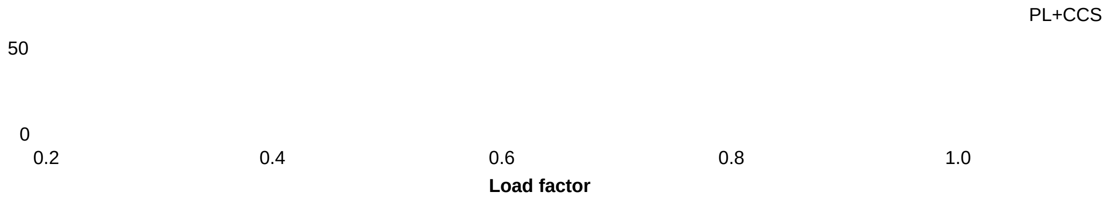


Figure 34 Averaged generation costs per unit [€/MWh] for sources to be launched approx. 2025.

The next units are lignite and hard coal power plants without CCS installation.

Competitiveness curves for sources to be launched around 2035 (fig. 35 and 36) indicate a competitiveness of nuclear power plants when compared to other units considered in the analysis, which grows along with fossil fuel prices and CO_2 emission allowances.

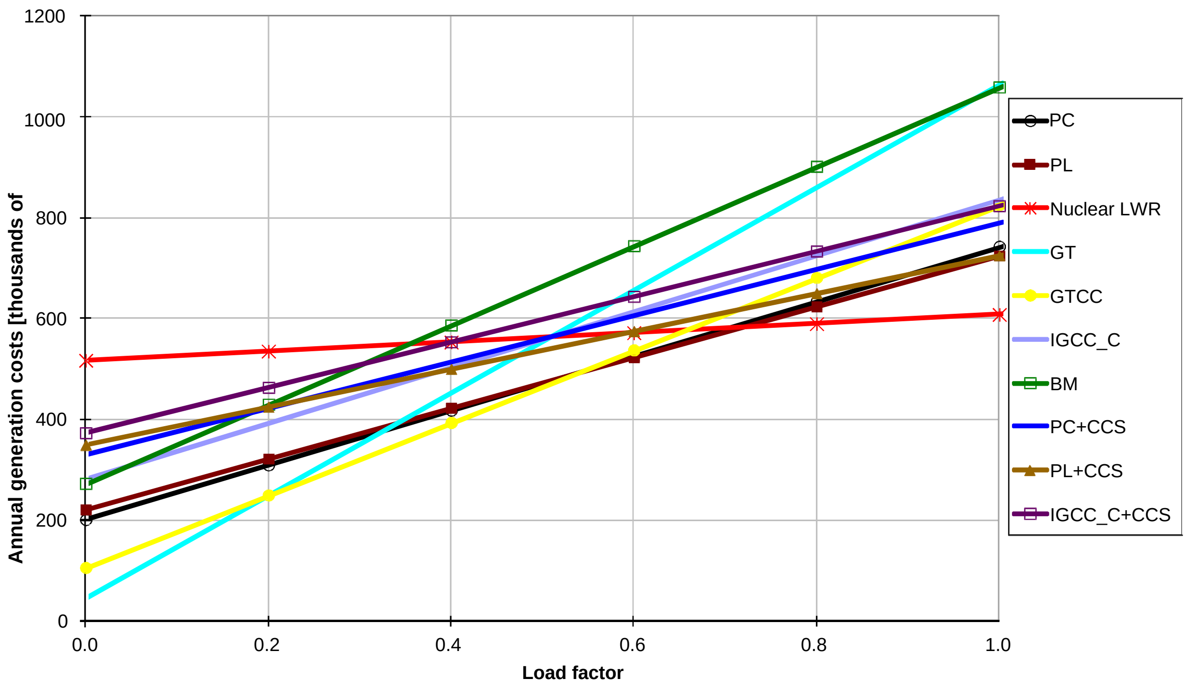
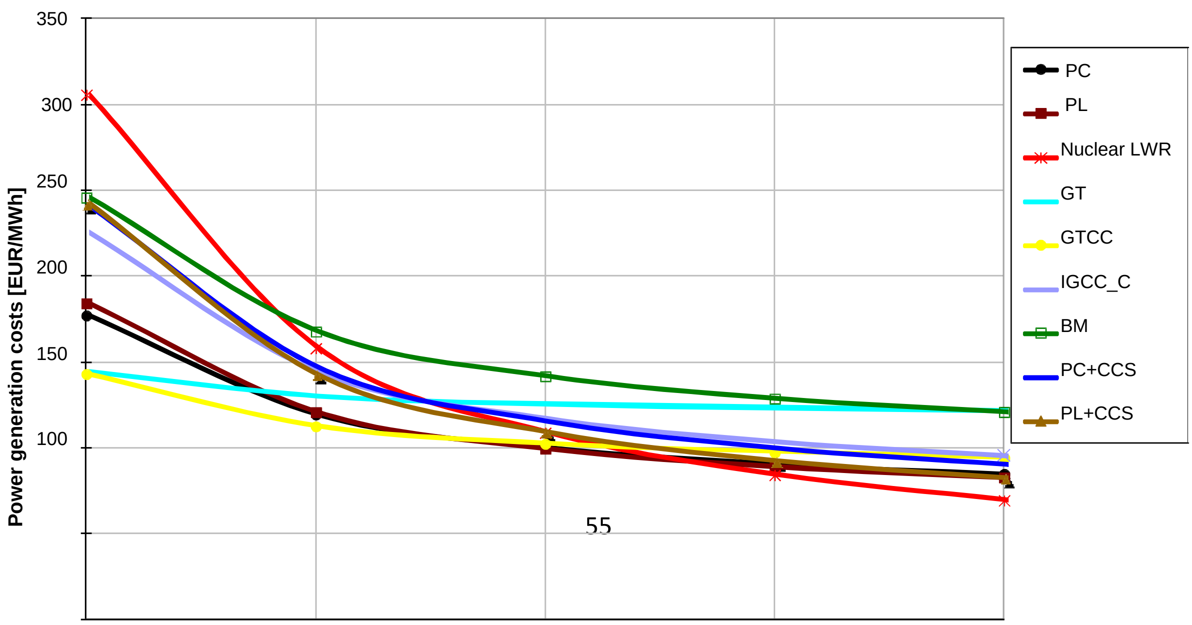


Figure 35 Averaged annual generation costs [thousands of €/MW-year] for sources to be launched around 2025.



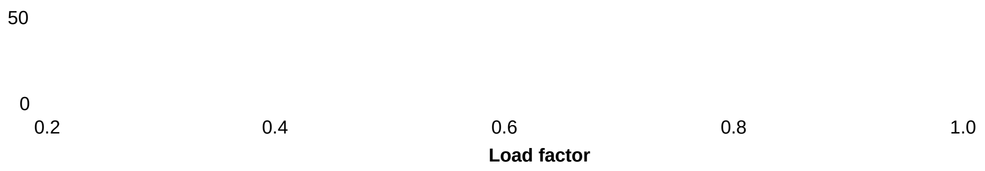


Figure 36 Averaged generation costs per unit [€/MWh] for sources to be launched approx. 2035.

2.3.3.2.4. Competitiveness of sources for typical operating conditions in the system

For the reference conditions, the power generation costs in sources to be launched approx. 2025 indicate certain competitive advantage of nuclear power plants, which—as it can be seen in fig. 37—depends to a substantial extent on the assumed level of prices of CO_2 emission allowances. Costs of generation in coal sources without CCS are—with costs of CO_2 taken into account—only slightly higher than for the nuclear power plant

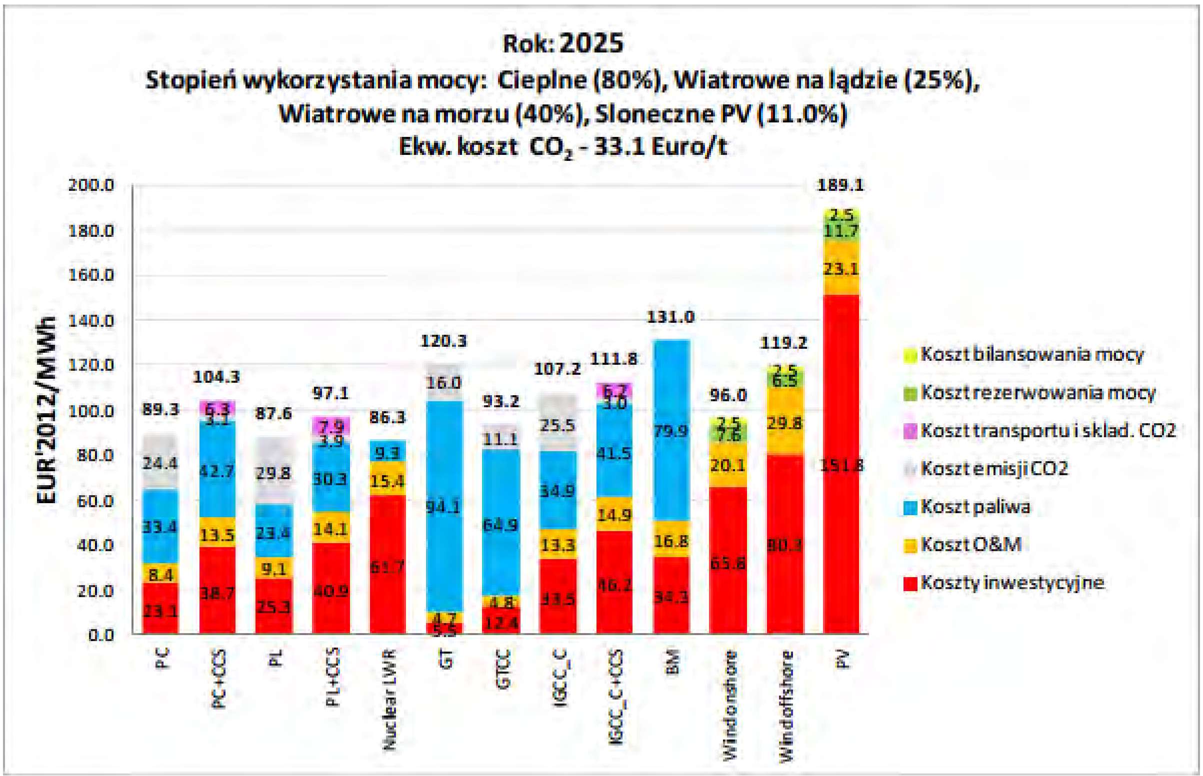


Figure 37 Averaged power generation cost per unit in sources to be launched in 2025. Full capacity operation time: for thermal and nuclear plants - 7000/year, on-shore wind farms - 2190h/year, off-shore wind farms - 3500h/year, PV -950h

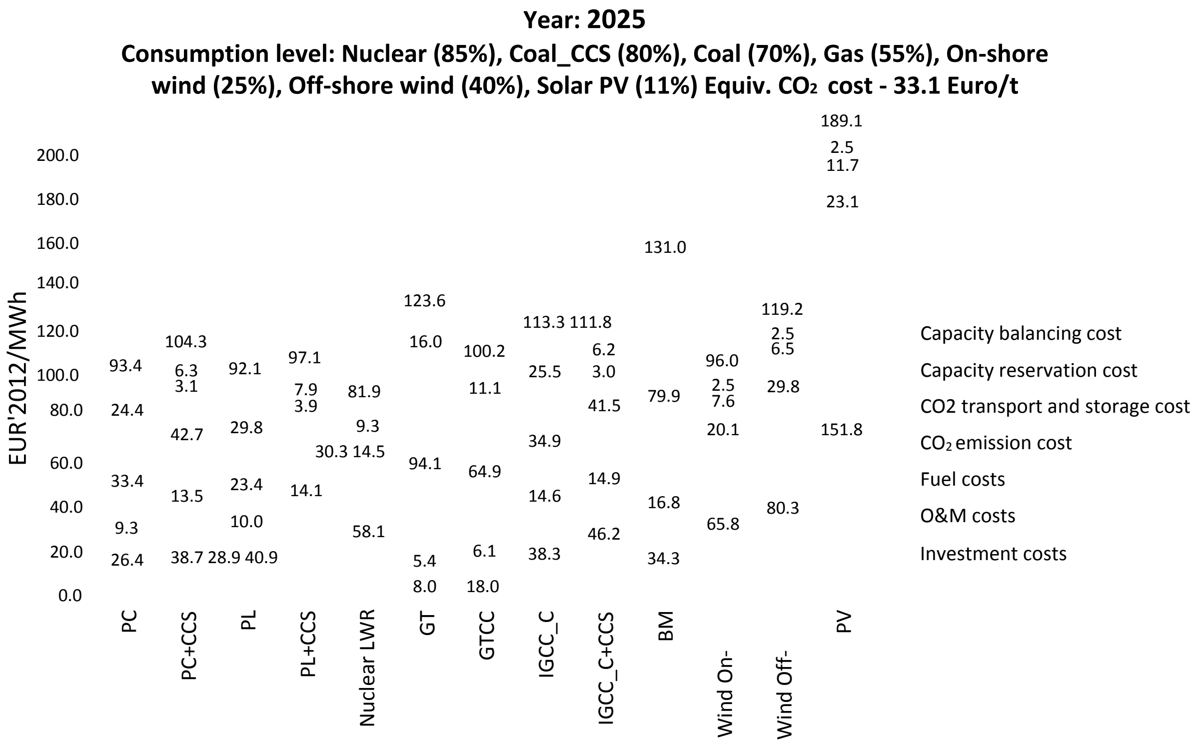
Rok: 2005 Stopień wykorzystania mocy: Cieplne (80%), Wiatrowe na lądzie (25%), Wiatrowe na morzu (40%), Słoneczne PV (11.0%) Ekw. koszt CO_2- 33.1 Euro/t	**Year: 2005 Consumption level: thermal plants (80%), on-shore wind farms (25%), off-shore wind farms (40%), PV (11%) Equiv. CO_2 cost-33.1 EUR/t**

Koszt bilansowania mocy	**Capacity balancing cost**
Koszt rezerwowania mocy	**Capacity reservation cost**
Koszt transport I skład CO2	**Transport cost - 1st CO2 repository**

Koszt emisji co2	**CO_2 emission cost**
Koszt paliwa	**Fuel costs**
Koszt O&M	**O&M costs**
Koszty inwestycyjne	**Investment costs**

In thermal power plants, in operating conditions with diversified load factor (fig. 37) the competitiveness of nuclear power plants when compared to coal plants increases. On the other hand, the competitiveness of combined cycle plants is shrinking, as their generation costs exceed the generation costs of lignite units with CCS, and even on-shore wind farms.

Due to high generation costs, PV plants, biomass plants, and off-shore wind farms are uncompetitive.



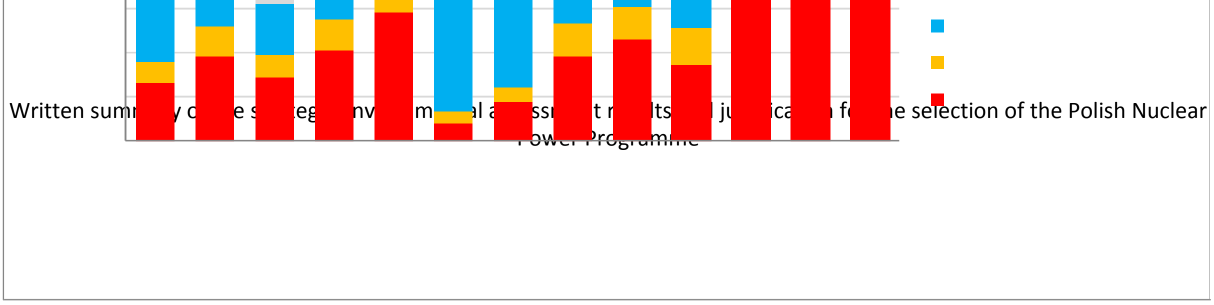


Figure 38 Averaged power generation cost per unit in sources to be launched in 2025. Full capacity operation time: for nuclear plants - 7450/year, coal plants - 6130 h/ year, gas plants - 4820, on-shore wind farms - 2190h/year, off-shore wind farms - 3500h/year, PV -950h/year.

Results of analyses conducted for sources to be launched approx. 2035 does not differ in qualitative terms from the results obtained for 2025 and presented above. Nuclear plants based on the proven LWR technology still remain the sources whose generation cost is the lowest. The next in terms of generation costs are power plants fired with lignite, with hard coal, lignite CCS plants and on-shore wind farms. Relatively favourable are combined cycle power plants—taking into account their high operational flexibility it seems that these sources can be a real competition for coal units.

2.3.3.3. Generation capacity portfolio forecast until 2030 given defined technical and economical parameters for a nuclear power plant

Because of conservative conditions for nuclear industry adopted in *Forecast 2013 (ARE analysis of June 2013), ME additionally ordered also a study of capacity portfolio and electricity generation until 2030, given the technical and economical parameters achieved on the market for newly built electricity generation sources (in accordance with EC and MAE analyses)*[21]. Changes are presented in table 12.

Table 12 Comparison of changed initial parameters for newly built electricity generation sources

	New analysis	Forecast_2013
Discount rate (for all generation sources)	6%	8%
NP consumption factor	0.90	0.85
NP operation time/years	60	40

Earlier ARE assumptions were partially based on technical and economical specification of 2nd generation reactors, mainly in relation to the assumed load factor and period of operation of a unit. Meanwhile, the conceptual design of 3rd generation reactors which are to be built in Poland, provide for a load factor not lower than 90% (at an availability exceeding 92%). Even today, 2nd generation reactors in many countries exceed this value markedly, e.g. in Finland, the old, post-Soviet WWER-440/W-213 reactors (of the same type as ordered for Żarnowiec NPP in the 80's) at Loviisa NPP have been achieving a load factor of 95% in the recent years, BWR units at Olkiluoto NPP—nearly 97%, in Germany, the newest BWR units (Emsland NPP and Isar NPP)—up to 94%, and many American NPP exceeds even 100% (given a few years average trend above 90%).

Another factor that had to be adjusted is operation time. The forecasts providing for 40 years, adopted in the earlier version, were based on the currently operating 2nd generation reactors whose life cycle is much longer anyway (at present, the operation period in many countries is being extended from 40 to 50-60 years, and further extensions are possible if the power plants will still comply with safety requirements). Whereas, all 3rd generation reactors are by definition designed

[21]Agencja Rynku Energii S.A. Update of the forecast for fuels and electric energy demand until 2030. September 2013

for 60 years of operation with a possible extension by next 20 years or even longer.

The third factor that changed is discount rate. The need for this change results from the fact that vast majority of investments in new electricity generation sources in the world are completed on the basis of a relatively inexpensive capital. Governments of many countries strive to ensure the conditions of predictability and stability of regulatory, political, and market framework, etc., for power investments (both nuclear and conventional), which translates directly into reduced investment risk, and thus the cost of capital. The construction of the first nuclear power plant is of key importance from the point of view of energy security and protection of the economy against high energy prices, and therefore requires an active cooperation of the State with the investors. Creation and maintenance of suitable conditions for investments should translate directly into the cost of capital both from domestic, as well as foreign sources. Also anticipated changes on the energy market shall have a positive influence on the profitability of new power units.

On the basis of comparison of results of the above mentioned analysis with the results of Forecast 2013, it follows that the main difference between them is pace of development of nuclear power plants (see fig. 39). In *Forecast_2013*, two nuclear units appear until 2030 (the first one approx. in 2026, the second one in 2030), with aggregate capacity of 3000 MW. In the new forecast (scenario), the first nuclear unit shall be present a year earlier—approx. in 2025, while the next one approx. in 2026, and the third one shall be commissioned in 2030. According to the current scenario, there will be approx. 4500 MW of nuclear capacities installed in 2030. It is worth highlighting that the next nuclear unit(s) shall appear as early as in 2031

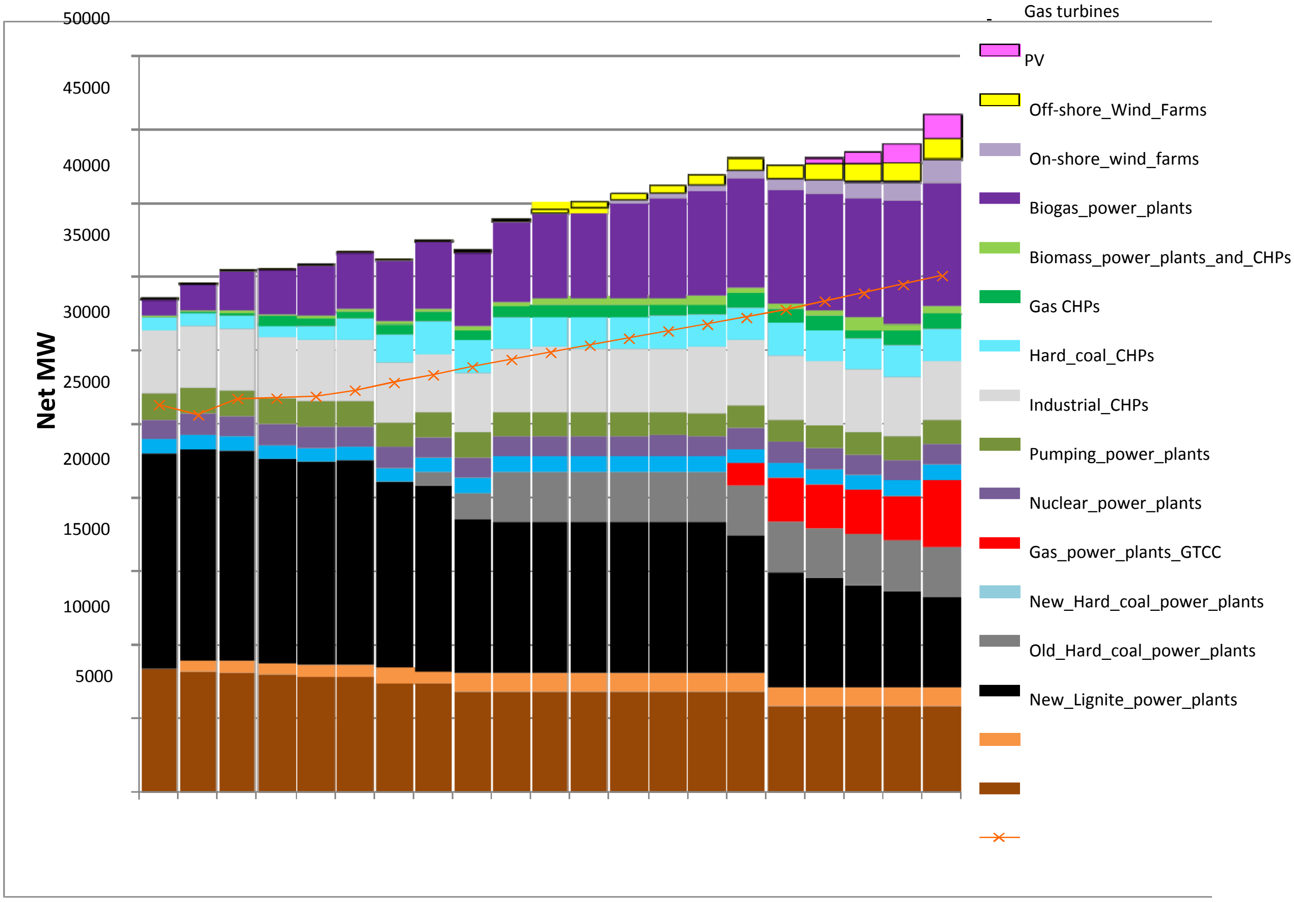


Figure 39 Maximum net capacity of electricity generation sources per technology in accordance with parameters for newly built generation sources

source: generation capacity portfolio forecast until 2030 given defined technical and economical parameters for a nuclear power plant, ARE S.A., September 2013

The quicker development of nuclear industry described above influences also the fuel structure of electricity generation. Nuclear technology is starting to be an important element of generation sources portfolio already from 2025, with 7% share in domestic net electricity generation. In 2026, already approx. 23 TWh (more than 13% of national production) shall be produced by nuclear plants, and in 2030, nuclear generation shall reach 35 TWh (a 19% share in national production).

Fuel structure of electricity generation from various sources shall be as in fig. 40.

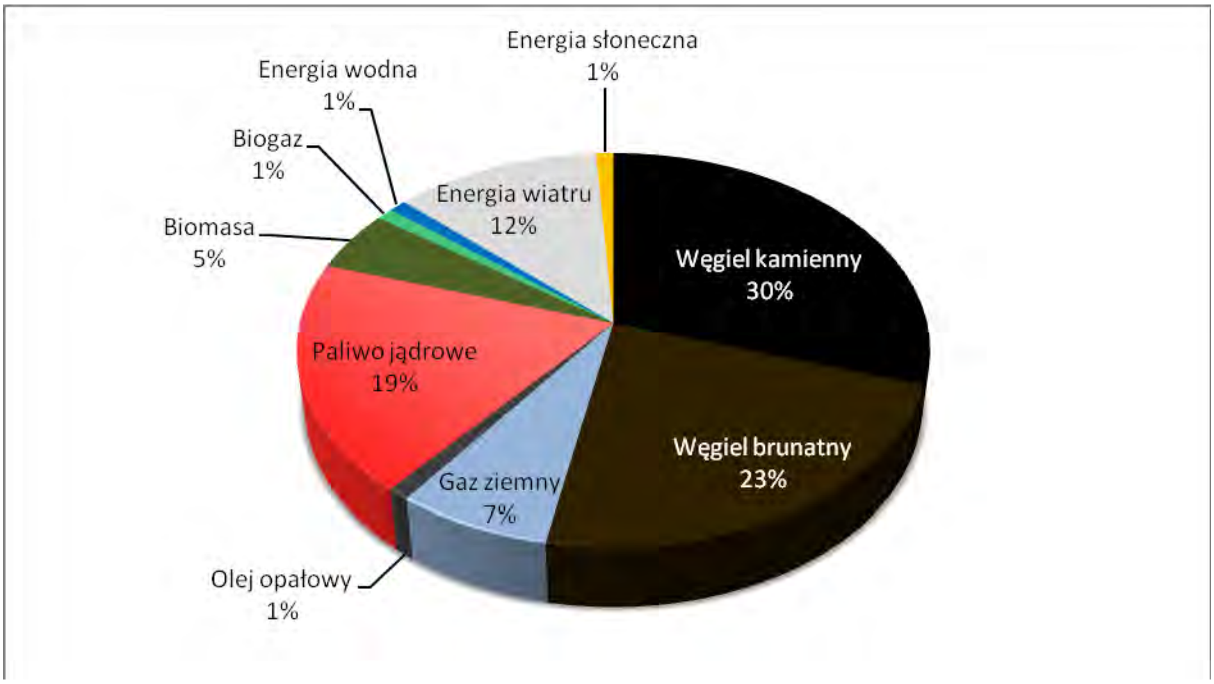


Figure 40 Fuel structure of electricity generation in 2030 in accordance with parameters for newly built generation sources

Węgiel brunatny	**Lignite**
Węgiel kamienny	**Hard coal**
Gaz ziemny	**Natural gas**
Biomasa	**Biomass**
Biogas	**Biogas**
Olej Opałowy	**Fuel oil**
Paliwo jądrowe	**Nuclear fuel**
Energia wodna	**Water energy**
Energia wiatru	**Wind energy**

2.3.3.4. Summary

The updates confirmed conclusions drawn on the basis of previous analyses.

1. Results of the analyses indicate that nuclear electricity generation technologies to be launched around 2025 are competitive to other, even the cheapest classical sources operating within the system load base, if the cost of CO_2 emission allowances is higher than 30 €'2012/tCO_2. In the next years, the competitiveness of nuclear sources grows because of the anticipated growth of organic fuel prices and fees for CO_2 emission allowances.

2. With a view to the EU requirements which have to be fulfilled by our country in the scope of CO_2 emission reduction, and considering the small probability that CCS installations will be used commercially (costs, technical reasons), as for today, the nuclear industry seems justified both in technical as well as economic terms. Having in mind the aims in the scope of greenhouse gas emission reduction adopted by Poland, nuclear power plants are the cheapest option and at the same time they ensure the highest level of supply and cost stability among technologies which can be used in Polish conditions.

3. The period under analysis shall see a growth of end user demand by approx. 36%, namely from the level of 119.1 TWh in 2010 to 161.4 TWh, which means the average annual growth rate of 1.5%. The increased demand concerns all sectors, but mostly trade and services (growth by 46%) and subsequently—households (by 33%) and industry (28%). Results of the update indicate a slight decline in anticipated values when compared to *Forecast_2011.* The decline is first of all a result of verification of macroeconomic forecasts which assume slightly lower domestic economic growth rate in the analysed period than three years ago.

4. The net electricity generation grows from the level of 143.8 TWh in 2010 to 187.6 TWh (a growth by 30%).

5. The gross electricity generation grows from the level of 158.6 TWh in 2010 up to the level of 201.9 TWh.

6. Significant changes should be expected in the fuel structure of electricity generation, mainly in result of the climate policy pursued and activities aimed at limiting the negative environmental impact of power industry:

   a. The share of coal in the electricity generation portfolio shall decline from approx. 88% in 2010 to approx. 54% in 2030.

   b. In 2030, the share of electricity produced in nuclear power plants shall reach 12%.

   c. The share of RES in the electricity generation portfolio shall grow markedly. In 2030, RES correspond to approx. 19% of electricity generation in Poland, of which the major part are wind farms (12%) and biomass technologies (3%).

   d. The level of electricity generation on the basis of RES ensures the fulfilment of the target under the requirements of Directive 2009/28/WE, providing for a 15% share of

RES power in the gross end user energy in 2020.

e. The role of natural gas shall be bigger, and its share in the electricity generation portfolio shall amount to approx. 9% in 2030.

7. Although coal fuels shall still dominate in the power sector, growing diversification of the fuel structure shall enable a substantial reduction of CO2 emissions and also of such pollutions as SO2, NOX, and dust, with the development of RES, nuclear industry and high-efficiency co-generation.

8. In the period under consideration, approx. 12,000 MW of conventional production units shall be excluded from operation (approx. 6000 MW until 2020, and next 6000 MW until 2030).

9. To replace the decommissioned production units and satisfy the national electricity demand, approx. 4600 MW of new capacities shall be created in plants based on coal fuels, 3000 MW in nuclear facilities, 9000 MW in wind farms, 1500 MW in PV installations, and approx. 6400 MWe in various CHPs.

10. The policy of RES promotion shall cause an intensive development of wind farms. Until 2030, approx. 9000 MW of on-shore and off-shore wind farms shall be created. Until 2030, new biomass power plants and CHPs shall deliver approx. 650 MWe, and new biogas plants—approx. 450 MWe.

11 Within the structure of the lowest discounted costs, the first nuclear power plant with capacity of 1500 MW shall be launched in 2025 (in line with the initial assumption that the year 2025 shall be the first one to consider the commissioning of such a unit feasible), and another unit with equal capacity shall be created in 2030.

2.4 PNPP ALTERNATIVES

2.4.1. Implementation opt-out for the Polish Nuclear Power Programme ("zero alternative")

The information in this chapter supplement chapter 5 Forecast of the Environmental Impact Assessment for the Polish Nuclear Power Programme.

The update of forecast demand for fuels and power until 2030, prepared by ARE S.A. in September 2011, contains also analyses of various scenarios—conducted as part of sensitivity analyses—of refraining from construction of nuclear power plants in Poland until 2030. Such "zero alternative" scenarios have been analysed, and the results are presented below.

It should be pointed out that the analyses indicate **that in the case of the opt-out alternative for nuclear power plants, the latter would be replaced by generation sources fired with fossil fuels—and not based on RES**, which is a result of cost-optimisation of the Electricity generation portfolio.

2.4.1.1.1. Opt-out scenario for nuclear power plant construction—in conditions assumed for the baseline scenario

Should the construction of nuclear power plants be abandoned and given the assumed prices of fuels and CO_2 emission allowances, the optimal solution shall be to construct **conventional energy sources based on hard coal.** In such a scenario, years 2016-2025 would see new hard coal units with total capacity of approx. 4000 MW, while after 2025, all new hard coal units are be equipped with CCS installations—and until 2030,units with capacity of approx. 3300 MW and equipped with CCS installations are available in total. It is a clear difference when compared to the baseline scenario results, in which no hard coal CCS power plants are built. In the case of lignite power plants, new units are also furnished with CCS technology, as in the baseline scenario. Results of the analyses for this scenario are presented in figures below.

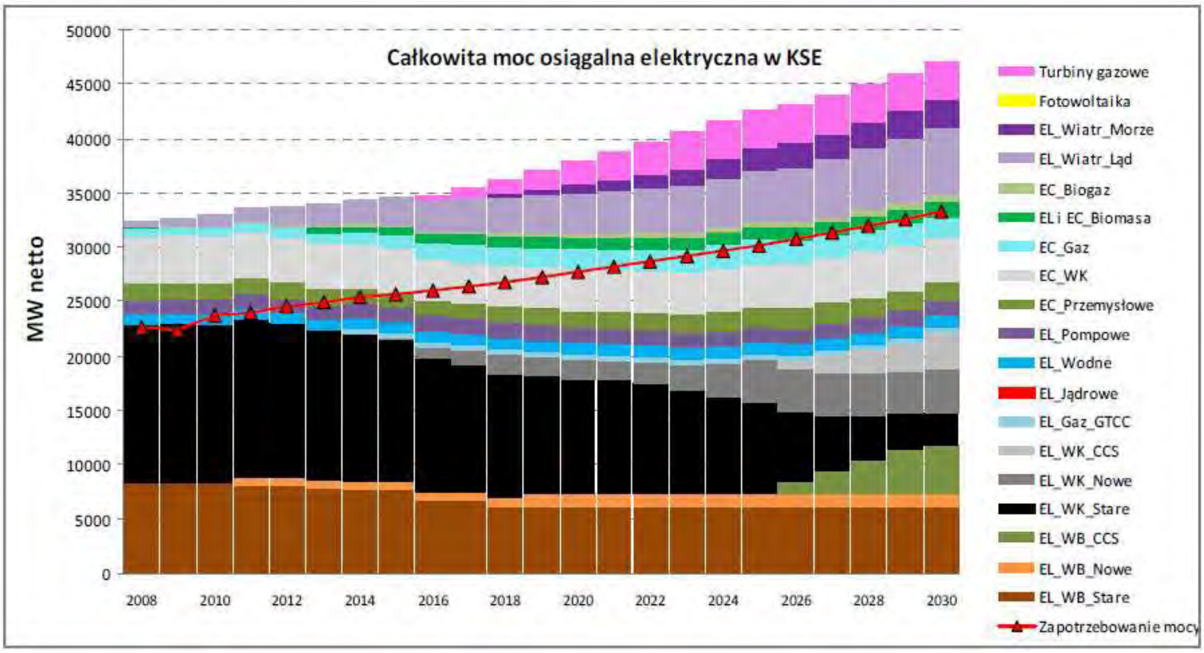


Figure 41. Electricity source capacity structure for the nuclear plant opt-out scenario.

Całkowita moc osiągalalna elektryczna w KSE	Total maximum capacity in NPS
MW netto	Net MW

Turbiny gazowe	Gas turbines
Fotowoltaika	PV
EL Wiatr Morze	Off-shore wind farms
EL Wiatr Ląd	On-shore wind farms
EC Biogaz	Biogas CHPs
EL i EC Biomasa	Biomass power plants and CHPs
EC Gaz	Gas CHPs
EC WK	Hard coal CHPs
EC Przemysłowe	Industrial CHPs
EL Pompowe	Pumping power plants
EL Wodne	Water power plants
EL Jądrowe	Nuclear power plants
EL Gaz GTCC	Gas power plants GTCC
EL WK Nowe	Hard coal power plants - New
EL WK Stare	Hard coal power plants - Old
EL WB CCS	Lignite power plants CCS

EL WB Nowe	Lignite power plants - New
EL WB Stare	Lignite power plants - Old
Zapotrzebowanie mocy	Demand for capacity

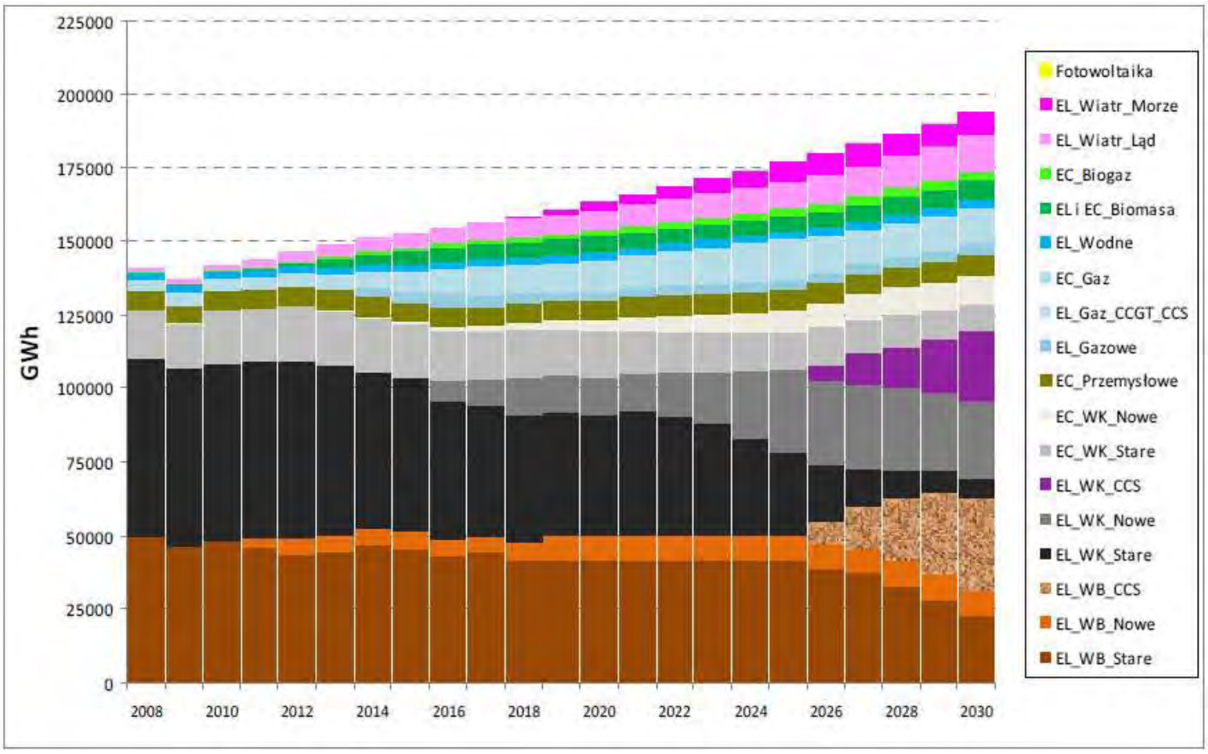


Figure 42. Net electricity generation portfolio for the scenario without nuclear plants

Fotowoltaika	PV
EL Wiatr Morze	Off-shore wind farms
EL Wiatr Ląd	On-shore wind farms
EC Biogaz	Biogas CHPs
EL i EC Biomasa	Biomass power plants and CHPs
EL Wodne	Water power plants
EC Gaz	Gas CHPs
EL Gaz CCGT CCS	Gas power plants CCGT CCS
EL Gazowe	Gas power plants
EC Przemysłowe	Industrial CHPs
EC WK Nowe	Hard coal CHPs - New
EC WK Stare	Hard coal CHPs - Old
EL WK CCS	Hard coal power plants CCS
EL WK Nowe	Hard coal power plants - New
EL WK Stare	Hard coal power plants - Old
EL WB CCS	Lignite power plants CCS
EL WB Nowe	Lignite power plants - New
WL WB Stare	Lignite power plants - Old

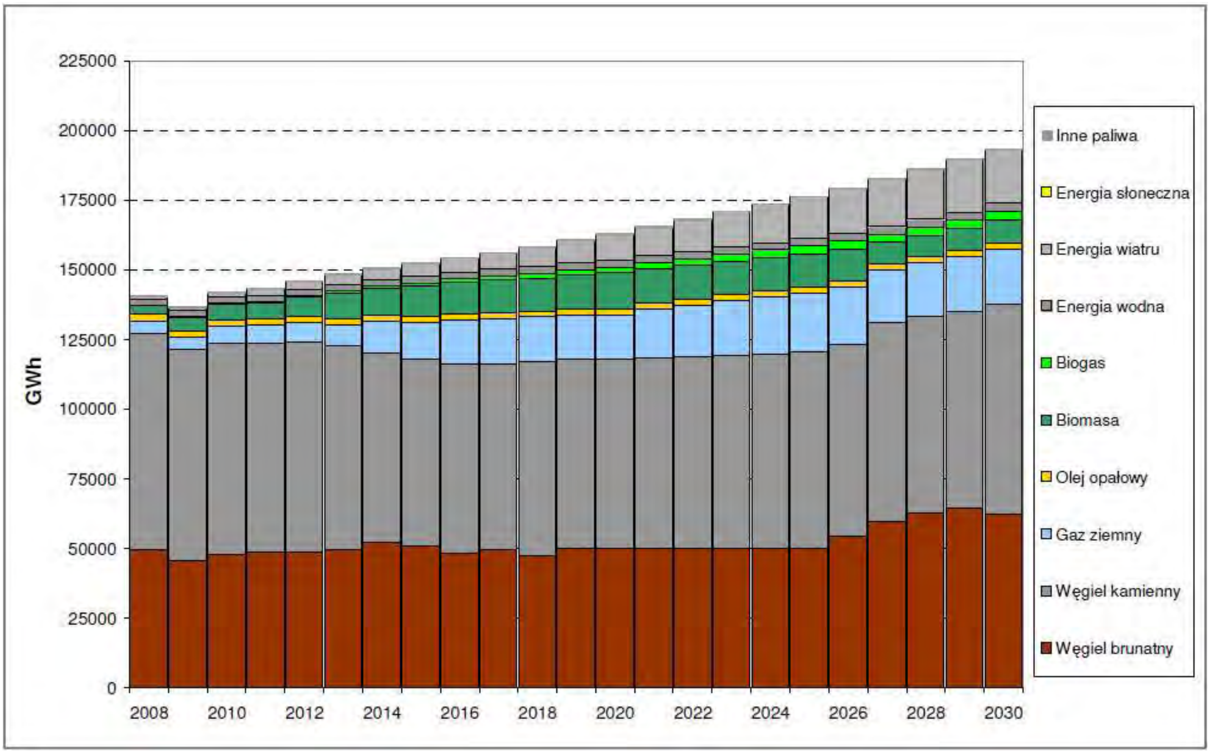


Figure 43. Fuel structure of electricity sources in the scenario without nuclear plants.

Inne paliwa	**Other fuels**
Energia słoneczna	**Solar energy**
Energia wiatru	**Wind energy**
Energia wodna	**Water energy**
Biogas	**Biogas**
Biomasa	**Biomass**
Olej opałowy	**Fuel oil**
Gaz ziemny	**Natural gas**
Węgiel kamienny	**Hard coal**
Węgiel brunatny	**Lignite**

To sum up: abandonment of nuclear power plants in conditions assumed for the baseline scenario would lead to hard coal units to be constructed with total capacity of **7300 MW**, of which 4000 MW would be without CCS and 3300 MW—with CCS installations. When compared to the baseline scenario, in which new hard coal units (without CCS) are created until 2020 with capacity of 2520 MW, it means that there is **a need to build additional hard coal units without CCS installation with capacity of 1480 MW, and coal units with CCS installations with capacity of 3300 MW.**

These results indicate that given the assumed natural gas prices and CO_2 emission allowance prices, the main alternative for nuclear power plants are coal plants with CCS installations. Combined cycle power plants are still little competitive here. However, taking into account the significant uncertainty as to the real costs of CCS installations—both investment expenses and operating costs—these results should be viewed with caution. If operating or investment costs of CCS units were higher, gas sources could prove to be significantly more competitive.

2.4.1.1.2. Opt-out scenario for nuclear power plant construction—in the case of unavailable carbon capture and storage technologies (CCS)

The results of the analysis of scenario presented above show that in the case of abandonment of construction of nuclear power plants, they would be to a significant extent replaced by sources equipped with CCS installations. Below, the generation capacities, production, and fuel consumption structure is presented for the opt-out scenario for for nuclear power plant construction if it is impossible to equip the conventional sources with CCS installations (see figures below).

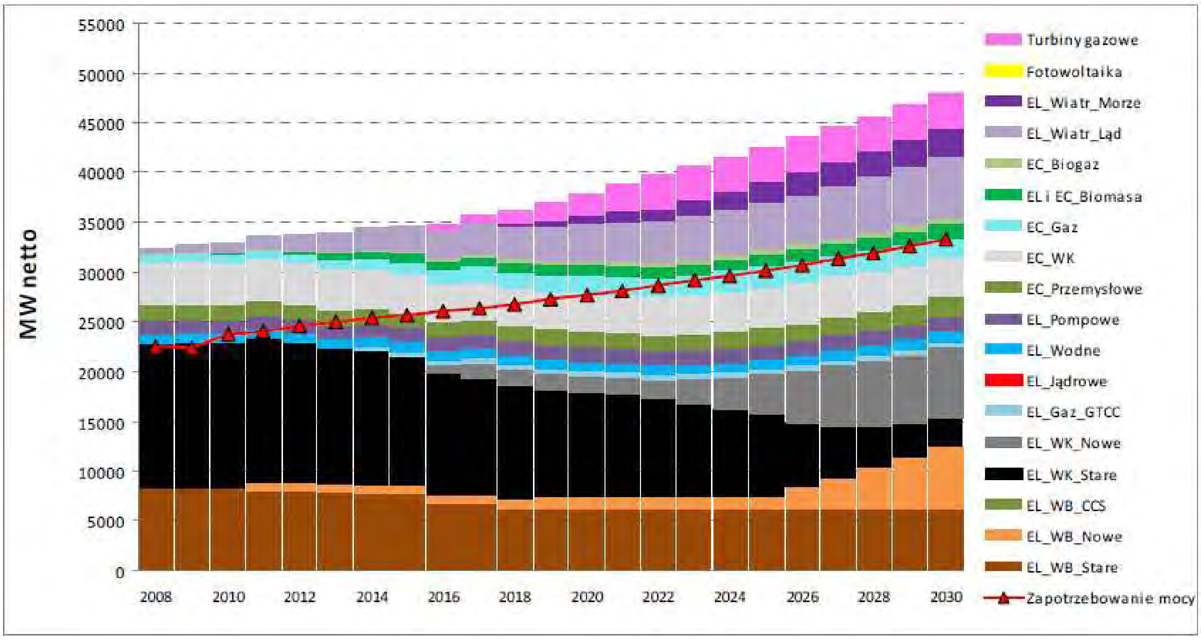


Figure 44. Electricity source capacity structure for the opt-out scenario for nuclear power plant construction and unavailability of CCS technology.

MW netto	Net MW
Turbiny gazowe	Gas turbines
Fotowoltaika	PV
EL Wiatr Morze	Off-shore wind farms
EL Wiatr Ląs	On-shore wind farms
EC Biogaz	Biogas CHPs
EL i EC Biomasa	Biomass power plants and CHPs
EC Gaz	Gas CHPs
EC WK	Hard coal CHPs
EC Przemysłowe	Industrial CHPs
EL Pompowe	Pumping power plants
EL Wodne	Water power plants
EL Jądrowe	Nuclear power plants
EL Gaz GTCC	Gas power plants GTCC
EL WK Nowe	Hard coal power plants - New
EL WK Stare	Hard coal power plants - Old
EL WB CCS	Lignite power plants CCS
EL WB Nowe	Lignite power plants - New
EL WB Stare	Lignite power plants - Old
Zapotrzebowanie mocy	Demand for capacity

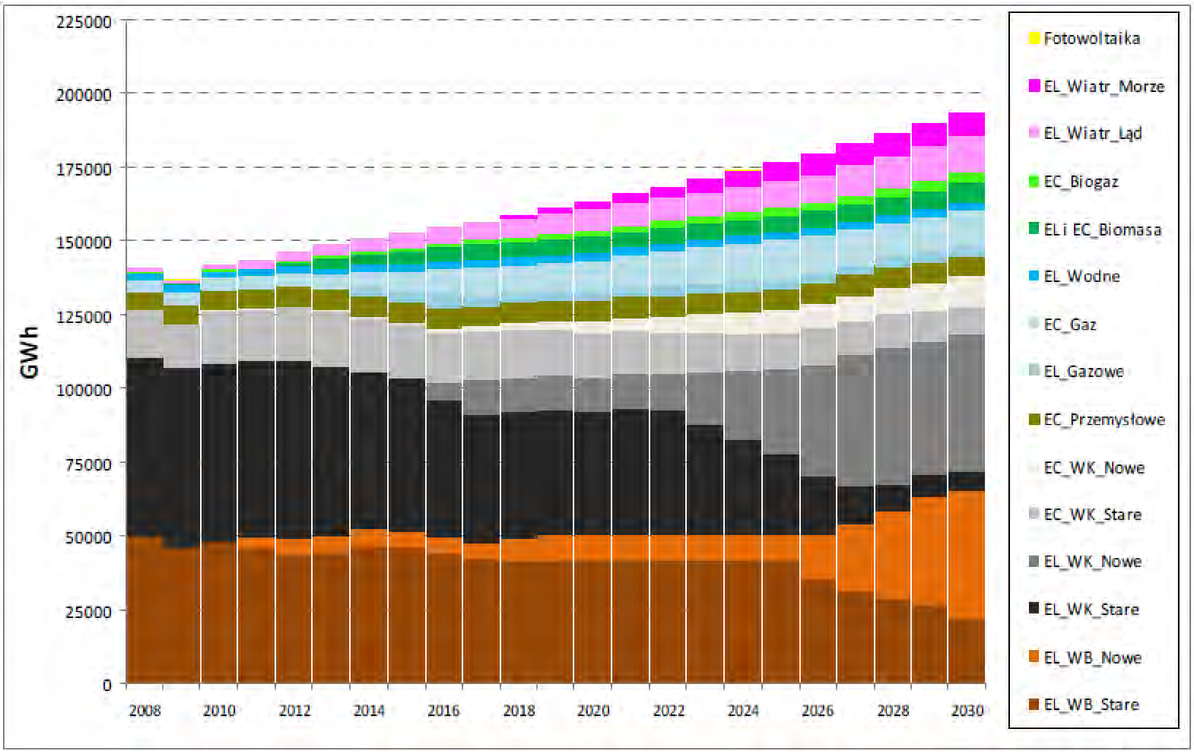


Figure 45. Net electricity generation portfolio for the opt-out scenario for nuclear power plant construction and unavailability of CCS technology.

Fotowoltaika	**PV**
EL Wiatr Morze	**Off-shore wind farms**
EL Wiatr Ląd	**On-shore wind farms**
EC Biogaz	**Biogas CHPs**
EL i EC Biomasa	**Biomass power plants and CHPs**
EL Wodne	**Water power plants**
EC Gaz	**Gas CHPs**
EL Gazowe	**Gas power plants**
EC Przemysłowe	**Industrial CHPs**
EC WK Nowe	**Hard coal CHPs - New**
EC WK Stare	**Hard coal CHPs - Old**
EL WK Nowe	**Hard coal power plants - New**
EL WK Stare	**Hard coal power plants - Old**
EL WB Nowe	**Lignite power plants - New**
WL WB Stare	**Lignite power plants - Old**

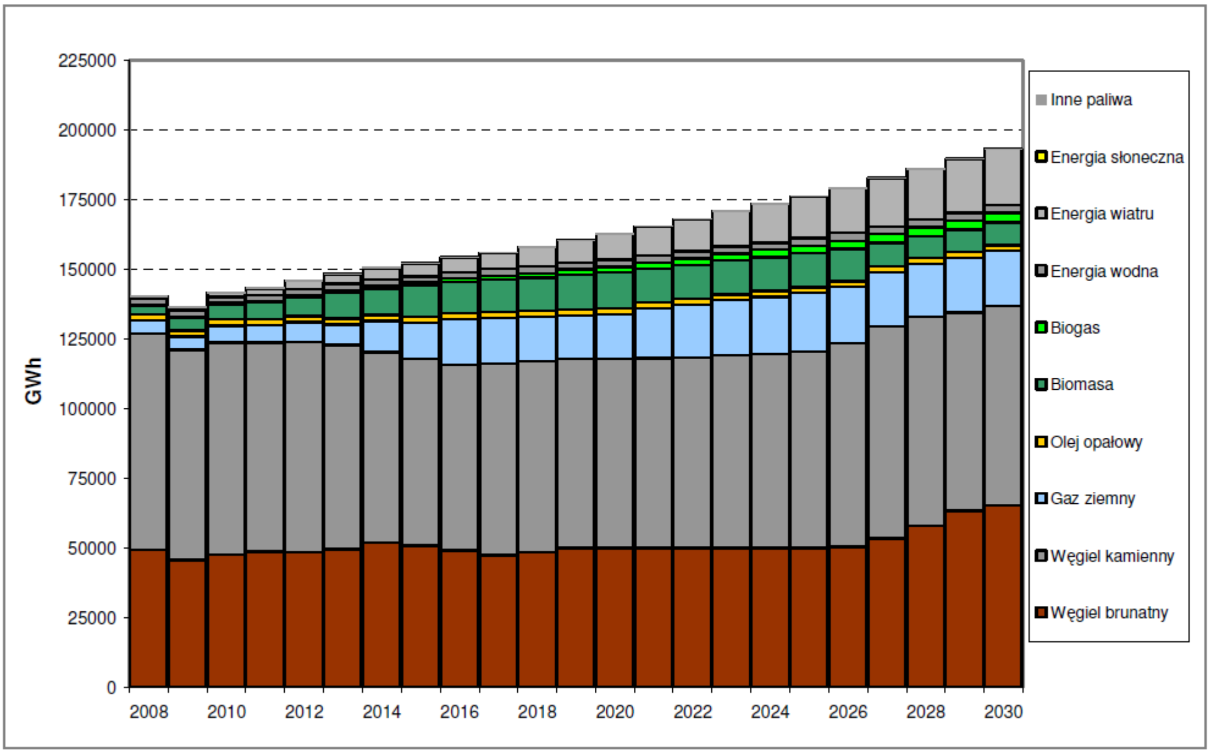


Figure 46. Fuel structure of electricity sources for the opt-out scenario for nuclear power plant construction and unavailability of CCS technology.

Inne paliwa	**Other fuels**
Energia słoneczna	**Solar energy**
Energia wiatru	**Wind energy**
Energia wodna	**Water energy**
Biogas	**Biogas**
Biomasa	**Biomass**
Olej opałowy	**Fuel oil**
Gaz ziemny	**Natural gas**
Węgiel kamienny	**Hard coal**
Węgiel brunatny	**Lignite**

The results that were obtained resemble the outcomes of the previous scenario with a difference that the power plants equipped with CO_2 capture installations, new hard coal (approx. 2900 MW) and lignite power plants appear (approx. 1000 MW) (after 2025). The fuel structure of electricity generation is nearly the same in both these scenarios. Sources fired with natural gas are also little competitive here.

Hence, the abandonment of construction of nuclear power plants shall result in this scenario in their **replacement of new hard coal and lignite plants, however without CCS installations.**

2.4.1.1.3. The opt-out scenario for nuclear power plant construction in the case of unavailability of CCS technology, given high prices of carbon dioxide emission allowances

This scenario assumes that as of 2030, no nuclear power plants or new conventional sources equipped with CCS shall be built in Poland, whereas it also assumes a higher price level of CO_2

emission allowances than in the baseline scenario.

The analyses of this scenario result in the structure of generation sources, electricity generation portfolio, and fuel consumption for electricity generation portfolio presented in figures below.

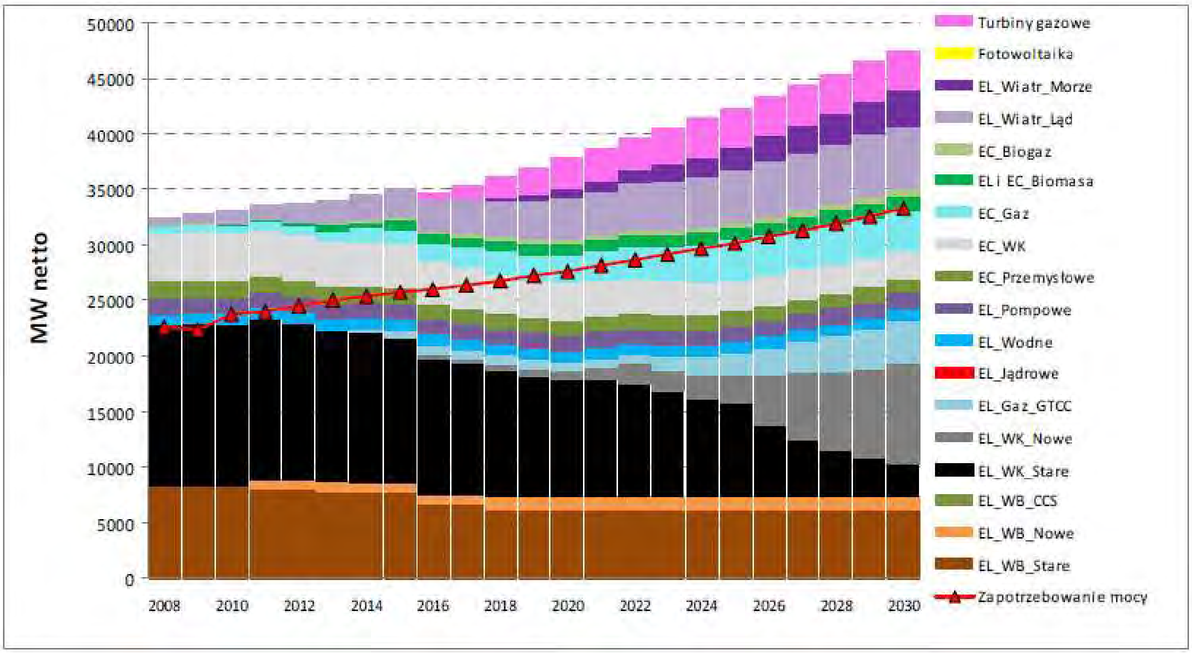


Figure 47. Electricity source capacity structure for the opt-out scenario for nuclear power plant construction and unavailability of CCS technology given high prices of CO_2 emission allowances.

MW netto	Net MW
Turbiny gazowe	Gas turbines
Fotowoltaika	PV
EL Wiatr Morze	Off-shore wind farms
EL Wiatr Ląs	On-shore wind farms
EC Biogaz	Biogas CHPs
EL i EC Biomasa	Biomass power plants and CHPs
EC Gaz	Gas CHPs
EC WK	Hard coal CHPs
EC Przemysłowe	Industrial CHPs
EL Pompowe	Pumping power plants
EL Wodne	Water power plants
EL Jądrowe	Nuclear power plants
EL Gaz GTCC	Gas power plants GTCC
EL WK Nowe	Hard coal power plants - New
EL WK Stare	Hard coal power plants - Old
EL WB CCS	Lignite power plants CCS
EL WB Nowe	Lignite power plants - New
EL WB Stare	Lignite power plants - Old
Zapotrzebowanie mocy	Demand for capacity

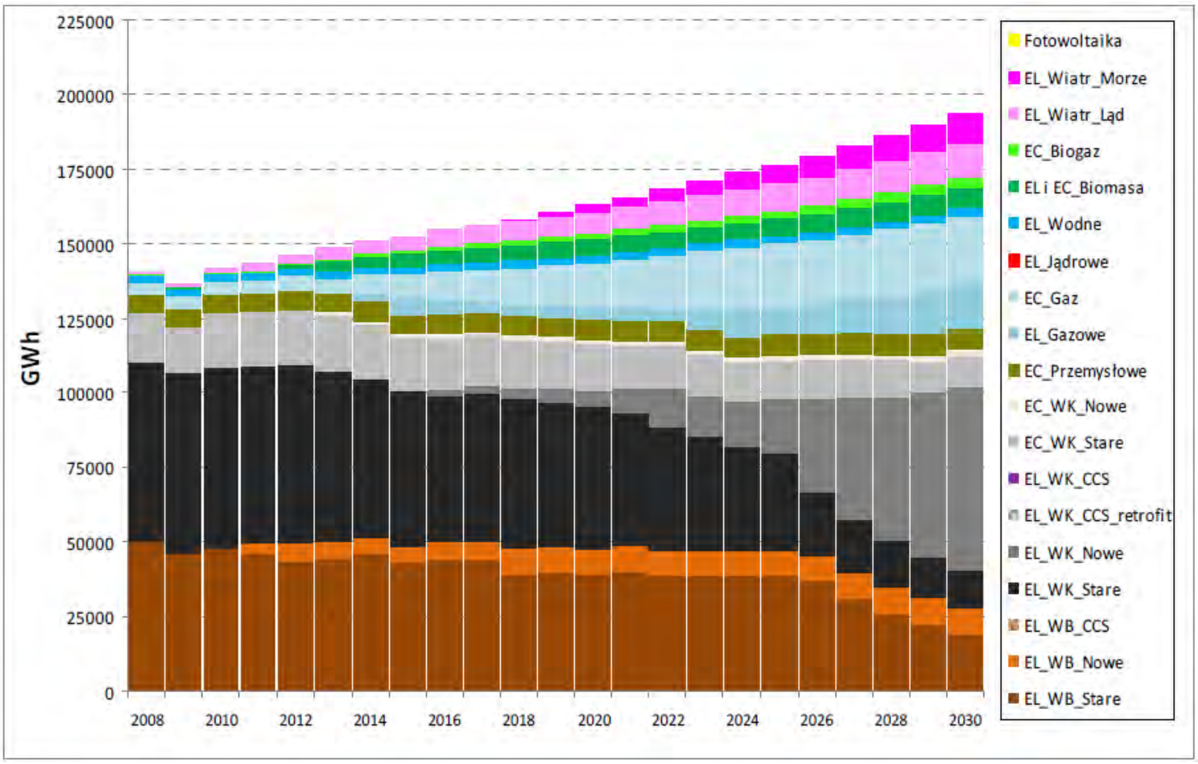


Figure 48. Net electricity generation portfolio for the opt-out scenario for nuclear power plant construction and unavailability of CCS technology given high prices of CO_2 emission allowances.

Fotowoltaika	**PV**
EL Wiatr Morze	**Off-shore wind farms**
EL Wiatr Ląd	**On-shore wind farms**
EC Biogaz	**Biogas CHPs**
EL i EC Biomasa	**Biomass power plants and CHPs**
EL Wodne	**Water power plants**
EL Jądrowe	**Nuclear power plants**
EC Gaz	**Gas CHPs**
EL Gazowe	**Gas power plants**
EC Przemysłowe	**Industrial CHPs**
EC WK Nowe	**Hard coal CHPs - New**
EC WK Stare	**Hard coal CHPs - Old**
EL WK CCS	**Hard coal power plants CCS**
EL WK CCS retrofit	**Hard coal power plants CCS retrofit**
EL WK Nowe	**Hard coal power plants - New**
EL WK Stare	**Hard coal power plants - Old**
EL WB CCS	**Lignite power plants CCS**
EL WB Nowe	**Lignite power plants - New**
WL WB Stare	**Lignite power plants - Old**

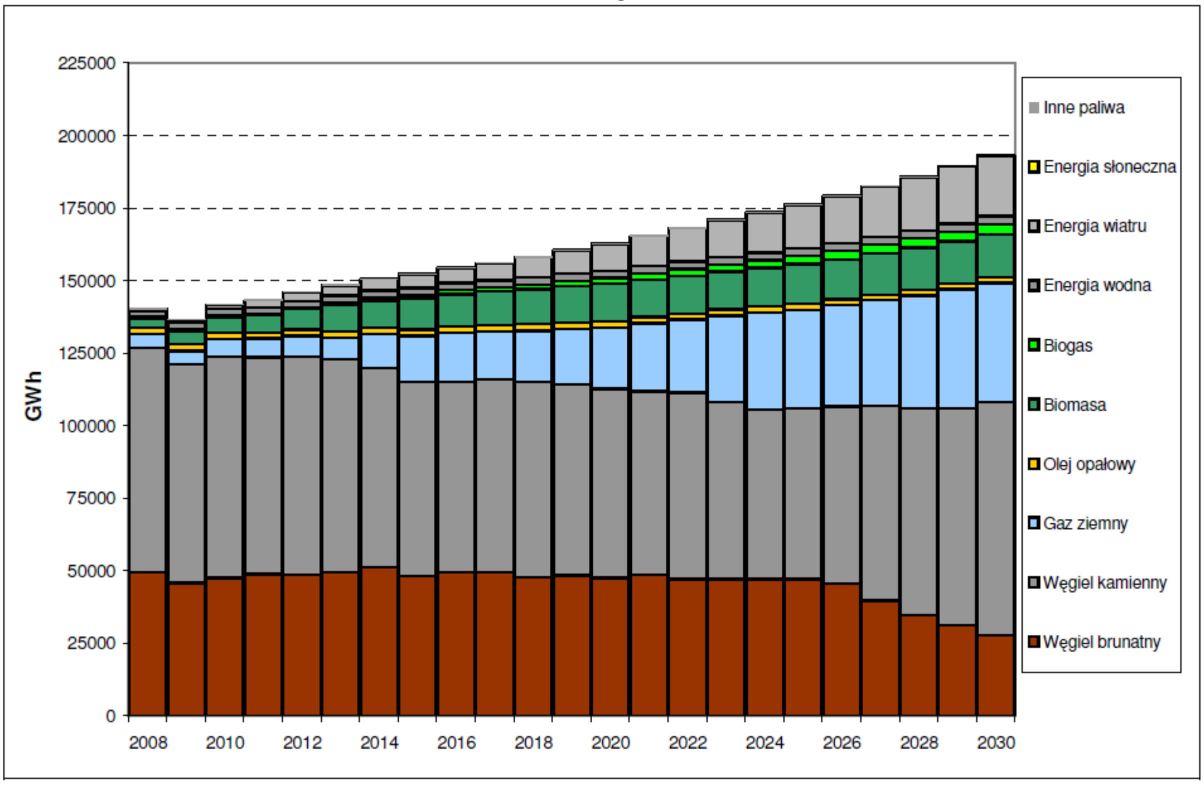


Figure 49. Fuel structure of electricity generation for the opt-out scenario for nuclear power plant construction and unavailability of CCS technology given high prices of CO_2 emission allowances.

Inne paliwa	**Other fuels**
Energia słoneczna	**Solar energy**
Energia wiatru	**Wind energy**
Energia wodna	**Water energy**
Biogas	**Biogas**
Biomasa	**Biomass**
Olej opałowy	**Fuel oil**
Gaz ziemny	**Natural gas**
Węgiel kamienny	**Hard coal**
Węgiel brunatny	**Lignite**

In the case of abandonment of nuclear power and sources furnished with CCS installations, the high level of prices of CO_2 emission allowances results in a **declining use of lignite** as the most emission-intensive of fuels, **in favour of hard coal and natural gas**. After 2020 no new power plants based on lignite come into being, and generation in the existing facilities in 2025-2030 is markedly reduced. The electricity generation from lignite in 2030 is by **approx. 40%** lower when compared to the scenario without nuclear power plants and CCS, and with lower CO_2 prices. On the other hand, the production in hard coal and natural gas plants is higher—approx. 3800 MW of capacity in 2030. Gas CHPs substantially increase their production at the cost of new CHPs based on hard coal.

In general, this scenario may be described in the following way: high prices of CO_2 emission allowances make the gas sources competitive to coal sources despite the unfavourable proportion of gas and hard coal prices. In this alternative, the share of natural gas in the electricity generation portfolio becomes significant (approx. **20%**).

At the same time, this scenario is characteristic in terms of **average systemic costs of electricity**

generation, which reach the highest level when compared to other scenarios.

2.4.1.1.4. Impact of cancellation of nuclear power plants on the electricity generation costs.

Figure 50 presents a comparison of estimated average systemic costs of electricity generation for individual scenarios taken into account in sensitivity analyses (generation costs include costs of purchase of CO_2emission allowances).

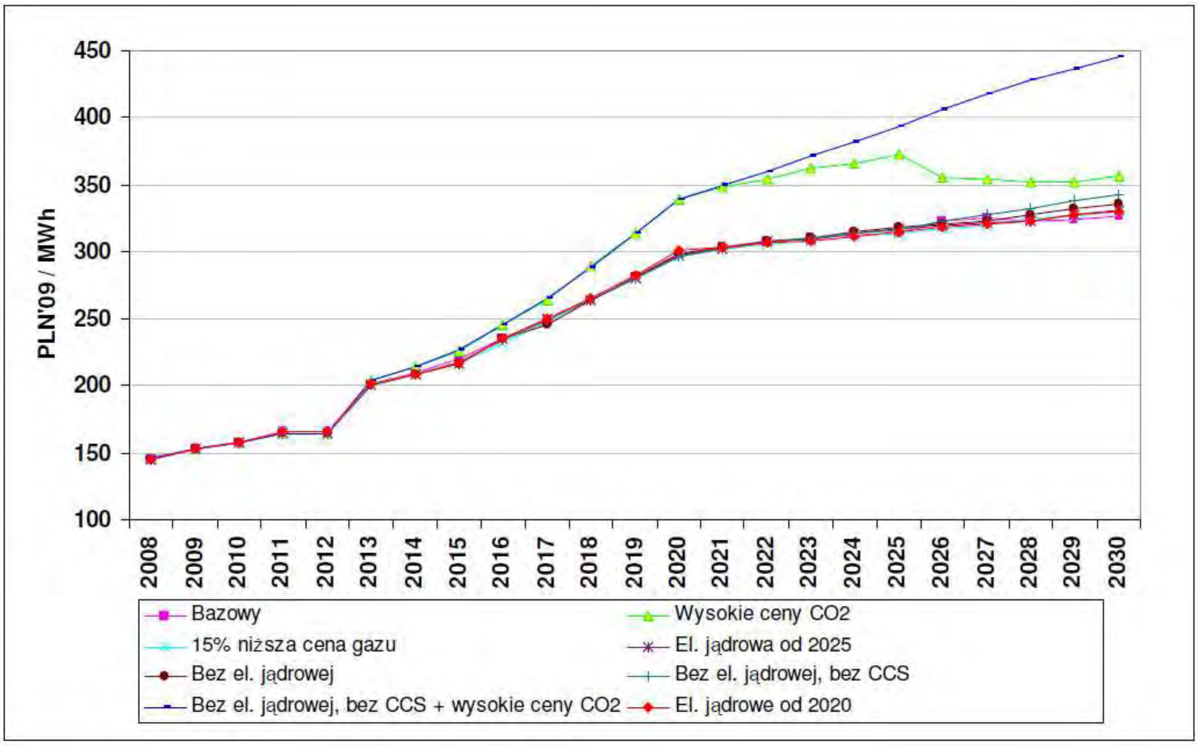


Figure 50. Comparison of electricity generation costs in various scenarios analysed as part of sensitivity analyses [PLN'09/MWh].

Bazowy	Baseline
15% niższa cena gazu	Gas price lower by 15%
Bez el. jądrowej	Without nuclear plant
Bez el. jądrowej, bez CCS + wysokie ceny CO2	Without nuclear plant, without CCS + high CO2 prices
Wysokie ceny CO2	High CO2 prices
El. jądrowa od 2025	Nuclear plants from 2025
Bez el. jądrowej, bez CCS	Without nuclear plant, without CCS
El. jądrowe od 2020	Nuclear plants from 2020

Whatever the scenario, a significant growth of generation costs, particularly strong in 2013-2020, shall take place, which is caused mainly by increasing CO_2 emission costs. **In the baseline scenario**, the costs of energy generation reach a level of approx. **PLN 330/MWh** in 2025-2030.

For all scenarios with low prices of CO_2 emission allowances, the course of changes in generation costs over time is similar. In this conditions, abandonment of construction of nuclear power plants does not significantly influence the generation costs, because the latter would be replaced then with conventional power plants equipped with CCS installations. Assuming that neither nuclear plants, nor CCS plants shall be built, the generation costs increase slightly, since the said technologies are replaced with conventional plants whose generation costs given baseline CO_2 prices are comparable or higher only a little bit.

In the case of two scenarios assuming high prices of CO_2emission allowances, the course of changes in generation costs over time is generally different when compared to the scenarios with low prices of CO_2emission allowances—first and foremost the costs of generation would be significantly higher.

In the baseline scenario, providing for a nuclear power plant to be constructed along with coal sources with CCS, the costs of energy generation grow faster than in the baseline scenario, reaching a level of approx. PLN 370/MWh in 2024-2025. After 2025, however, the increasing share of nuclear plants and plants equipped with CCS installations stabilises the costs of generation. For that reason—despite significantly higher prices of CO_2—generation costs in 2030 are higher in 2030 by only 8% in comparison to the baseline scenario.

Under conditions of high prices of CO_2 emission allowances, if nuclear power plant are not built, and CCS installations are not available, generation costs would be the highest and growing in the whole forecast period. In 2030, the costs would reach approx. PLN 445/MWh, which is above 25% more than in the scenario of high prices of CO_2 which allows for the nuclear energy and CCS.

Summing up, it should be said that:

- Cancellation of construction of nuclear power plants until 2030, given the costs of CO_2 emission allowances assumed for the baseline alternative (a growth from the present level to the level of 33 €'05/tCO_2 in 2030) would result in a generation portfolio changed towards a greater usage of sources based on lignite and hard coal with CCS installations. Should CCS installations not be available, conventional power plants shall be built, based mostly on lignite and hard coal. Because of the limited share of NPP in the forecast and the moderate growth of CO_2 emission allowances assumed, significant changes of the average electricity generation costs when compared to the baseline scenario do not occur here.
- In the case of cancellation of nuclear plants construction under conditions of high costs of CO_2 emission allowances (a growth from the present level to the level of 60 €'05/tCO_2 in 2030) and unavailability of CCS installations, the growing generation costs make the combined cycle plants competitive (the share of gas in the electricity generation portfolio in this scenario grows to 20% in 2030). However, it would result in a significant increase of electricity generation costs. The average electricity generation cost in the system would rise to the level of approx. 445 PLN'09/MWh in 2030, which would mean it is above 20% higher when compared to the baseline scenario.
- In the case of unavailability of CCS technologies, nuclear power is the main technology making it possible to significantly reduce CO_2 emissions. Scenarios providing for no nuclear power plants and sources equipped with CCS in the portfolio of national generation sources are characterised by the highest CO_2 emission levels (higher by approx. 55% when compared to the baseline scenario).

2.4.1.2. Impact of cancellation of nuclear power plants on the electricity generation costs.

2.4.1.2.1. Higher carbon dioxide emissions

Figure 51 presents a comparison of the calculated volume of CO_2 emissions for individual scenarios included in sensitivity analyses contained in the update of forecast demand for fuel and power until 2030, prepared by ARE S.A.

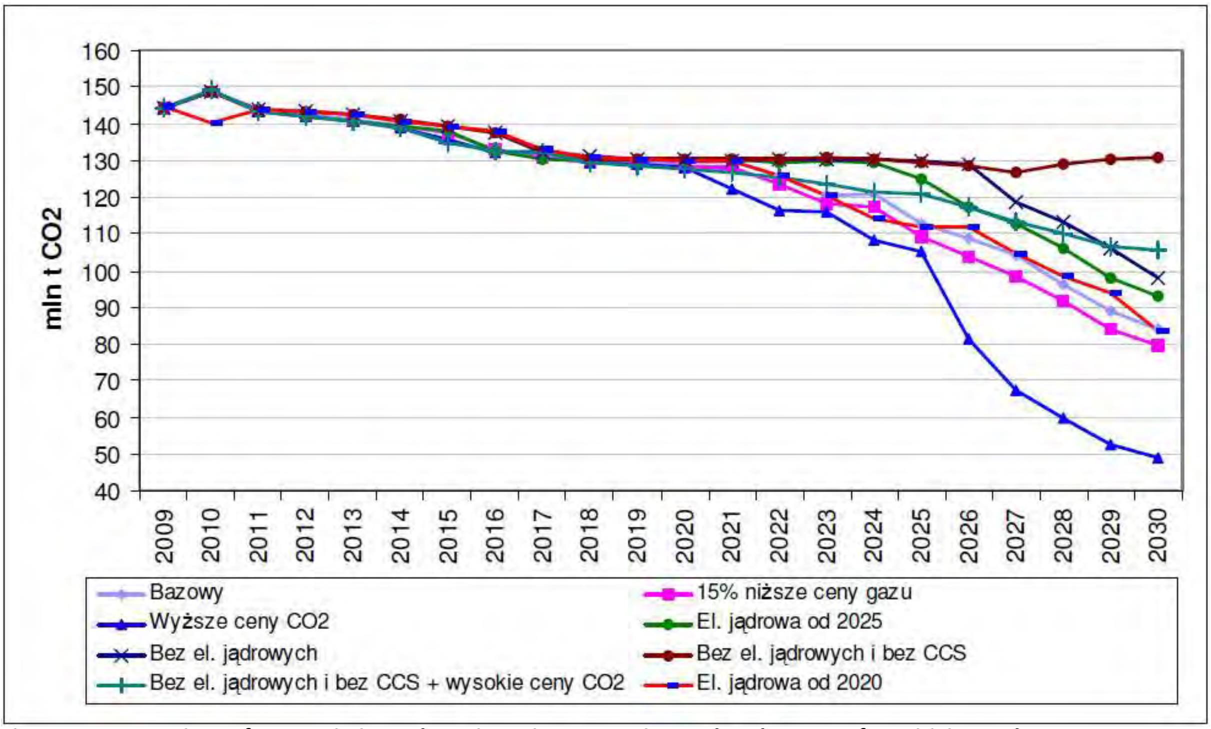


Figure 51. Comparison of CO_2 emission volume in various scenarios analysed as part of sensitivity analyses.

Bazowy	**Baseline**
Wyższe ceny CO2	**Higher CO2 prices**
Bez el. jądrowej	**Without nuclear plant**
Bez el. jądrowej, bez CCS + wysokie ceny CO2	**Without nuclear plant, without CCS + high CO2 prices**
15% niższe ceny ceny gazu	**Gas prices lower by 15%**
El. jądrowa od 2025	**Nuclear plants from 2025**
Bez el. jądrowej, bez CCS	**Without nuclear plant, without CCS**
El. jądrowe od 2020	**Nuclear plants from 2020**

Lower volumes of CO_2 emissions when compared to the baseline scenario occur only in two analysed scenarios: the scenario of lower (by 15%) gas prices and the scenario of higher prices of CO_2 emission allowances (with the highest emission reductions). **Both scenarios provide for construction of nuclear plants.**

While for **all scenarios assuming cancellation of construction of nuclear power plants until 2030, the CO_2 emission levels are higher than in the baseline scenario.** In particular, the analyses indicated that **in the case of cancellation of construction of nuclear power plants,** CO_2 emissions **in 2030 would be higher** than emissions assumed in the baseline scenario (84.2 million t), by approximately:

- 14 million (i.e. approx. **17%**)—for the opt-out scenario for nuclear power plant construction—in conditions assumed for the baseline scenario;
- 21 million (i.e. approx. **25%**)—for the opt-out scenario for nuclear power plant construction with CCS technology unavailable, given high prices of carbon dioxide emission allowances
- 46 million (i.e. approx. **55%**)—for the opt-out scenario for nuclear power plant construction with CCS technology unavailable, in which case **no reduction of CO_2 emission after 2017 would be available,**

and after 2027, there would be a slight growth in emission.

2.4.1.2.2. Growth of SO_2, NO_x and dust emissions

Abandonment of nuclear power, apart from increasing CO_2 emissions, **would also result in additional SO_2, NO_x and dust emissions** originating from generation sources fired with organic fuels that would replace the nuclear units.

While the updated forecast demand for fuel and power until 2030 developed by ARE S.A. does not include analysis of the increasing impact of the abandonment on these pollutions, they may be estimated on the basis of the assumption that nuclear power plants would be replaced with additional, advanced hard coal units (alternative described in item 2.4.1.1.1), with total capacity of **4780 MW** (in 2030). Assuming a typical annual consumption time for the installed capacity of these units at a level of 7500 h, we arrive at an estimate value of annual electricity generation from these units a level of **36 TWh**.

The newly built thermal units must comply with Directive 2010/75/EU[22], Appendix V, providing for reduction of air pollutant emitted to air. Nevertheless, SO_2, NO_x and dust emission factors per power unit for newly designed hard coal facilities are significantly different (it concerns mostly NO_x). The table below includes selected factors for power units. Ostrołęka C (1000 MW)[23], 5. and 6. power unit. Opole (2x900 MW)[24] and their average values adopted in this estimate.

Table 13. Comparison of emission factors for Ostrołęka and Opole units.

Emission type	Ostrołęka C	Opole, 5. and 6. unit	Average
SO_2 [kg/MWh]	0.554	0.64	0.60
NO_x [kg/MWh]	0.507	1.52	1.01
Dust [kg/MWh]	0.083	0.05	0.07

Assuming the above values of emission factors and the annual average generation of these additional coal units at a level of 36 TWh, we arrive at the following estimated values of additional annual emissions:

- SO_2: 22 thousand t/a
- NO_x: 36 thousand t/a
- Dust: 2,5 thousand t/a.

2.4.1.2.3. Spatial aspect of environmental impact of cancellation of nuclear power plants construction

The updated forecast demand for fuel and power until 2030 developed by ARE S.A. does not examine the aspect of location of possible additional power units fired with organic fuels, which should be built in the case of cancellation of nuclear plans. Depending on the scenario, these might be hard coal, hard coal and lignite, or hard coal and natural gas (combined cycle) units.

[22] Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control). Offical Journal of the European Union L 334/17.
[23] "Energoprojekt Warszawa" S.A. Construction of Ostrołęka C power plant. Environmental impact report. Technical description.
[24] Marek Wdowiak (Investments Department of PGE GiEK S.A.) : Advanced power technologies—as demonstrated by desings of new power units at PGE GiE S.A. http://redinpe.d2.pl/attachments/article/191/Inpe_154-155_art_01.pdf

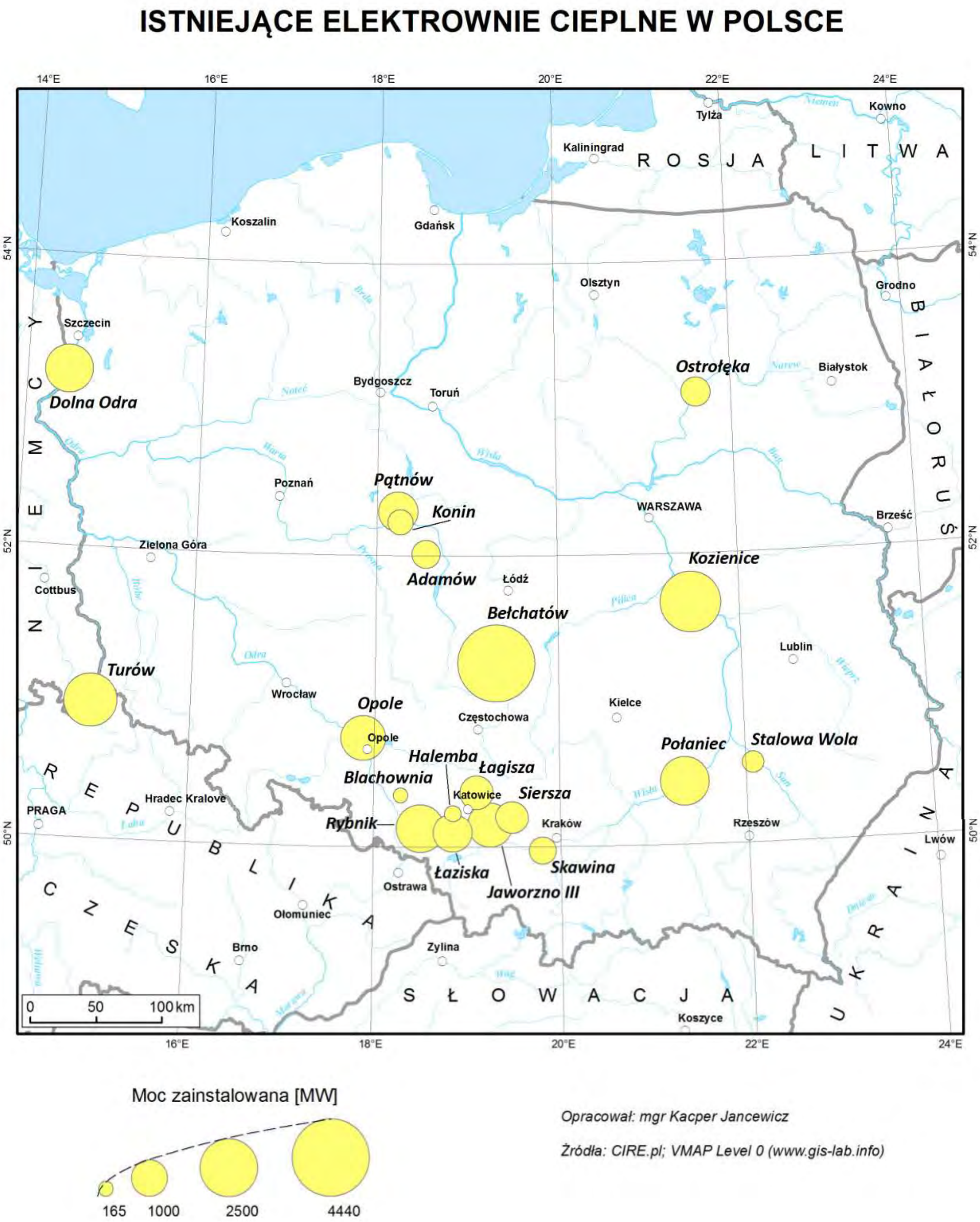


Figure 52. Existing thermal power plants in Poland [source: CIRE.pl].

ISTNIEJĄCE ELEKTROWNIE CIEPLNE W POLSCE	EXISTING THERMAL PLANTS IN POLAND
Moc zainstalowana [MW]	Installed capacity [MW]
Opracował: mgr Kacper Jancewicz	Prepared by: Kacper Jancewicz, MSc
Źródła: CIRE.pl; VMAP Level 0 (www.gis-lab.info)	Source: CIRE.pl; VMAP Level 0 (www.gis-lab.info)

However, it can be assumed that additional power units fired with organic fuels would be first of all located in the existing sites of large thermal plants based on hard coal or lignite—where the extension is possible (see Figure 52). Moreover, further expansion of power industry based on lignite which in the case of cancellation of nuclear plans would be more reasonable, would require launching new excavations in the area of Legnica (Dolnośląskie province) and Gubin (Lubuskie province)[25]. It can be

[25] Which seems dubious, however, because of social protests, especially those related to excavations planned in the area of Legnica

also assumed that new power plants based on hard coal—due to high costs of coal transport—will be rather located in central and southern Poland (especially in Śląskie province)—see Figure 53. An exception are the presently planned power plants: "Północ"[26] (in the area of village Rajkowy near Pelplin) and "Ostrołęka C" (however this investment is presently suspended). In turn, combined cycle units shall be located near transmission pipelines, mostly in central and western Poland

Summing up, the cancellation of nuclear plans—nuclear power plants which are presently planned to be located in the seaside region—would result in strengthening and **further deepening of the actual disproportion of spatial distribution of larger electricity generation sources**, which are mostly located in central and southern part of the country.

Figure 53.Implemented and planned construction and extension projects related to power plants/CHPs in Poland. Source:http://www.rynek-energii-elektrycznej.cire.pl/st,33,335,tr,145,0,0,0,0,0,budowane-i-

[26] This plant is to be fired with hard coal from Bogdanka Mine.

planowane- elektrownie.html

LEGENDA	
KEY	
Blok na węgiel kamienny	Hard coal unit
Blok na węgiel brunatny	Lignite unit
Blok na gaz	Gas unit
Blok na biomasę	Biomass unit
Planowane lokalizacje elektrowni jądrowej	Planned sites of nuclear plants

The concentration of generation sources in central and southern part of the country and their deficit in the northern part result in **the need of power transmission over long distances**, which is connected not only with **significant transmission losses**, but also compromises the security of supply of recipients in the north and north-east of the country. In particular, the Pomorskie province is currently a large "capacity importer", in the amount estimated by Tractebel Engineering S.A.[27] (taking into account the operation of ESP Żarnowiec) between 798 MW (winter peak) and 1258 MW (summer off-peak). As much as approx. 2/3 of electricity consumed in Pomorskie (5863 GWh/a—as estimated by Tractebel Engineering S.A. on the basis of data for 2007) is "imported" from other regions of the country, the power comes mostly from large thermal plants hundreds kilometres away such as: Dolna Odra PP (approx. 300 km in a straight line from Gdańsk), Kozienice PP (approx. 300 km in a straight line from Gdańsk), and to a lesser extent Pątnów PP (approx. 230 km in a straight line from Gdańsk). The average annual loss factor in transmission grids (400 kV and 220 kV) was estimated by the Transmission System Operator at 1.9%[28]. Assuming this factor, the annual transmission loss to the Pomorskie province only can be roughly estimated at approx. 110 GWh/a. Moreover, a very high deficit of electricity is also present in other provinces: Kujawsko-Pomorskie (6304 GWh/a), Warmińsko-Mazurskie (3473 GWh/a) and Podlaskie (2391 GWh/a)[29].

At the same time it should be borne in mind that emissions of pollutants from thermal units which would have to be built instead of nuclear ones would additionally burdened the environment in these regions of the country, already significantly degraded in result of industrial activity, including coal power industry.

2.4.2. Discussion of the argument on the development of renewable power industry and improvement of energy efficiency as an alternative for implementation of the Polish Nuclear Power Programme.

The study entitled "Energy Policy of Poland until 2030" (PEP 2030) was preceded with analyses of alternatives conducted with the use of reliable and objective data and professional planning tools by an impartial agency with extensive experience in this field (in Poland, such agency is ARE S.A.). The result of this planning activities is a sustainable and optimised energy policy of Poland whose aim is to satisfy the country's demand for energy (including electricity), **at the lowest costs possible and at the same time observing the requirements of environment protection (which were significantly tightened in the recent years).**

[27] K. Halaczek-Nowak i K. Nowak: Draft Update of Regional Power Strategy including renewable energy sources in Pomorskie province from 2025 in power industry. Tractebel Engineering S.A. Katowice, September 2009.
[28] Z. Maciejewski: Estimation of transmission losses in the National Power System in the years 1999-2003. PSE S.A. Elektroenergetyka No. 3/2004 (50).
[29] Ibidem.

As it was said in item 2.3.1, **very ambitious energy efficiency targets** were assumed in planning of the energy policy of Poland until 2030, significantly exceeding targets set by the EU as part of the so-called energy and climate package. It concerns the forecast demand for fuel and energy until 2030, which is one of the fundamental documents on which PEP 2030 is based, both the version of November 2009 as well as its update of September 2011.

When addressing the proposal to base the energy economy on renewable energy sources, one should pay attention to the following factors: electricity generation costs, opportunities to ensure satisfaction of the country's growing demand for electricity, and possibilities and costs of compensation of interrupted supply. Detailed analyses pointed to the lack of economic justification for the complete replacement of the power generated by nuclear power only for sources that use renewable energy[30].

2.4.2.1. High electricity generation costs for RES

From all professional and objective analyses—performed both by ARE S.A. (see: item 2.3.1.1.4.) as well as other renowned consulting companies—it clearly follows that the electricity generation costs for renewable sources are markedly higher than for nuclear energy. Therefore, in the case of cancellation of construction of nuclear power plants, they would be replaced not by RES, but thermal plants fired with fossil fuels—see results of analyses for "zero alternative" (item 2.4.1).

An account of the costs of energy for various sources is provided in particular by the study of Ernst and Young,[31] recently published in Poland and prepared in cooperation with the Polish Wind Energy Association and the European Wind Energy Association. It includes the costs of electricity generation with the use of various technologies, taking into account operating costs and investment outlays to be incurred, should new sources be built in 2011. The authors inform that the calculation reflects also other market conditions of 2011, including certificates of origin (renewable resources) or the amount of substitution fees[32], exchange rates, prices of heat and fuels, and other regulatory conditions applicable in 2011.

One of main factors influencing the costs of electricity generation are investment costs incurred for construction of generation sources. Analyses by Ernst&Young indicate that in conditions of 2011, wind power was the cheapest option per 1 MW of the installed peak capacity in renewable power industry—6.6 million PLN/MW. It should be remembered, however, that it is the peak, and not the average capacity. Therefore, when assessing the average capacity obtained during a year it is necessary to multiply the peak capacity by the consumption factor, which equals between 0.2 and 0.25 for on-shore wind farms. The study by Ernst and Young provides equivalent full capacity operation times during a year for each of energy sources under consideration, as it is shown in the table below. On-shore and off-shore wind, biomass, and biogas used to fire CHPs, small hydroelectric plants were taken into account as well as biomass used to generate electricity, PV panels, coal, gas, and nuclear plants.

CAPEX values per 1 MW of peak capacity and operation time in annual account was derived from the report by Ernst and Young. The next row, the amount of investment expenditures for 1 MW of

[30] Andrzej Strupczewski, Władysław Kiełbasa, Łukasz Szkudlarek: Odnawialne źródła energii a energetyka jądrowa. [Renewable energy sources and power industry.] Warsaw, July 2012.

[31] http://energetyka.wnp.pl/energia-z-oze-ciagle-duzo-drozsza-niz-z-wegla,171686_1_0_0.html

[32] Paid by energy companies failing to fulfil the obligation of ensuring a specific energy share from renewable sources in electricity delivered to end users.

average capacity during a year, was calculated on the basis of data from the two preceding rows of the table. For example, if the full capacity equivalent operation time for on-shore wind farms is 2300 hours a year[33], the investment outlays for the average power unit shall amount to:

Outlays for a peak capacity unit/fraction of full capacity equivalent operation time = 6.6 million PLN/MW x 8760 h/2300 h = 25.1 PLN/MW of the average capacity.

Table 14. Amount of investment outlays for one unit of peak capacity and average capacity, data from the report of Ernst and Young[34], own study.

		Wind on-shore	MFW	Biomass (CHPs) *	Biogas (CHPs)*	Hydro	Biomass	PV	Hard coal	Gas	NP
CAPEX per one MW of peak capacity	millions of PLN/MW	6,6	13,6	10,7	14,4	18,5**	10,3	7,8	6,6	3,9	14,4
Installed capacity consumption time	h/a	2300	3100	8000	6000	4000	7000	900	7000	7000	8000
CAPEX per one MW of average capacity	millions of PLN/MW average capacity	25.1	38.4	11.7	21.0	40.5	12.9	75.9	8.2	4.9	15.8

** Includes costs of the heat generation section*

*** Includes costs of works related to water management.*

The results provided in the table above indicate that the investment outlays per one MW of average capacity during a year are significantly higher for on-shore wind turbines (25.1 million PLN/MW of average capacity), on-shore wind turbines (38.4 million PLN/MW of average capacity) and PV panels (75.9 million PLN/MW of average capacity) than for nuclear power plants (15.9 million PLN/MW of average capacity). Investment outlays for a unit of average capacity for little hydroelectric plants are also high (40.5 million PLN/MW of average capacity), which is caused by a relatively short time of their operation during a year. However, hydroelectric plant fulfil an important role not only as sources of electricity, but also as systems that regulate water management and prevent floods causing substantial losses that exceed the costs of construction of a hydroelectric plant.

Electricity and thermal energy generation based on biomass and biogas requires fairly lower investment expenditures than for wind power or PV panels. Unfortunately, it is expensive due to high fuel costs, which are 3 times higher than the cost of hard coal.

Taking into account the investment and operating costs of plants for individual technologies of renewable energy sources (RES) and i.a. the expected return from capital invested at the level of 10% annually, the authors estimated the costs of electricity generation for new capacities in the conditions of 2011.

The analyses show that among the electricity generation methods analysed, the least expensive in economic terms is still conventional coal and gas power, and apart of them, nuclear power (see Figure 54). In the case of hard coal plants, the cost of generation of 1 MWh was estimated at PLN 282, and in the case of gas energy—at PLN 314. In both cases with the assumption of no free-of-charge allocation of allowances, and given the price of PLN 60 for one ton of CO_2.
Estimated cost of energy from a nuclear power plant is PLN 313/MWh.

[33] Ernst and Young ibid, p. 30
[34] Ernst and Young, PSEW - Wpływ energetyki wiatrowej na wzrost gospodarczy w Polsce [Impact of wind power on economic growth in Poland], Warsaw, 2012 http://psew.pl/pl/publikacje/raporty?download=96:raport-eay-wplyw-energetyki-wiatrowej-na-wzrost-gospodarczy

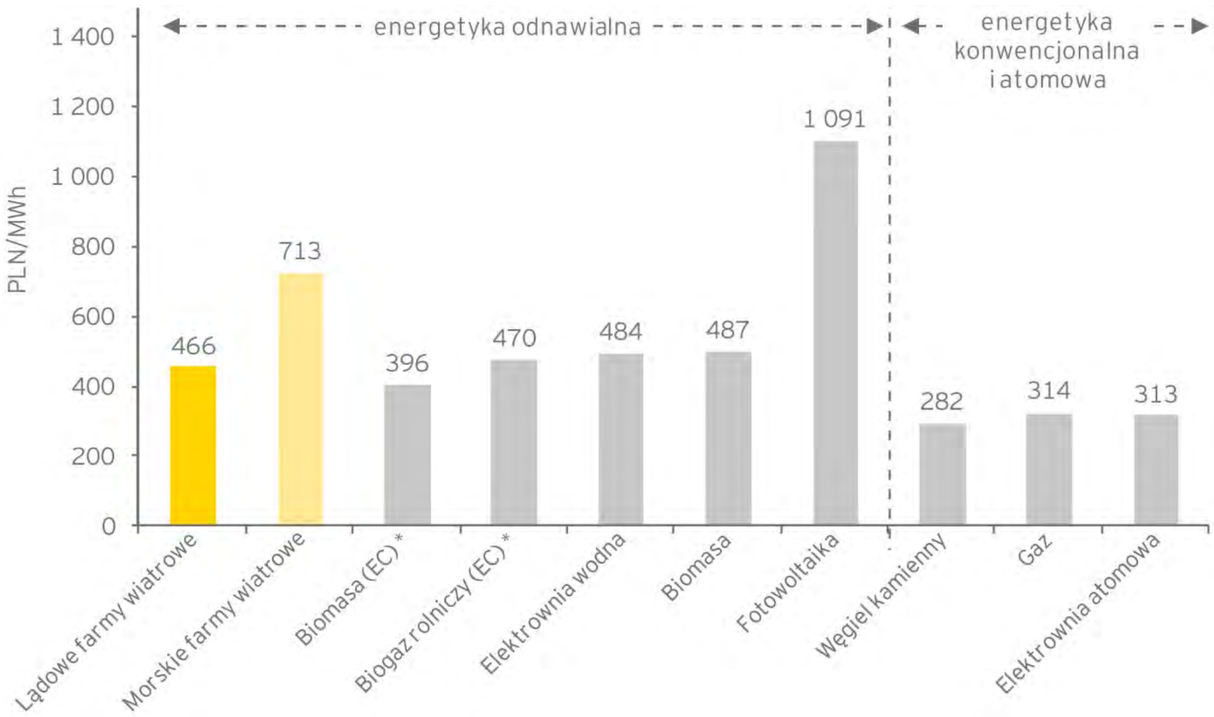


Figure 54. Presentation of costs of electricity from various sources in accordance with Polish data in 2011, the diagram taken from the report of Ernst and Young[35].

Energetyka odnawialna	Renewable energy
Energetyka konwencjonalna I atomowa	Conventional and nuclear energy
Lądowe farmy wiatrowe	On-shore wind farms
Morskie farmy wiatrowe	Off-shore wind farms
Biomasa(EC)	Biomass (CHPs)
Biogaz rolniczy(EC)	Agricultural biogas (CHPs)
Elektrownia wodna	Water power plant
Biomasa	Biomass
Fotowoltaika	PV
Węgiel kamienny	Hard coal
Gaz	Gas
Elektrownia atomowa	Nuclear power plant

As for RES, the analyses showed that the lowest cost of generation of 1 MWh is possible thanks to biomass cogeneration - PLN 393/MWh. It is less than the costs of generation of an on-shore wind farm, estimated at PLN 466/MWh, and less than the costs of generation of a combined heat and power plant fired with agricultural biogas PLN 470/MWh. Generation costs of small water plants—PLN 484/MWh, and biomass plants—PLN 487/MWh, turned out to be higher than of on-shore wind farms and CHPs. The estimated cost of electricity generation for off-shore wind farms turned out to be high—PLN 713/MWh, and the costs for PV were the highest—PLN 1091/MWh, according to authors, mainly because of the low consumption time of the installed capacity, approx. 1000 hours a year. These results are close to the purchase prices for electricity from off-shore wind farms—EUR 190/MWh and PV panels—between EUR 220 and 287/MWh, adopted in Germany. Introduction of RES and construction of nuclear power plants entails huge expenditures, whereby nuclear power

[35] http://psew.pl/pl/publikacje/raporty?download=96:raport-eay-wplyw-energetyki-wiatrowej-na-wzrost-gospodarcz

allows to keep the prices paid by users at a level close to the price of electricity based on fossil fuels.

These assessments are confirmed by the substantiation to RES bill of 4.10.2012. RES energy prices provided there are shown in Figure 29 below, with nuclear energy prices defined in the study of Ernst and Young referred to above, added for the sake of comparison.

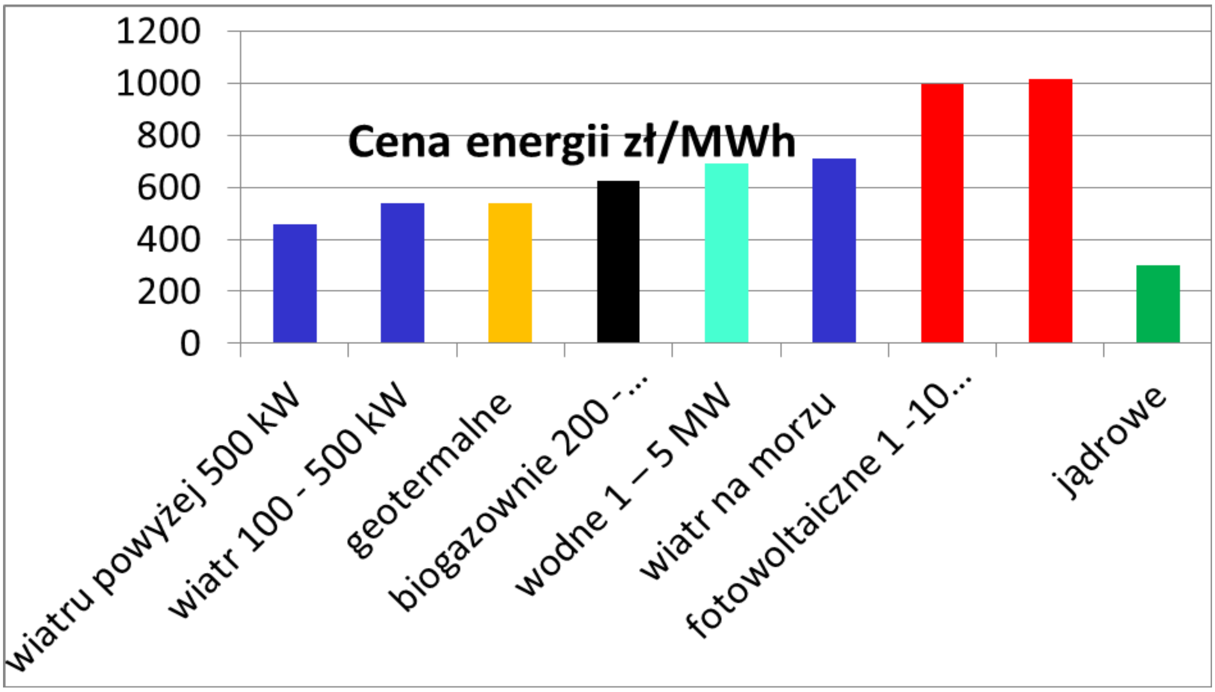


Figure 55. Renewable energy prices in Poland according to the RES bill of 4.10.2012.

Cena energii zł/ MWh:	Energy prices PLN / MWh:
wiatru powyżej 500kW	wind above 500kW
wiatr 100- 500 kW	wind 100- 500 kW
geotermalne	geothermal
bigazownie 200-..	biogas plants 200-..
wodne 1-5 MW	water 1-5 MW
wioatr na morzu	off-shore wind
fotowoltaiczne 1-10…	PV 1-10...
jądrowe	nuclear

It should also be noted that nuclear power is not only characterised by competitive electricity generation costs ("internal costs"), but also very low "external costs" (which are a measure of impact on the health of people and the environment). The European Union's study, External Energy Costs (ExternE), indicates that external electricity generation costs in nuclear power plants are among the lowest (Figure 56)[36] and comparable only with water and wind power.

[36] Externalities of Energy: Extension of accounting framework and Policy applications. Final Technical Report ExternE-Pol, Version 2, August 2005. ExternE – Externalities of Energy. A Research Project of the European Commission

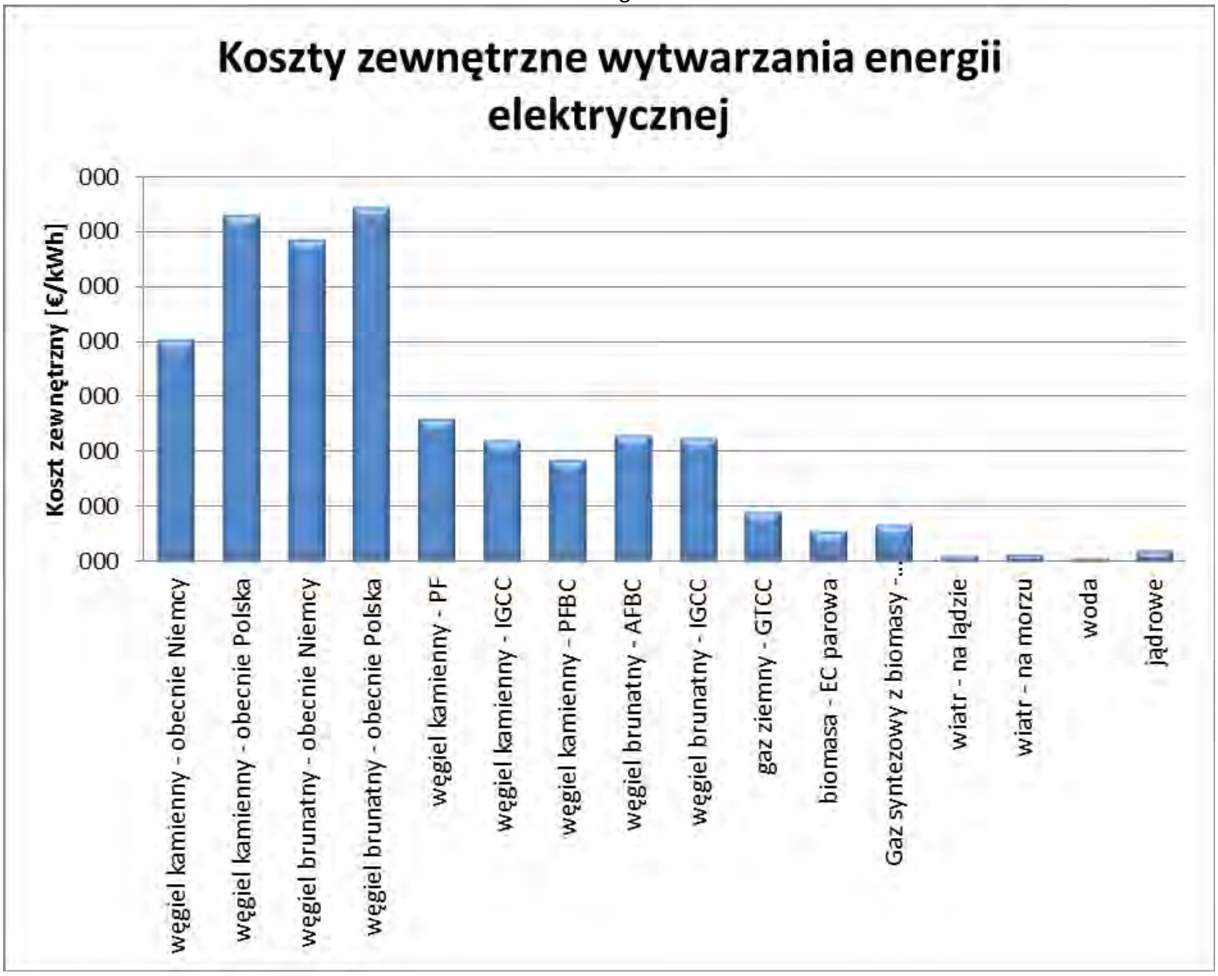


Figure 56. External electricity generation costs for different technologies [data source: ExternE-Pol].

Koszty zewnętrzene wytwarzania energii elektrycznej External electricity generation costs	
węgiel kamienny – obecnie Niemcy	hard coal—currently Germany
węgiel kamienny- obecnie Polska	hard coal—currently Poland
węgiel brunatny- obecnie Niemcy	lignite—currently Germany
węgiel brunatny- obecnie Polska	lignite—currently Poland
węgiel kamienny- PF	hard coal—PF
węgiel kamienny- IGCC	hard coal—IGCC
węgiel kamienny- PFBC	hard coal—PFBC
węgiel brunatny- AFBC	lignite—FBC
węgiel brunatny- IGCC	lignite—IGCC
gaz ziemny- GTCC	natural gas—GTCC
biomasa- EC parowa	biomass—steam CHP
gaz syntezowy z biomacy	synthetic gas from biomass
wiatr na lądzie	on-shore wind
wiatr na morzu	off-shore wind
woda	water
jądrowe	nuclear

The sum of planned surcharges to generation sources based on RES provided for in the RES bill until 2020 totals approximately PLN 74 billion, as it is shown on the diagram below. It should be highlighted that these are not the full costs of RES power, but only subsidies—payments incurred by Poland additionally for introduction of RES

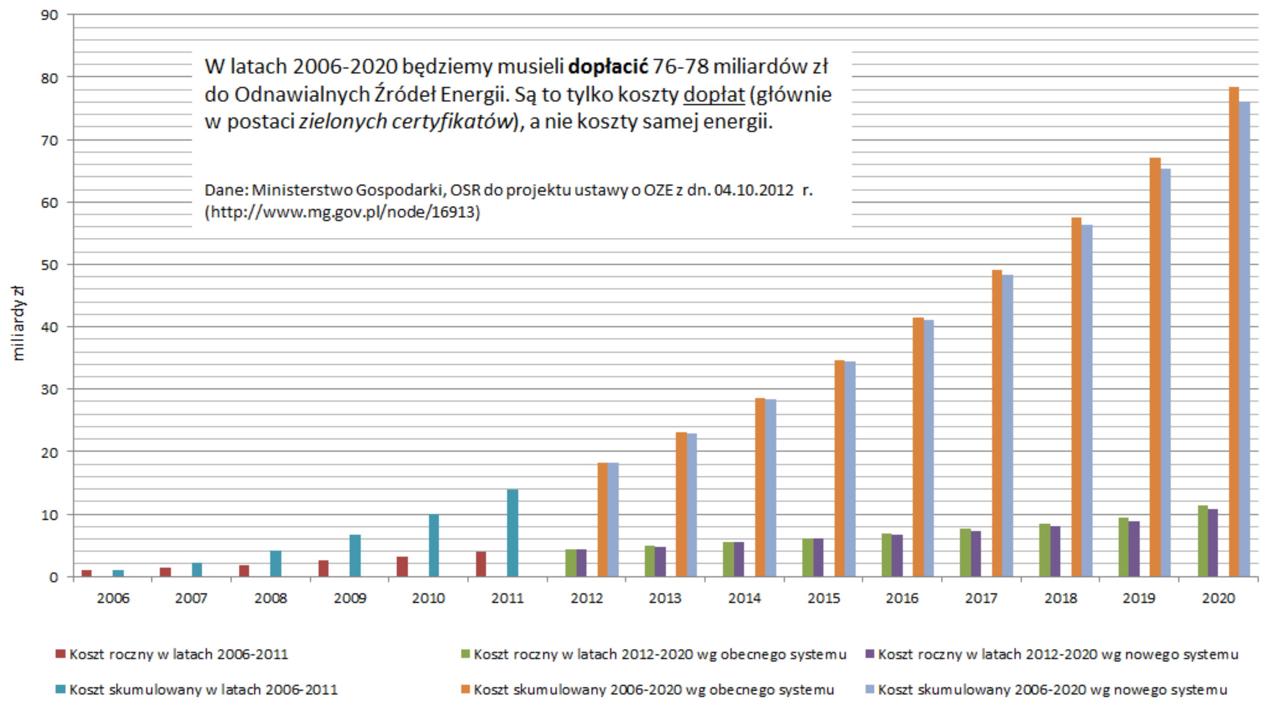


Figure 57. RES surcharges in 2006-2020 in line with the RES bill of 04.10.2012.

W latach 2006- 2020 będziemy musieli **dopłacić** 76- 78 miliardów zł do Odnawialnych Żródeł Energii. Są to tylko koszty dopłat (głównie w postaci *zielonych certyfikatów*), a nie koszty samej energii. Dane: Ministerstwo Gospodarki, OSR do projektu ustawy, OSR do projektu ustawy o OZE z dn. 04.10.2012 r. (http://www.mg.gov.pl/mode/16913)
In 2006-2020, we will have to pay, for Renewable Energy Sources, PLN 76-78 billion **in addition**. These are only the costs of surcharges (mainly in the form of *green certificates*), and not the costs of energy itself. Data: Ministry of Economy, RIA to the bill, RIA the RES bill of 04.10.2012 (http://www.mg.gov.pl/mode/16913)

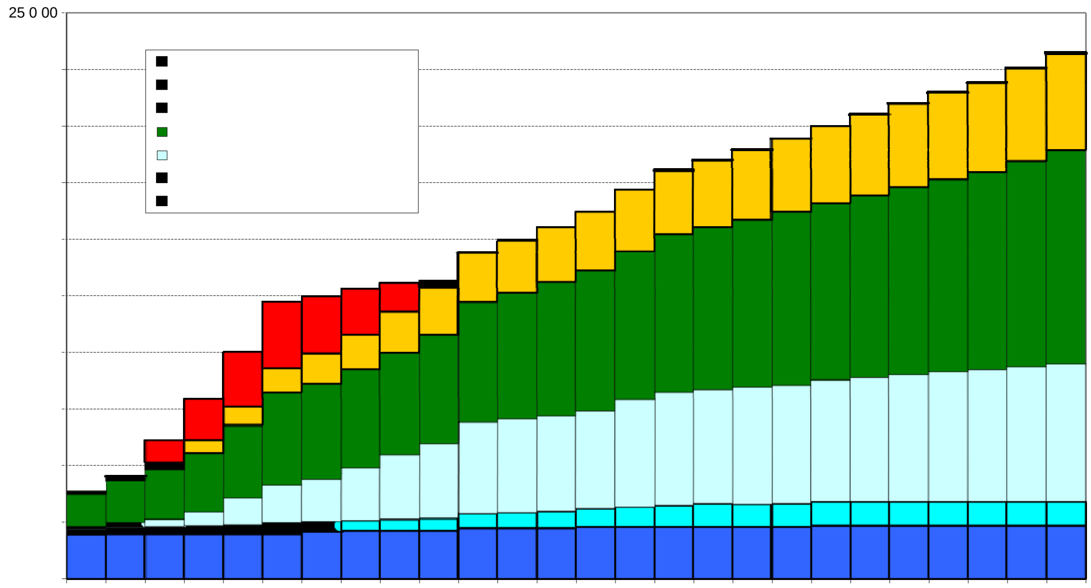
Miliardy zł	Billions of PLN

Koszt roczny w latach 2006-2011	Annual costs in 2006–2011
Koszt skumulowany w latach 2006-2011	Cumulated cost in 2006–2011
Koszt roczny w latach 2012-2020 wg obecnego stanu	Annual cost in 2012-2020 as per current state
Koszt skumulowany 2006-2020 wg obecnego systemu	Cumulated cost 2006-2020 as per current system
Koszt roczny w latach 2012-2020 wg nowego system	Annual cost in 2012-2020 as per new system
Koszt skumulowany 2006-2020 wg nowego systemu	Cumulated cost 2006-2020 as per new system

2.4.2.2. Limited economically viable RES

Another reason for Poland not to rely only on RES is lack of possibility to satisfy the growing national demand for electricity only from such sources, in the face of the necessary significant reduction of pollutants (including CO_2 emissions) by Polish energy industry based in approx. 92% on hard coal and lignite, and in the face of a shrinking fuel base of coal industry and growing costs of mining and (especially hard) coal prices.

As professional analyses indicate[37] [38] (Figure 58), economically viable RES resources (those which can be used at reasonable costs) for electricity generation until 2030 in Poland are limited to approx. 2030 TWh, while the total electricity generation potential of RES was estimated at approx. 44 TWh.



[37] Legal assessment and economic analysis of the viability of objectives stemming from the Strategy of Development for Renewable Power Industry and directive 2001/77/EC of the European Parliament and the Council of 27.09.2001 on the promotion of electricity produced from renewable energy sources in the internal electricity market. Krajowa Agencja Poszanowania Energii S.A., Warsaw, August 2007.

[38] Definition of the optimal scope and pace of development of nuclear industry in Poland until 2030—update based on the best knowledge as at 1 June 2007, Agencja Rynku Energii S.A., Warsaw, October 2007

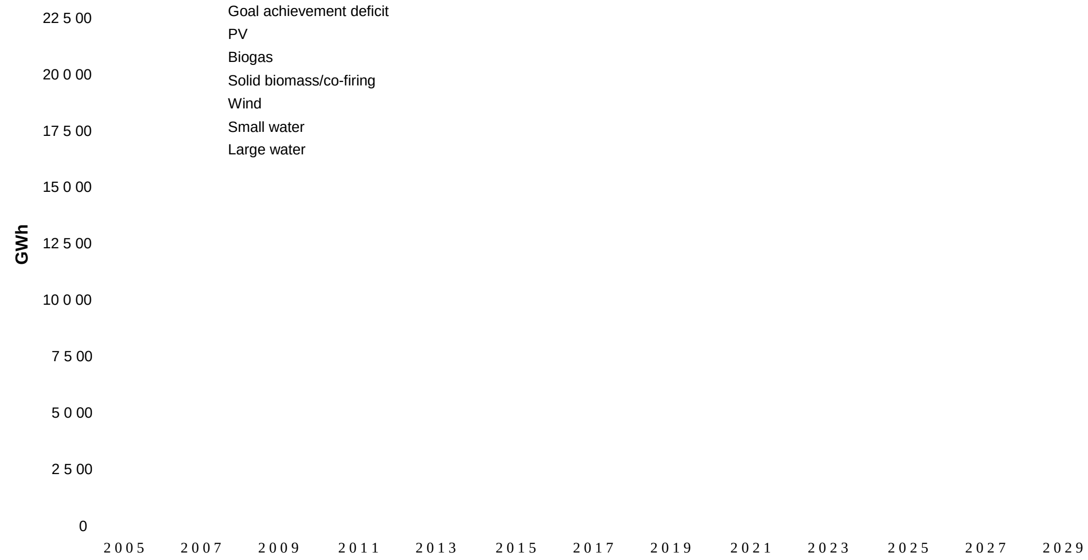


Figure 58. Electricity generation forecast for RES until 2003 [ARE S.A. 2007][39].

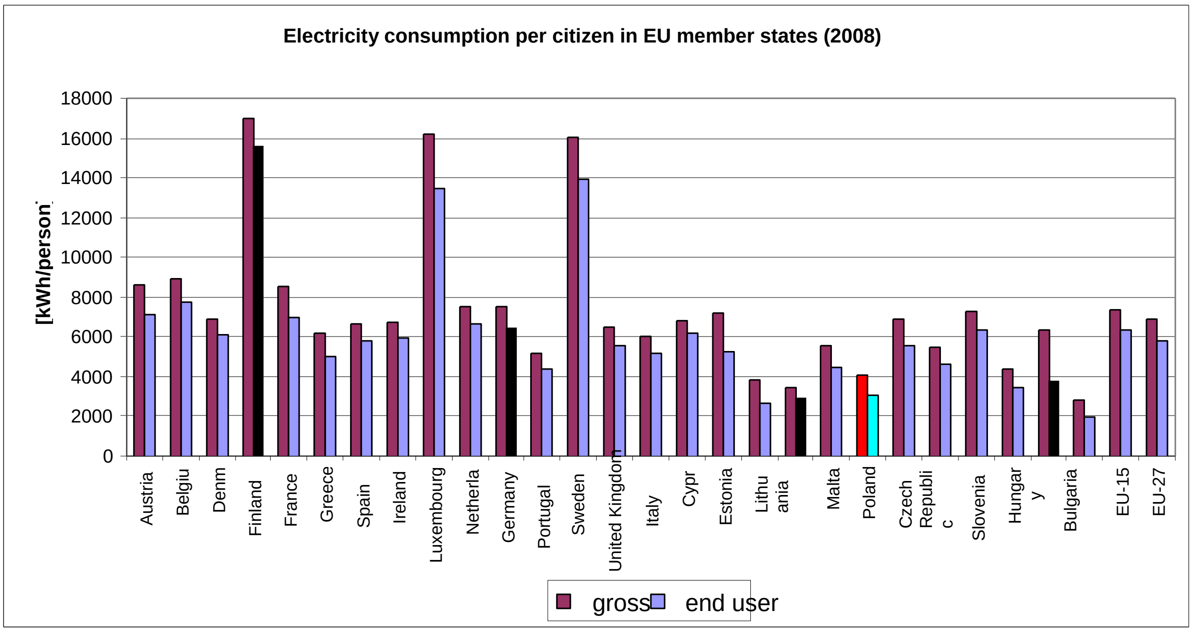


Figure 59. Comparison of electricity consumption per citizen in EU member states [based on Eurostat 2010 data][40] and GUS 2010[41]].

Present electricity consumption per Polish citizen is one of the lowest in the EU (it is approx. 2 times lower than the average for EU-15 (see Figure 59), while its prices—in relation to the purchasing power—are among the highest.

[39] Definition of the optimal scope and pace of development of nuclear industry in Poland until 2030—update based on the best knowledge as at 1 June 2007, Agencja Rynku Energii S.A., Warsaw, October 2007.

[40] Energy. Yearly statistics 2008. 2010 Edition. Eurostat. European Commission.

[41] Central Statistical Office: Statistical Pocketbook for Poland 2010. Warsaw, year LIII.

According to the most recent data[42] when compared to Germany, end user electricity consumption per citizen is 2.05 times lower in Poland (Germany—6,043 kWh/person, Poland—2,955 kWh/person). At the same time, the power-intensity of Polish GDP (in relation to the purchasing power—PPP) is close to the average for EU-15, so further economic growth of the country shall require a substantial growth of electricity supply—even when ambitious plans to improve the efficiency of electricity consumption (assumed in PEP 2030) are achieved.

The Polish Nuclear Power Programme (PNPP) is a necessary element of diversification of electricity generation sources—towards more sustainable generation portfolio, including also a significant share of RES, and an ambitious programme of necessary modernisation of the Polish power industry[43]. The optimum electricity generation portfolio has been defined (taking into account the resources comprising various carriers of primary energy and electricity generation costs for different technologies) by ARE S.A., with the use of professional integration planning tools for power system development. In accordance with the updated forecast demand for fuels and energy in 2030, the cost-optimal electricity generation portfolio forecast for 2030 provides for a share of RES at a level of 17%—the same as the share of nuclear energy.

As part of the modernisation programme for the electricity generation sector in Poland, worn power units of coal plants fired with hard coal or lignite which do not comply with the requirements in the scope of pollutants emissions, defined in EU directives, and are not suitable for modernisation, shall be decommissioned and gradually replaced with modern ones.

Together with the introduction of nuclear power and developing use of renewable energy sources (RES), it shall enable a significant reduction of emissions by Polish power industry (Figure 60 and Figure 61) and a stabilisation of prices of electricity after 2020. (Figure 62).

[42] Energy, transport and environment indicators. 2011 Edition. Eurostat. European Commission

[43] Until 2030, coal power units with capacity of more than 14,000 MW will be decommissioned, and units with capacity above 4200 MW will be thoroughly modernised. In addition to launching nuclear power plant with capacity of 6000 MW, old coal power units need to be replaced with an advanced, highly efficient units equipped with flue gas cleaning installations compliant with the requirements of EU directives.

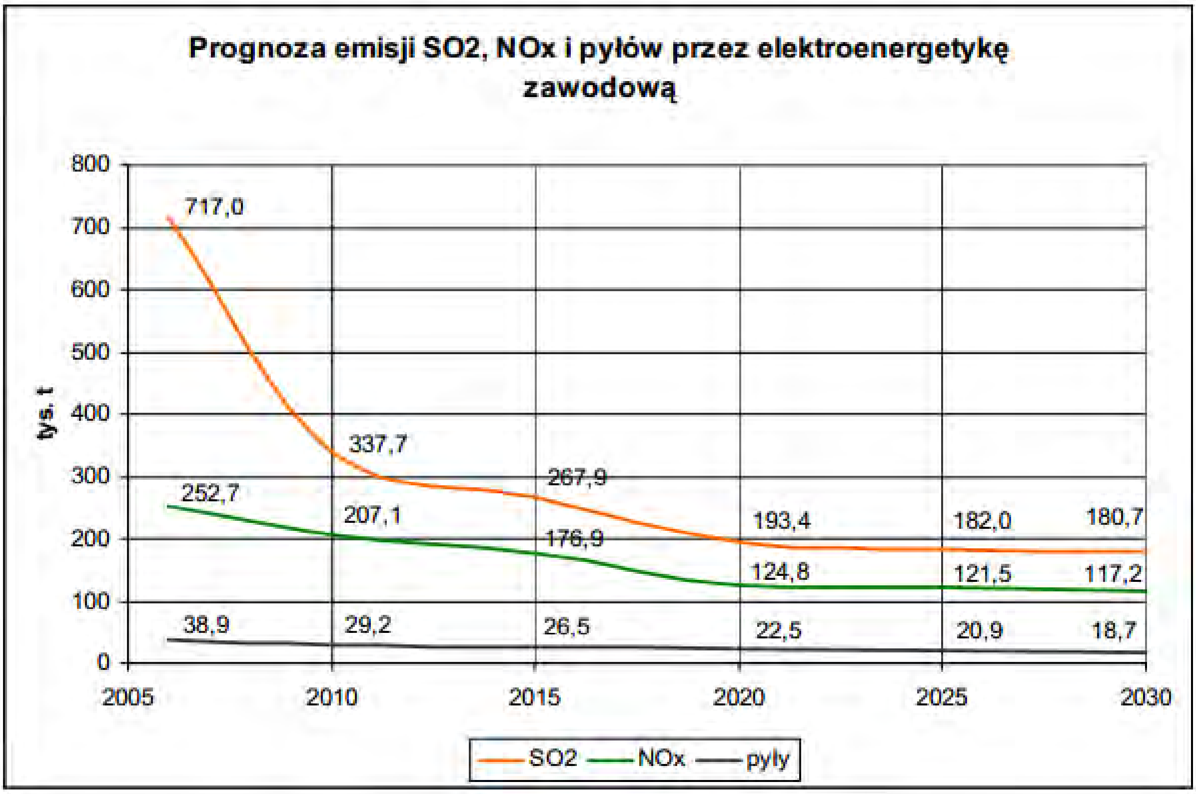
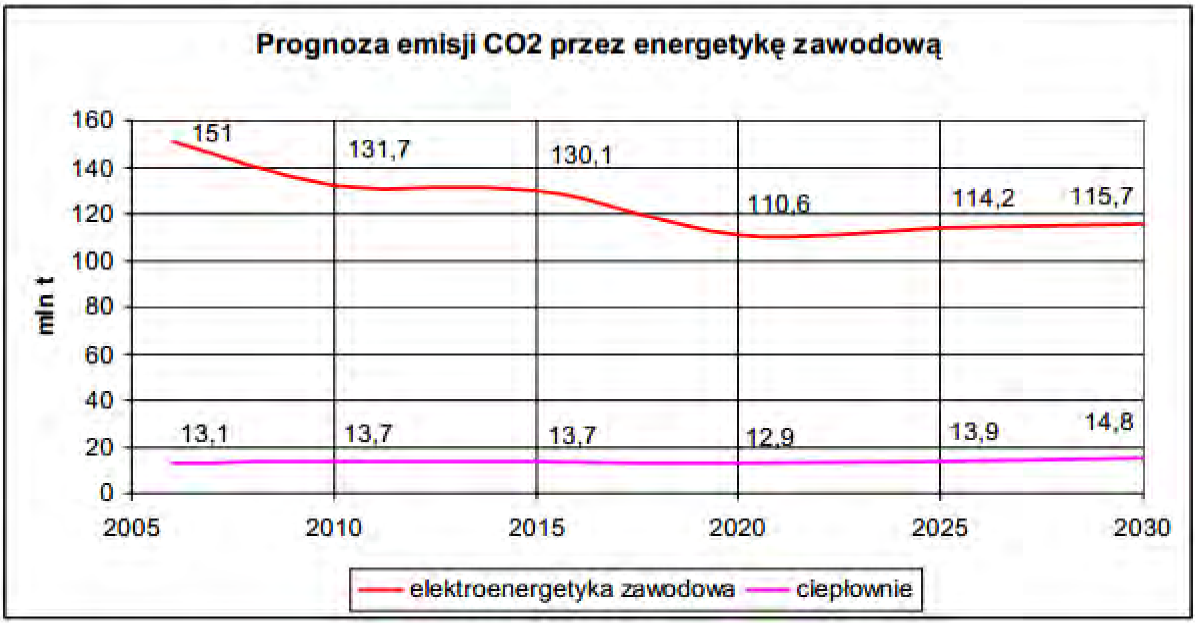


Figure 60. Forecast emissions of SO_2, NOx, and dust by the Polish professional power industry until 2030 [data source: PEP 2030, Appendix 2[44]].

Prognoza emisji SO@, NOx I pyłów przez elektroenergetykę zawodową	
Forecast emissions of SO@, NOx, and dust by professional power industry	
tys. t	thousands of tons
SO2	SO2
NOx	NOx
pyły	dust



[44]Ministry of Economy: Forecast demand for fuels and electric energy until 2030. Appendix no. 2 to the "Energy Policy of Poland until 2030" project. 15-03-2009.

Figure 61. Forecast emissions of CO_2 by the Polish professional power industry until 2030 [data source: PEP 2030, Appendix 2].

Prognoza emisji CO@ przez energetykę zawodową	
Forecast CO2 emissions by the professional power industry	
elektroenergetyka zawodowa	professional power industry
ciepłownie	heat plants

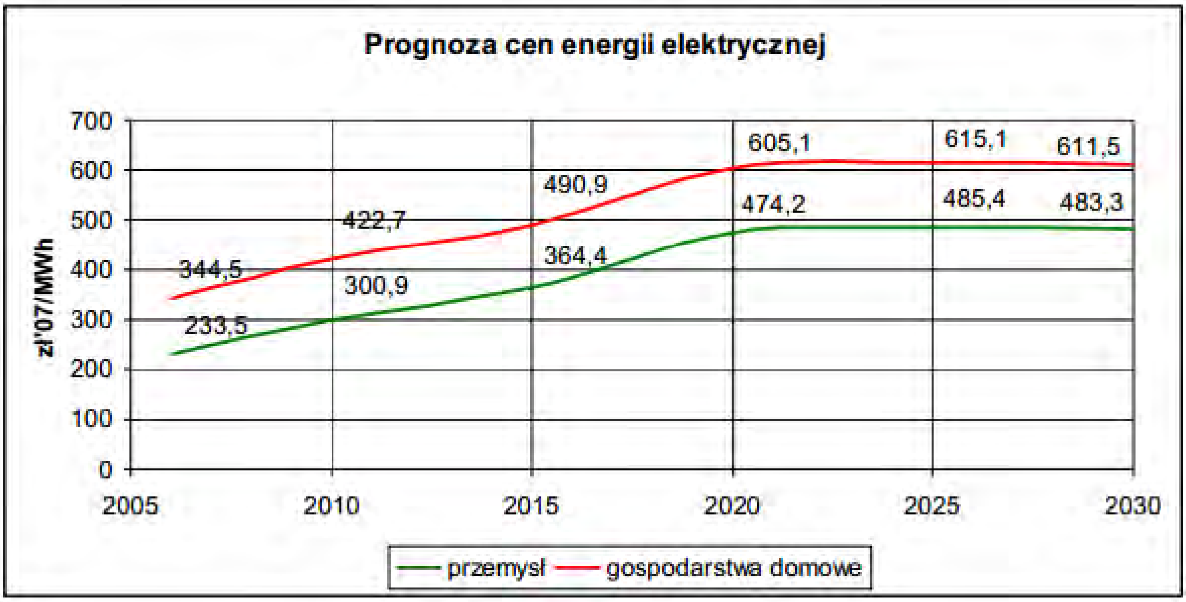


Figure 62. Forecast of changes in electricity prices until 2030 [data sources: PEP 2030, Appendix 2].

Prognoza cen energii elektrycznej	
Forecast of electricity prices	
przemysł	industry
gospodarstwa domowe	households

2.4.2.3. Technical limits and high costs of compensation of volatility and unpredictability of generation for wind and PV sources

The third important constraint of the RES development in Poland, when compared to Germany, is current lack of technical possibilities of compensation for volatility of wind strength and sunlight intensity, and high costs of ensuring a quick emergency reserve in the event of a generation decrease in wind or solar farms, with a capacity of thousands of MW.

The Germans have access to a powerful power bridge with throughput of 5 GW, connecting the country with Scandinavian countries. The connection with Scandinavia is particularly important for the wind industry, as hydroelectric plants are best suitable to compensate the volatility of wind turbines. Start-up of plants fired with fossil fuels is too slow to cover the power deficit caused by a drop in wind speed.

Norway produces its power almost entirely with hydroelectric plants, and Sweden with water and nuclear plants. The total electricity generation of hydroelectric plants alone in these countries totals 178 TWh, and of nuclear plants i Sweden—60 TWh. These countries are able to absorb a temporary surplus energy from wind farms, reducing the capacity of hydroelectric plants or pumping water to upper tanks to recover energy when needed.

While in Poland, the total power generated in natural-flow hydroelectric plants is approx. 1.8 TWh, one hundredth of Scandinavian capacity. At the same time, we dispose of only a couple of water plants suitable for load regulation. These are pumped-storage power plants (Żarnowiec, Porąbka-Żar, Żydowo) and power plants with pumped-storage unit (Solina, Dychów and Niedzica) with aggregate maximum capacity of 1754 MW. Therefore, to compensate the volatility of wind power in Poland, spinning reserve in conventional, mostly coal, plants, is needed. A thermal plant operating with partial capacity consumes additional fuel, emits additional amounts of CO_2 and increases general costs of the system. Such a solution may be applied to a small portion of capacity in the system, but it should not compensate fluctuations in energy supplies from periodic sources, if the latter comprise a large part of capacity. In Polish conditions, the only possibility to ensure an intervention reserve of capacity in amount necessary to compensate changes of power from RES, with a capacity of many thousands of MW, is to build open-cycle gas plants whose electricity generation costs are very high (because of a high cost of fuel and short time of usage of the installed capacity). The costs of creation of capacity reserves from wind farms have been estimated by the Polish Engineering, Procurement and Construction Office Energoprojekt Katowice at PLN 43/MWh[45], while by the British Royal Academy of Engineering—at 1.58-1.67 pence/KWh[46] (which according to the exchange rate of 10.06.2013 gives PLN 79.0-83.5/MWh—nearly twice more than estimated by Energoprojekt Katowice).

Hence, the solution based on sources using RES as the main element in the electricity generation portfolio would be too costly for Poland. At the same time it should be highlighted that Poland is introducing renewable energy and shall continue to do so, whereby the share of RES amounting to 15% of electricity generation in 2020 is the maximal level to be reasonably justified. The rest of demand for electricity must be ensured by systemic plants based on fossil fuels (mainly hard coal and lignite) or on nuclear fuel.

2.4.3. Discussion of the argument on the conflict between the systemic and scattered power industry and not accounting for the alternative technologies of electricity generation.

There is no conflict between the systemic ("centralised") and scattered power industry. Both should be developed, and at the same time transmission and distribution grids should be developed and modernised. It is necessary, because there is a need to connect new sources, as well as—first and foremost—it will result in the improvement of security, reliability and supply of the recipients, including in particular large municipal agglomerations and large industrial recipients. The scattered power industry has indisputable advantages, as it contributes to reducing the transmission losses and improving the supply reliability for the recipients. However, it cannot replace the large-scale systemic power industry, and—in addition—electricity generation costs for RES (connected to the distribution grids) are significantly higher than the electricity generation costs for large systemic sources, hence their development requires lots of subsidies on the part of energy recipients. This position is supported by Polish scientists dealing with issues related to the power system and energy market in Poland. Below you can find a quote from the paper by Józef Pasek, Mariusz Sałek (Warsaw University of Technology) entitled: "Scattered power and heat generation technologies". 13th Conf. REE'2007: „One should also be aware that development of scattered generation may not be seen as a significant competition for large power plants, which shall constitute basic energy sources. The future of scattered generation lays in making use of specific niches in the power market, such as e.g. covering

[45] The analysis of economical viability conditions for PSE/PGE, concerning the participation in the construction of a new nuclear plant in Ignalin and Poland-Lithuania power link. BSPiR „Energoprojekt-Katowice" S.A., August 2007.
[46] The Costs of Generating Electricity. The Royal Academy of Engineering, March 2004

peak loads by gas turbines, or ensuring a reserve that guarantees uninterruptible supply".

It is necessary to bear in mind here, that large wind farms with capacities exceeding 100 MW, and even (in the case of off-shore wind farms) 1000 MW, may not be included into scattered power industry. The costs of necessary extension of the grids to connect these wind farms are very high and in Poland, they are transferred directly to the electricity recipients in the form of charges for transmission and distribution. One of Polish distribution grid operators, ENEA Operator, has informed that it is planning to expend 700 million PLN until mid-2013 to connect 1000 MW of wind farms[47] (which means that connection of 1 MW of wind farms to the distribution grid costs 700 thousand PLN at average, and one should remember that these costs do not include the costs on the part of the transmission system operator.[48] Another distribution grid operator in the northern Poland, ENERGA Operator, estimates the costs of connection of wind farms to be even higher. According to the estimates of Polish experts, connection costs for wind farms per one km of grid shall quickly grow and shall reach 300 thousand PLN/km in 2015, and in 2030—500 thousand PLN/km.

The argument that the development focused on renewable energy entails development of rural areas and creation of new work places is only part of the truth. Subsidising of development of any branch of industry results in creation of work places in the field being subsidised. But the problem is whether it is the optimal use of available funds—wouldn't it be better to create more work places in another field with that money? Besides, there is also a question whether subsidising of a selected field will not result in atrophy of other branches of industry, resulting in reductions in work places. Actually, high subsidies for RES cause electricity prices to grow or—in the case of state subsidies—they result in a burden on the budget.

It is not true that technologies which are alternative to nuclear power were not taken into account when planning electricity generation sources (in PEP 2030, and not in PNPP). The optimal electricity generation portfolio (baseline scenario) includes all RES technologies, whose share in 2030 is to reach 17%, and high-efficiency co-generation as well (see: item 2.3.1.1.3).

2.4.4. Discussion of the argument that the necessity of modernisation of Polish power industry is an opportunity to employ state-of-the-art technologies, with co-generation particularly taken into account

Despite modernisation works conducted after 1990, the generation assets of Polish power industry are mostly obsolete. The age structure of main generation installations is shown on the diagram below.

Figure 63. As it can be seen on the diagram, approx. 77% of generation installations are more than 20 years old, of which 44.5-47.5% are more than 30 years old. To modern or relatively modern, remaining in good technical condition, the following installations may be included: Bełchatów power plant (12 units) and Opole power plant (4 units), 6 thoroughly modernised units of Turów plant, and new units of Bełchatów II, Pątnów II and Łagisza II.

[47] http://m.onet.pl/bizes/4974112,detal.html

[48] The costs of necessary grid investments and balancing and regulation services related with the volatility and unpredictability of generation with the use of wind farms.

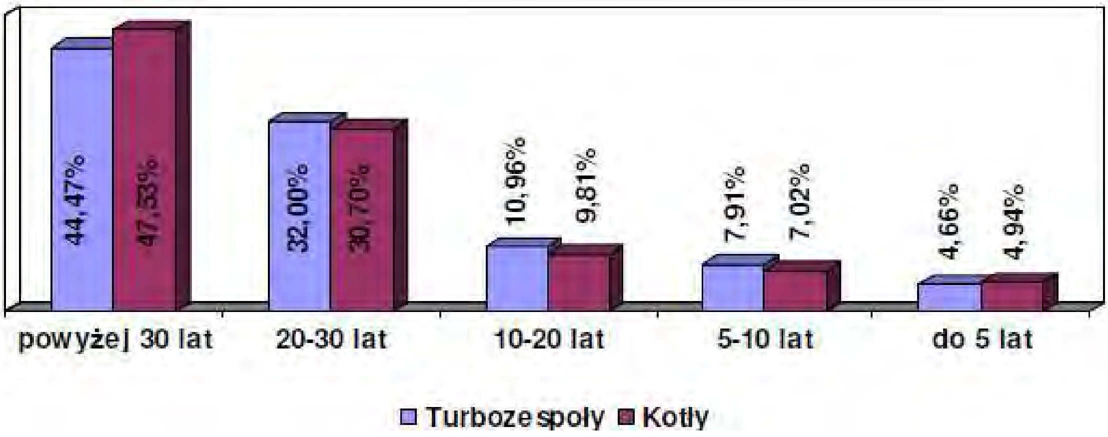


Figure 63. Age structure of generation units in Poland [sources: URE, ME i MT[49]].

Powyżej 30 lat	**More than 30 years**
20-30 lat	**20-30 years**
10-20 lat	**10-20 years**
5-10 lat	**5-10 years**
Do 5 lat	**Up to 5 years**
Turboze społy	**Turbounits**
Kotły	**Boilers**

The consequence of overexploitation and bad technical condition of power plants are unplanned power shortages caused by breakdowns of generation units. Because of technical decapitalisation and emission standards tightened by the EU, the oldest units, not suitable for modernisation, will be successively decommissioned.

In accordance with the government programme (PEP 2030[50]), the total generation capacity of 14,355 MW shall be decommissioned until 2030, of which 7023 MW until 2020 and 7332 in the years 2021-2030. In addition, 4,204 MW of installations shall be "thoroughly modernised". Nevertheless—in the face of emission standards tightened by the EU—it is possible that it will be necessary to decommission larger number of units until 2030. old power units need to be replaced with an advanced, highly efficient units equipped with flue gas cleaning installations compliant with the requirements of EU directives.

As part of the modernisation programme for the electricity generation sector in Poland, the worn power units of coal plants fired with hard coal or lignite which do not comply with the requirements in the scope of pollutants emissions and are not suitable for modernisation, shall be decommissioned and replaced with modern, highly-efficient ones (for supercritical parameters), equipped with relevant installations reducing emissions of air pollutants. Apart from nuclear units, generation sources based or RES shall be built, and also highly-efficient co-generation units (CHP).

2.4.5. Discussion of the objection relating to inflexibility of nuclear power plants

[49]Ministry of Economy, Ministry of Treasury. Government release on the current state and perspectives of Polish power industry. Warsaw, Decemeber 2010.

[50]The Ministry of Economy Forecast demand for fuels and electric energy until 2030. Appendix no. 2 to "Energy Policy of Poland until 2030". Warsaw, 10 November 2009.

In relation to the capacity regulation possibilities to be ensured in the power system, it should be indicated that modern nuclear power plants (NPPs) are able to operate in a track mode—i.e. to regulate capacity depending on changing load of the power system (so-called load-following), just as modern conventional thermal plants. It is worth emphasising that it is a solution practically used, as French and German nuclear power plants have been participating in regulation of daily load for many years (see figures below).

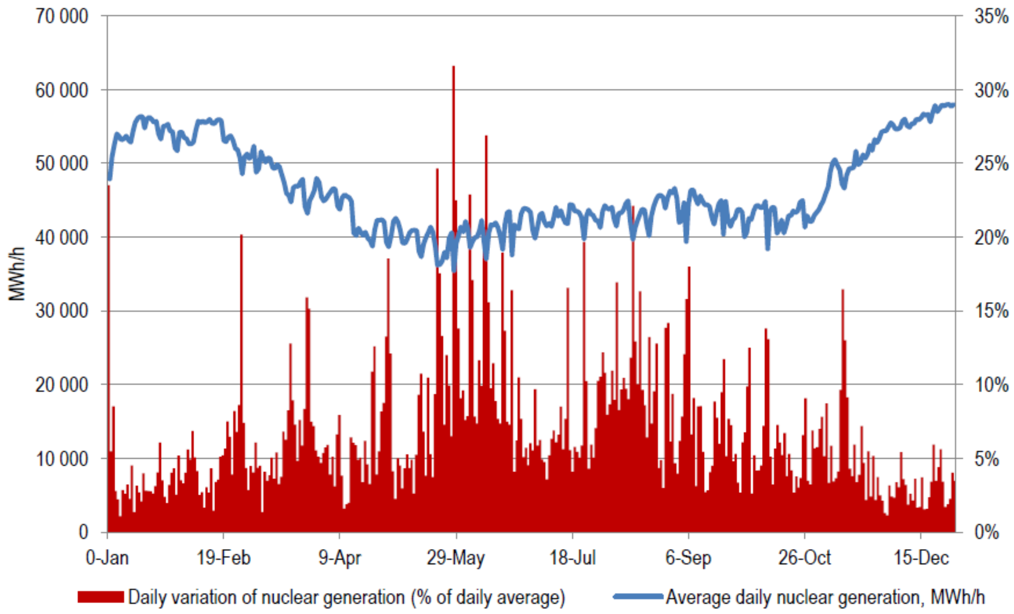


Figure 64. Changes in daily generation in French nuclear plants in 2010[51]

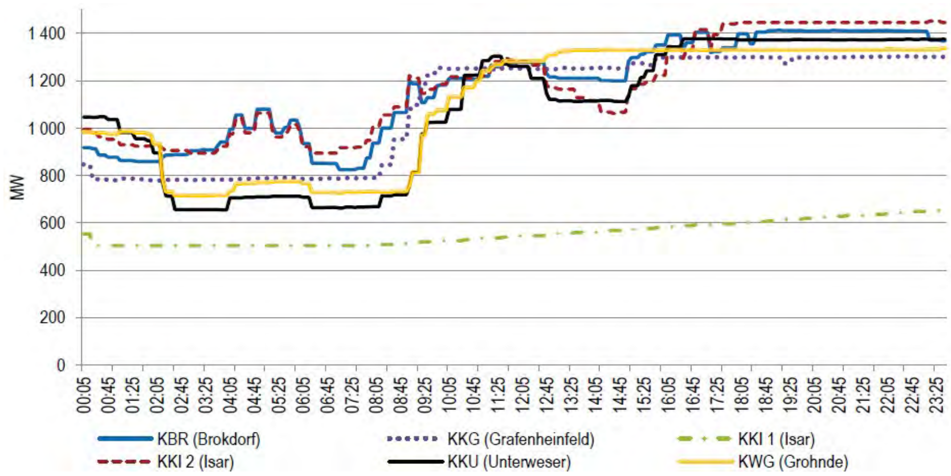


Figure 65. Selected capacity changes of certain German nuclear plants (with PWRs and BWRs)[52]

In the "EUR" document, defining the requirements of European power enterprises, there is a requirement that [53]a nuclear unit must be suitable for continuous operation with a variable load between 50% and 100% of the nominal capacity. Operation with a lower load is also allowed (depending on engineering solutions)—typically down to 20% of the nominal capacity. 3rd generation nuclear units that were granted a certificate of compliance with EUR requirements are beyond doubt

[51] Ibidem.
[52] Ibidem.
[53] European Utility Requirements for LWR Power Plants, Rev. D. October 2012, sec. 2.3.2.1.1.

suitable for continuous operation with variable load. It is reasonable to use nuclear power plants to regulate capacity (not only in daily (load following), but also quick regulation—(load-frequency control)) in the power system, and with a significant share of such sources in the system—it is necessary.

In Poland until 2030, the capacity share of nuclear power plants in the system shall reach a level of approx. 15%; with such a share, it will be not necessary to use them for daily load regulation. However it is possible, if a need arise. Thus, operation of a NPP in quasi-stationary modes does not need any ancillary services.

2.4.6. Discussion of the German example—abandonment of nuclear energy

After the breakdown of Fukushima, German government decided to abandon the nuclear power and switch the German economy to "green energy". It is a courageous decision and entails very high costs. While the energy supplied from the systemic (coal and nuclear) plants costs approx. EUR 68/MWh, this price for on-shore wind farms is approx. 50% higher—EUR 102/MWh, for off-shore wind farms—EUR 190/MWh, and for PV energy—between EUR 127 and 184/MWh[54] [55]. According to recent estimates prepared by independent consulting companies, including the renowned McKinsey, the costs of subsidising generation sources using RES in 2012 shall exceed EUR 14 billion, and until 2020 they will reach EUR 20 billion annually. All in all, between 2011 and 2020, Germany will have to pay EUR 175 billion in subsidies for RES[56], which means that the energy price paid by private recipients, already twice as high as in France, shall increase in 2011 from 25.9 cents/kWh to 29 cents/kWh in 2020.

The growth of energy prices shall affect also industry. Prices of electricity for industry in German are the highest in the European Union. Further growth of prices, connected with the increased share of "green energy" in the power grid can induce industrial entrepreneurs to move their factories to other countries, especially in the most energy-intensive branches. A large-scale introduction of "green energy" is therefore an enormous burden for the economy, which, at the current level of Polish economy, may constitute too heavy a burden for Poland. Moreover, a large-scale utilisation of renewable power shall not allow to ensure reliable power supplies to all recipients. This year, Germany earmarked 200 billion EUR for research on energy storage, but unfortunately, real perspectives to solve this problem are lacking today[57]Energy storage with the purpose of ensuring continuous power supplies is particularly important in the context of more and more frequent and prolonging periods in which, due to unfavourable weather conditions, wind farms and PV plants generate only 5-10% of peak capacity. At present, in periods of lower RES generation possibilities—given a markedly lower share of renewable energy than planned in the future—Germany, in order to make up for energy shortages, rely on supplies from the Scandinavian grid, using high-capacity power transmission links between Scandinavia and Germany. When the goal of increasing the share of RES in energy generation to 50% is finally achieved, the existing solutions securing energy supplies in the periods of lower production from renewable sources shall be insufficient, which will cause a significant increase of energy prices to ensure capacity reserves and can pose a threat of difficulties in power supply to industry.

---

[54] Bundesrat Clears Reduced German Solar Feed-in Tariffs http://www.germanenergyblog.de/?p=9756

[55] http://oilprice.com/Alternative-Energy/Renewable-Energy/Germanys-Rising-Cost-of-Going-Green.html

[56]http://thegwpf.org/international-news/5613-175-billion-bombshell-germanys-green-energy-policy-to-hit-households-hard.html

[57] http://energetyka.wnp.pl/niemcy-akumulatory-nie-pomoga-oze-potrzebny-inny-patent,176720_1_0_0.html

Poland does not have such possibilities of foreign power exchange as Germany, hence it is only possible to introduce the 15% share of RES energy until 2020 as part of assumed obligations to EU.

Nuclear energy in Poland is needed to maintain stability and reliability of power supplies. Without such substantial funds and links with Scandinavian hydroelectric plants as Germany, Poland cannot follow Germany and switch to "green energy" as the main power source.

2.4.7. DISCUSSION OF THE RESULTS OF RESEARCH CONDUCTED IN GERMANY

German results and experiences confirm that RES power is costly and unpredictable. According to DENA report, p. 40, in 2009, biomass-fired plants worked for 5800 hours with full capacity, hydroelectric plants—for 4000 hours, and geothermal plants—for 3000 hours. In the case of solar and wind energy, electricity generation depends on weather and location of the installation particularly strongly. In 2009, on-shore turbines reached in Germany only 1500 hours, and PV panels—700 hours of full capacity operation. These weather-dependent renewable sources are highly volatile (see figure below).

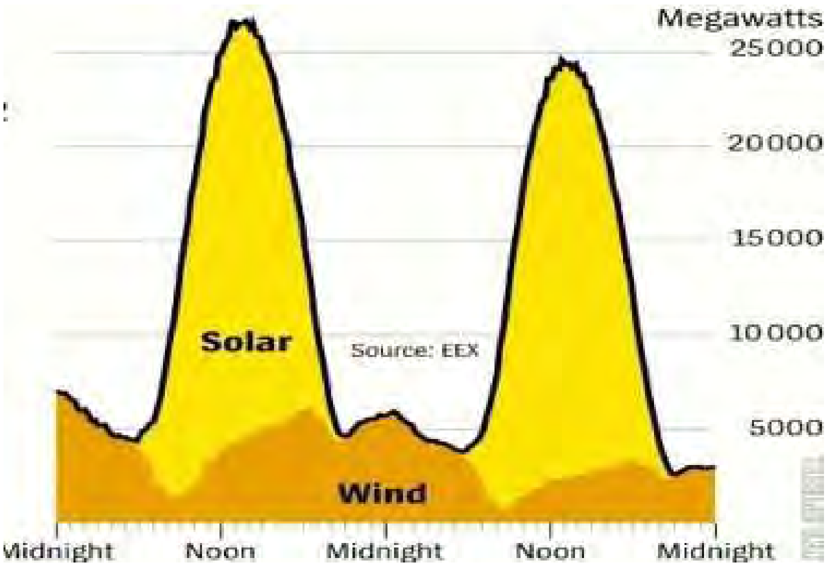


Figure 66. Typical changes of electricity generation in optimal weather conditions - 23-24 May 2012[58]

Renewable energy sources in Germany in 2010 generated 101.7 TWh in total, which constitutes 16.7% of gross electricity consumption. The largest contribution was that of wind farms—36.5 TWh, which corresponds to 35.8%, and biomass—28.7 THw, which is 28.2%. PV panels generated 12 TWh, which constituted 11.8% of energy from RES and approx. 2% of total power demand in Germany.

DENA Report[59] indicates that electricity costs per unit without nuclear plants in Germany shall grow and from EUR 50/MWh in 2011, they will reach EUR 170/MWh in 2050. In the scenario adopted by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMU), from 2009, the absolute amount of electricity generation costs for renewable sources shall grow from the present 12.5 billion EUR yearly to 36.5 billion EUR in 2050.

[58]Der Spiegel, http://www.spiegel.de/international/germany/instability-in-power-grid-comes-at-high-cost-for-german-industry-a-850419.html

[59] Gemäß dem zugrunde gelegten EE-Ausbauszenario (BMU-Leitszenario 2009) steigt die absolute Summe der Stromgestehungskosten zwischen 2010 und 2050 um 22 Mrd. Euro/Jahr (+176 Prozent) von 12,5 auf 36,5 Mrd. Eurpo/Jahr

DENA Report points out the necessity to thoroughly restructure the energy market and states that with its present shape, RES will not be a viable alternative even in 2050. From a power exporter, Germany shall change into an importer, and shall obtain approx. 20% of its energy from imports. Due to the instability of energy supplies from RES, Germany will have to create a reliable reserve of power sources on which to rely. Therefore, despite the planned extension of RES to 170 GW (with the assumption that the current power demand will be maintained), Germany will need conventional plants fired with coal and gas, offering total capacity of 61 GW. These plants shall constitute approx. 60% of the reliable reserve able to satisfy the power demand in Germany at any time.[60].

The present volume of electricity generation from RES is 108 TWh, given the total German generation of 600 TWh.

A restructuring of power industry means construction of new plants based on organic fuels, extension of grids, power storage systems, greater flexibility of supplies and take-up, and energy savings wherever possible. To ensure that minimal needs are satisfied, the capacity of the conventional plants must remain in 2030 at the level of 83 GW, and 61 GW in 2050. Although 80% of electricity in 2050 will be supplied by RES, they will produce only 24% of the guaranteed capacity, and the storage systems shall supply approx. 9% of the guaranteed capacity. In accordance with the model adopted by DENA, new conventional plants providing capacity of 49,000 MW shall be needed[61]. They are to be built up till 2030, and mostly until 2020.

In 2050, due to the irregular and unpredictable nature of RES operation, approx. 66 TWh generated by RES will not be suitable for use in Germany and abroad[62].
Despite temporary surpluses in electricity generation, Germany shall become a net power importer and in 2050, it will need to import 134 TWh, approx. 22% of the domestic consumption. To transmit power from renewable sources over long distances, it will be necessary to extend the transmission grid, additionally to the existing, integrated European grid.

In this scenario, the electricity price in 2050 shall be significantly higher than it is now. It will be a consequence of grid extension, reserve and balancing sources introduced, connection of off-shore wind farms and measures ensuring supply flexibility, such as power storage systems.

Summing up—the model proposed by Germany is very expensive and needs support of countries with large power storage possibilities. Poland cannot afford such an increase in energy prices—also, we do not have any significant exchange possibilities.

2.4.8. Discussion of the argument that abandonment of nuclear power should result from the European energy policy

Present, electricity consumption per Polish citizen (2,955 kWh/person—end user consumption[63]) is one of the lowest in the EU, it is approx. 2 times lower than the average for EU-15 (see diagram in Figure 59, item 2.4.2.2). For example, annual consumption per person in Austria is 6,927 kWh, and in Germany - 6,043 kWh/person. At the same time, the power-intensity of Polish GDP (in relation to the

---

[60] http://www.dena.de/index.php?id=5625&L=1&no_cache=1
[61] http://www.cire.pl/item,65149,1.html?utm_source=newsletter&utm_campaign=newsletter&utm_ medium=link
[62] "Integration of Renewable Energy Sources into the German-European Electricity Market" DENA in co-operation with the Institute of Power Systems and Power Economics at RWTH Aachen University www.dena.de/studien

[63] Energy, transport and environment indicators. 2011 Edition. Eurostat. European Commission.

purchasing power—PPP) is close to the average for EU-15. Therefore, even assuming that the very ambitious goals in terms of energy consumption efficiency adopted in PEP 2030 (significantly exceeding the targets set by EU) will be achieved, further economic growth of our country requires increasing the supply of electricity (see: updated forecast demand for end user electricity in item 2.3.1.1.2).

The European climate policy is aimed at reduction of CO_2 and maintaining the reduced emissions in a stable way, in conditions of sustainable economic development. With no doubt this goal will be achieved by construction of low-emission energy sources whose CO_2 emissions are small enough to be included to the lowest emissions in power industry, while at the same time their operation time is very long. Nuclear power plants may be included to such sources. It was demonstrated in detail in item 2.5—with the full life cycle of a nuclear power plant examined (along with all deliveries of equipment, fuel, and energy for auxiliary purposes), and its decommissioning and disposal of waste.

Due to low emissions of nuclear power plants, the European Parliament (in the resolution of November 2007), and also the Intergovernmental Panel on Climate Change, the World Energy Council, and other organisations confirmed the important role played by nuclear power in reduction of CO_2 emissions in the contemporary world.

Therefore, implementing the nuclear power, Poland absolutely contributes to the reduction of CO_2 emissions.

2.4.9. Analyses of technological alternatives for Polish nuclear power plants

Referring to the alternatives related with possible technological solutions, it should be stressed that part of the analysis of the alternatives was examined in various sections of the Forecast. For example, the design of individual reactor types (EPR, AP1000, ABWR, ESBWR) along with discussion of security systems, was presented in detail in section 6.4 to enable the analysis of alternatives as part of the whole document. For each of impact factors, factors for individual reactor types have been discussed, if variable depending on the reactor type. In particular, the reactor design determines the amount of radioactive emissions to the environment. The amounts of radioactive emissions under standard operation conditions of power units with various types of reactors installed (EPR, AP1000, ESBWR) are presented in sections 7.3.1 - 7.3.3, and the comparison is made in section 7.3.4 of the SEA Forecast. Analogically, for transient states and emergency conditions, possible emissions were analysed in the case of design basis accidents for the three reactor types in section 7.4.1– 7.4.3, and summarised in section 7.4.4 of the SEA Forecast. Similarly, the amounts of possible emissions were analysed for severe accidents related to the said reactors in sections 7.5.1– 7.5.3 and summarised in section 7.5.4 of the SEA Forecast. Impacts connected with the emissions amounts discussed above, based on estimated doses of radiation for the exposed population were also subject to a detailed analysis for individual reactor types:

- for standard NPP operation—comparison of impacts of the reactors in section 7.3.4;
- in transient and emergency states—comparison of impacts of the reactors in section 7.4.4;
- for severe accidents—comparison of impacts of the reactors in section 7.5.4.

- Individual reactor types were also analysed in terms of their energy parameters (Tab. 8.3.5), cooling water consumption (Tab. 8.3.6, Tab. 8.3.7, Tab. 8.3.8) and land occupation area.

As part of the analysis of alternatives, also different cooling systems were analysed, which can be alternatively applied for a NPP (installation description in section 8.3.2.1): open cooling systems (without cooling tower) and closed cooling systems (with wet or hybrid cooling towers). These installations are characterised by different environmental impact in terms of demand for cooling water (section 8.3.2.2), waste heat discharge to water or atmosphere (section 8.3.2.5/8.3.2.6), emission of chemical substances to water or atmosphere (section 8.3.3/ 8.3.4), noise (section 8.3.5) and landscape impact (section 8.3.8.

2.5 THE DECREASING IMPACT OF NUCLEAR POWER PLANTS ON THE USAGE OF FOSSIL FUELS AND CO_2 EMISSIONS

2.5.1. Discussion of arguments on the lack of NPP reducing influence on the usage of fossil fuels and on the economic inefficiency of CO_2 emission reduction by NPP.

Nuclear power in Poland shall partially replace power generated in plants fired with hard coal or lignite (at least until 2030), and—along with power generated in gas plants and with the use of renewable energy sources (RES) it shall satisfy also the growth of energy demand in Poland (see figure below).

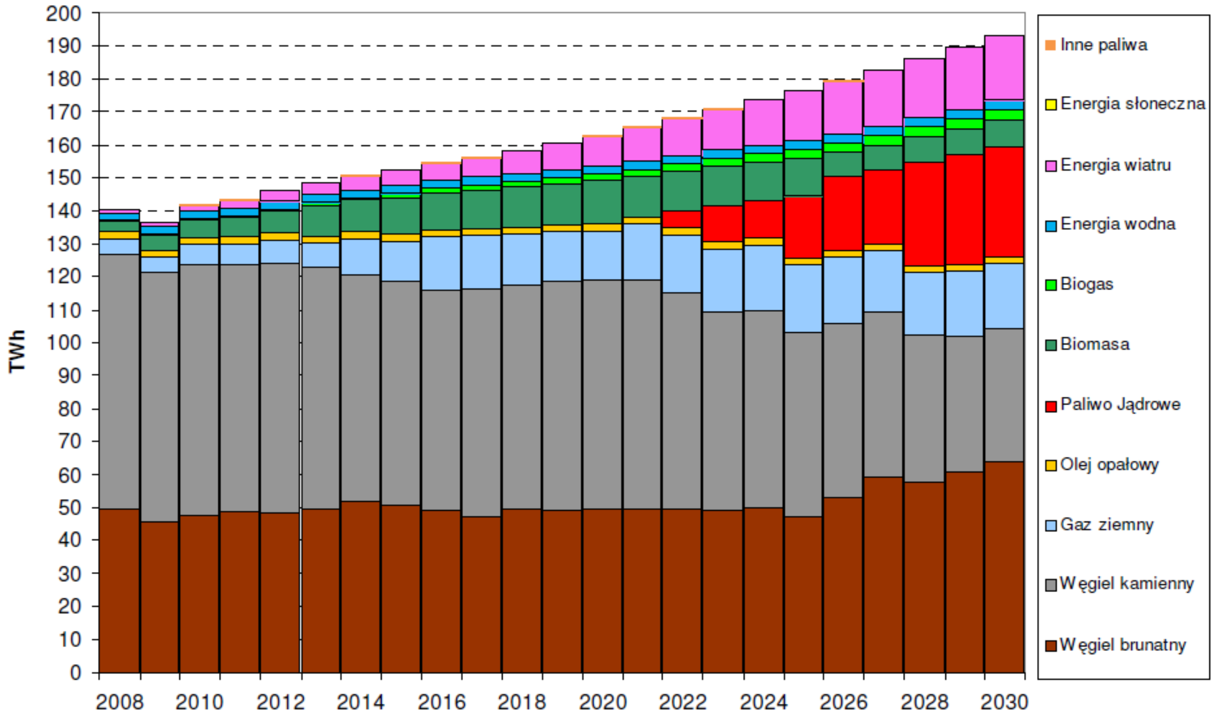


Figure 67. Net electricity generation by fuels in the baseline scenario [source: ARE S.A.— updated forecast demand for fuels and energy].

Inne paliwa	**Other fuels**
Energia słonczeczna	**Solar energy**
Energia wiatru	**Wind energy**

Energia wodna	**Water energy**
Biogas	**Biogas**
Biomasa	**Biomass**
Paliwo Jądrowe	**Nuclear fuel**
Olej opałowy	**Fuel oil**
Gaz ziemny	**Natural gas**
Węgiel kamienny	**Hard coal**
Węgiel brunatny	**Lignite**

In result of the obligation to purchase CO_2 emission allowances on auctions by power enterprises, consumption of hard coal and lignite shall decrease by approx. 16.5% and 23%, correspondingly, and gas consumption shall grow by approx. 40%. Nevertheless, electricity generation in coal plants (both hard coal and lignite plants) for the next 20 years shall remain at a level of approx. 110 TWh. The increase of gas consumption will be caused by the profitability of construction of gas cogeneration sources (combined power and heat production) and the necessity to build gas sources in order to ensure reserve capacity given the anticipated high growth of the share of wind farms.

It should be noted, however, that as part of the modernisation programme for the electricity generation sector in Poland, worn power units of coal plants fired with hard coal or lignite (with a capacity of approx. 37%, or even lower), which do not comply with the requirements in the scope of pollutants emissions, defined in EU directives and are not suitable for modernisation, shall be decommissioned and gradually replaced with modern, supercritical parameters units (with capacity of approx. 45-47%). In result, CO_2 emissions shall be significantly reduced.

Modern units of thermal plants, commissioned in the recent years, and those currently under construction or in design, feature emission factors compliant with the requirements of the most recent Directive 2010/75/EU. E.g. the new 100 MW currently designed at Ostrołęka Power Plant (Ostrołęka C)—fired with hard coal and equipped with a supercritical parameters dust boiler—shall feature the following emission factors[64]:

- CO_2: 728 kg/MWh,
- SO_2: 0.554 kg/MWh,
- NO_x: 0.507 kg/MWh,
- dust: 0.083 kg/MWh.

For the sake of comparison, the current average emission factors for Polish professional power industry are as follows:

- CO_2: 1 005 kg/MWh,
- SO_2: 2.351 kg/MWh,
- NO_x: 1.619 kg/MWh,
- dust: 0.144 kg/MWh.

As it can be seen from the comparison above, the possible reduction of emission of pollutants from power plants and combined heat and power plants in result of replacement of old generation units with modern ones is very high.

[64] „Energoprojekt Warszawa" S.A. Construction of Ostrołęka C power plant. Environmental impact report. Technical description.

The necessary requirement of the European Union to obtain a 15% share of renewable energy in the gross end user power portfolio in 2020 will result in a significant growth of share of the energy generated with RES—up to 17% in 2030 (in accordance with the updated forecast demand for fuels and energy).

Introduction of nuclear power will substantially contribute to reduction (avoiding) of CO_2 emissions. The analyses carried out by McKinsey & Company[65] indicate that in Polish conditions, the nuclear power has the greatest potential to reduce CO_2 emissions, at the lowest costs, from among all electricity generation sources (see Figure 68).

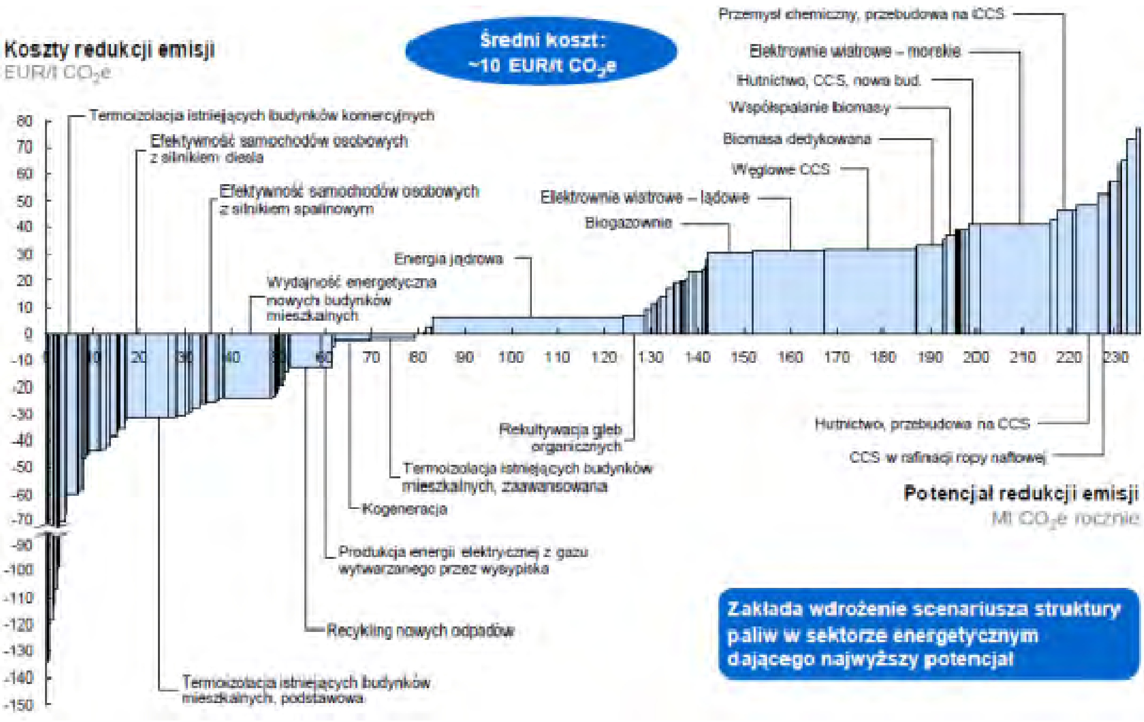


Figure 68. Cost reduction curve for greenhouse gas emissions for Poland until 2030 [source: McKinsey & Company].

Średni koszt:	Average cost:
Zakłada wdrożenie scenariusza struktury paliw w sektorze energetycznym dającego najwyższy potencjał	Assumes the implementation of a fuel portfolio with the highest potential in the power sector
Koszty redukcji emisnji EUR/t CO_2e	Emission reduction costs EUR/t CO_2e
Potencjał redukcji emisji Mt CO_2e rocznie	Potential for emission reduction Mt CO_2e annually
Termoizolacja istniejących budynków komercyjnych	Thermal insulation of the existing commercial buildings
Efektywnosć samochodów osobowych z silnikiem diesla	Diesel passenger car efficiency
Efektywnosć samochodów osobowych z silnikiem spalinowym	Gasoline passenger car efficiency
Wydajność energetyczna nowych budynków mieszkalnych	Energy efficiency of new residential buildings
Energia jądrowa	Nuclear energy
Biogazownie	Biogas plants

[65] McKinsey & Company: Assessment of Greenhouse Gas Emissions Abatement Potential in Poland by 2030. Warsaw 2009.

Elektrownie wiatrowe- lądowe	**On-shore wind farms**
Węglowe CCS	**Coal plants CCS**
Biomasa dedykowana	**Dedicated biomass**
Współspalanie biomasy	**Co-firing of biomass**
Hutnictwo, CCS, nowa bud.	**Metallurgy, CCS, new constr.**
Elektrownie wiatrowe- morskie	**Off-shore wind farms**
Przemysł chemiczny, przebudowa na CCS	**Chemical industry, conversion to CCS**
Termoizolacja istniejących budynków mieszkalnych, podstawowa	**Basic thermal insulation of the existing commercial buildings**
Recykling nowych odpadów	**Recycling of new waste**
Produkcja energii elektrycznej z gazu wytwarzanego przez wysypiska	**Electricity generation from gas produced by waste landfills**
Kogeneracja	**Co-generation**
Termoizolacja istniejących budynków mieszkalnych, zaawansowana	**Advanced thermal insulation of the existing commercial buildings**
Rekultywacja gleb organicznych	**Restoration of organic soils**
Hutnictwo, przebudowa na CCS	**Metallurgy, conversion to CCS**
CCS q rafinacji ropy naftowej	**CCS in oil refinement**

In turn—as it follows from the analyses of the "zero alternative" (see item 2.4.1.2.1)—cancellation of nuclear plans shall result in a significant increase of CO_2 emissions by the Polish power industry when compared to scenarios providing for launching of nuclear power plants until 2030.

McKinsey's diagram presents actions generating net profit, which means that carrying them out reduces the emissions of greenhouse gases and additionally brings savings. Such actions include improvement of thermal insulation of buildings or increasing the energy efficiency of transportation. Nevertheless, those are only methods reducing power consumption, and not generation methods. Irrespectively of the size of power demand, the power must be generated. A crucial question arises here—on what sources power generation should be based. In the forecasts prepared, a very substantial reduction of power consumption per GDP unit was assumed, but still there will be a demand for large amounts of electricity. However, as it is shown on the McKinsey's diagram, reduction of CO_2 emission costs with RES are markedly higher than in the case of nuclear energy used for that purpose.

A frequently used argument that introduction of nuclear energy in Poland shall have little reducing effect on the CO_2 concentration globally is inconsistent with the principle adopted in the world and in the European Union, that each country shall contribute to CO_2 emission reduction. So even if for individual countries, the effects of emissions reduction on a global scale are small, the aggregate effect of reduction of carbon dioxide emissions in the whole European Union shall be nevertheless significant. This connection should be obvious for the countries that support the Kyoto Protocol.

2.5.1.1. Summarised evaluations of the impact of nuclear energy on the power consumption and greenhouse gas emissions—for the whole power cycle

Similarly to hydroelectric plants, wind farms or PV cells, nuclear power plants do not cause CO_2 or greenhouse gas emissions[66]. While at the other stages of the fuel cycle, starting with uranium mining

[66] Each of greenhouse gases has different properties. In order to compare the emissions of greenhouse gases from various

and production of devices for nuclear plants to decommissioning of the plant and disposal of the waste, there are processes causing emissions of greenhouse gases, similarly as in the case of generation sources using RES. All these processes—e.g. Diesel fuel combustion in engines of trucks shipping uranium ore—were taking into account in the comparison of CO_2 emissions prepared by the World Energy Council (see figure below according to WEC[67]).

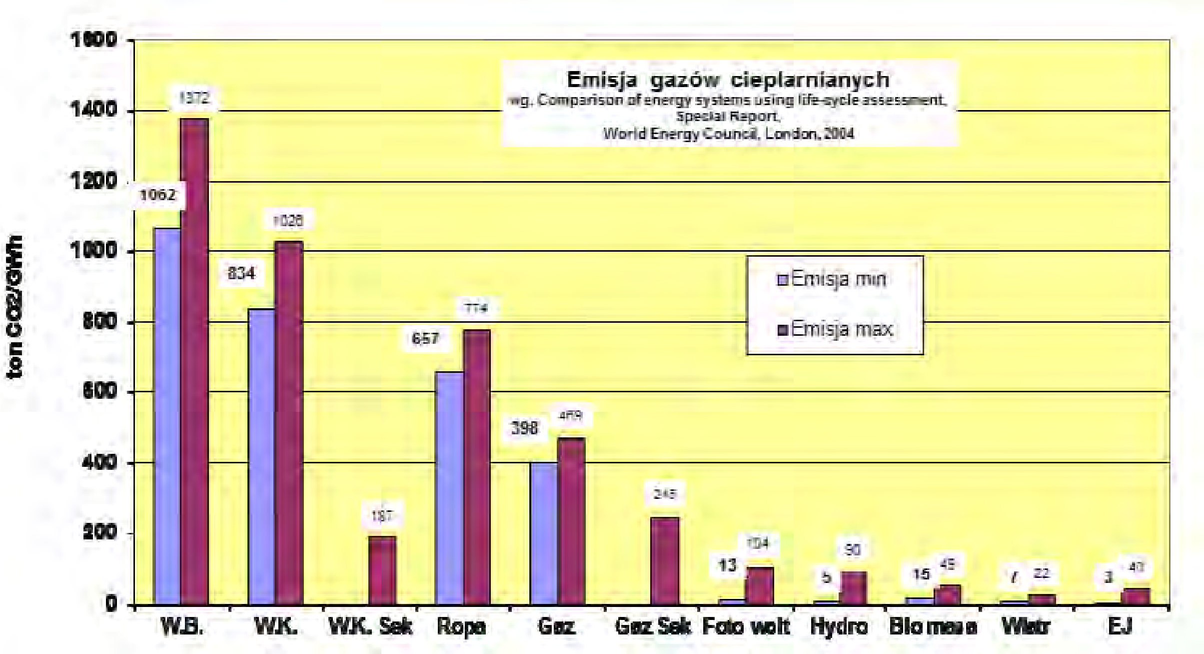


Figure 69. Comparison of emissions of greenhouse gases as part of life cycle assessment. Data from the Special Report of the World Energy Council [Ibid, fig. B.1] (L – lignite, HC – hard coal, seq – with CO_2 sequestration, NPP – nuclear power).

Emisja gazów cieplarnianych	
Emission of greenhouse gases	
Emisja min	Emission min.
Emisja max	Emission max.
W.B.	L
W.K.	HC
W.K. Sek	HC Seq
Ropa	Oil
Gaz	Gas
Gaz Sek	Gas seq
Foto Wolt	PV
Hydro	Hydro
Biomasa	Biomass
Wiatr	Wind
EJ	NPP

Estimates of the amount of energy necessary in the whole power cycle starting with the production of materials needed to build a nuclear power plant, through fuel, up to the decommissioning of the plant and waste, are available in various sources, and their reliability is verified by independent organisations and government agencies.

sources, the global warming potential has been determined for each of the gases in relation to reference amount of CO2. According to the evaluation of IPCC of 2001, methane (CH4) and nitrous oxide (N2O) have 23 and 296 times higher global warming potential than CO2.

[67] World Energy Council Comparison of energy systems using lifecycle assessment, Special report, London 2004

It is claimed that power needed for the construction of a nuclear plants, its operation (with mining and enrichment of uranium), decommissioning and radioactive waste management all high already today, and with depletion of the ore deposits shall grow even higher and exceed the energy obtained in fission. This argument rests on the theory of "energy cliff" which "allegedly" occur when the contents of U_3O_8 in the ore is below 0,013%[68], expressed by **Storm van Leeuwen and Smith (SLS).** A benefit of their work is drawing attention to the energy contribution and relevant CO_2 emissions connected with the process of obtaining uranium from a lean ore, which will be exploited in the future, after the resources of richer ores are depleted. However, the assumptions and results of the SLS work of 2005[69] and its updates of 2008, 2010, and 2012[70] contradict the data and results of extended professional literature on the subject. In the work of May 2005, Storm van Leeuwen writes that "*presently, CO_2 emissions of nuclear energy are from 80 to 130 g. of CO_2/kWh."* [71] Reports prepared by experts and verified by government agencies indicate significantly lower emissions.

These are for example:

- Vattenfall (2004; 2005)[72]: Life Cycle Assessment (LCA) for the NPP Environment Product Declaration developed in line with the requirements of Swedish law and controlled by independent agencies. According to this study, the emission of greenhouse gases for Swedish water reactors (PWRs and BWRs), taking into account the process of obtaining and enrichment of uranium, decommissioning of NPP and radioactive waste, totals less than 4 g (CO_2eq)/kWh. Construction and decommissioning of mines, fuel conversion, enrichment, and production plants is not included, but the authors argue that the related error does not exceed 2%.

- BE (2005)[73]: Life Cycle Assessment (LCA) for the NPP Environment Product Declaration for two units with AGRs in Torness NPP, indicating, that the emissions of greenhouse gases total 5 g(CO_2)/kWh. If ore from Olympic Dam mine was used to satisfy 100% of the Torness NP's needs, then given the pessimistic assumption that 25% of total energy consumed at the mine results from acquisition of uranium, emissions from Torness would increase to 6.85 (CO_2)/kWh.

- SDC (2006)[74]: Review of 31 studies discussing LWR fuel cycle. The range of emissions in 30 studies is between 2 and 77 g(CO_2)/kWh, and only 3 works provide figures >40 g(CO_2)/kWh. One work departs from all the others and gives the value of 140-230 g(CO_2)/kWh—it is a publication of the antinuclear organisation WISE (based on SLS results).

[68] SLS (2005) Storm van Leeuwen J.W. and Smith P., "Nuclear Power: the Energy Balance".2005. Retrieved from http://www.stormsmith.nl/

[69] SLS (2005) Storm van Leeuwen J.W. and Smith P., "Nuclear Power: the Energy Balance". Updates 2005. Retrieved from http://www.stormsmith.nl

[70] http://www.stormsmith.nl/Media/downloads/insights.pdf

[71] Ibid p. 23

[72] Vattenfall (2005) Vattenfall AB Generation Nordic Countries − Certified Environmental Product Declaration of Electricity from Forsmarks Kraftgrupp AB (FKA). S-P-00021, June, 2004. Updated 2005. http://www.vattenfall.de/www/vf_com/vf_com/Gemeinsame_Inhalte/DOCUMENT/360168vatt/386246envi/2005-EPD-FKA.pdf

[73] BE (2005) British Energy, "Carbon footprint of the nuclear fuel cycle – Environmental Product Declaration of Electricity from Torness Nuclear Power Station – Technical Report". AEA Technology Environment, London, UK. Retrieved from http://www.british-energy.com/pagetemplate.php?pid=251

[74] SDC (2006) Sustainable Development Commission, "The role of nuclear power in a low carbon economy − Paper 2: Reducing CO2 emissions − nuclear and the alternatives − An evidence-based report by the Sustainable Development Commission, March 2006, UK. Retrieved from: http://www.sd-commission.org.uk/publications/downloads/Nuclear-paper2-reducingCO2emissions.pdf

- Weisser (2007)[75]: Review of current studies on electricity generation methods as part of life cycle assessment; four studies dealing with LWRs provide results between 3-24 g(CO_2-eq)/kWh.

- Dones (2003; et al. 2005)[76]: Life Cycle Assessments for LWRs in the European Union and Switzerland, with studies on other energy sources (Dones et al. 2004) [77]. The range for LWR is 5-12 g(CO_2-eq)/kWh (the lowest value for centrifugation, the highest for diffusion enrichment.

Moreover, a report by Fthenakis and Kim (2007)[78], presents life cycle assessments for PV cells and power energy in specific conditions of the USE, and provides a range for LWR totalling between 16 and 55 g(CO_2-eq)/kWh.

The biggest component of the energy balance is energy needed for uranium enrichment—in the case of diffusion enrichment. It constitutes more than a half of the whole energy necessary to generate electricity in a nuclear plant, taking into account its all life cycle, its decommissioning and disposal of waste. In the case of centrifugation, the energy necessary for enrichment of a uranium mass unit is fairly lower. For the whole cycle it turns out that the expenditures for energy for the cycle with centrifuges are three times lower than for diffusion.

What is more, the amounts of energy used for uranium enrichment, NPP construction and decommissioning, and disposal of waste, are estimated by SLS as a couple or even dozens of times higher than it stems from technical specifications. On the basis of these inflated data, SLS created the theory of energy debt incurred by the nuclear industry when building a NPP, and whose repayment "allegedly" needs great amounts of carbon dioxide emissions.

According to SLS, time required for the energy necessary for the currently operating nuclear power plants to be returned, assuming the average contents of uranium in the existing mines measured in relation to the whole life cycle "from the cradle to the grave" is full 9 years of operation at full load (ibid, p. 45). On that basis, Storm van Leeuven prepared an account presenting the sum of energy necessary to build a nuclear power plant, uranium mining, enrichment, and fuel production, maintaining the operation of the plant, its decommissioning and disposal of radioactive waste. Energy needs of the back-end of the fuel cycle, namely fuel and plant decommissioning, are called energy debt by SLS, as they must be repaid many years after the plant is closed (Ibid, p. 47).

The actual course of changes of the energy balance for a NPP with life cycle of 40 and 60 years is presented in the figure below.

[75] Weisser D. (2007) A guide to life-cycle greenhouse gas (GHG) emissions from electric supply technologies. http://www.iaea.org/OurWork/ST/NE/Pess/assets/GHG_manuscript_pre-print_versionDanielWeisser.pdf

[76] Dones R. (2003) Kernenergie. In Dones R. (Ed.) Sachbilanzen von Energiesystemen: Grundlagen für den ökologischen Vergleich von Energiesystemen und den Einbezug von Energiesystemen in Ökobilanzen für die Schweiz. Final report ecoinvent 2000 No. 6-VII. Paul Scherrer Institut Villigen, Swiss Centre for Life Cycle Inventories, Dübendorf, CH (2004). Retrieved from: www.ecoinvent.ch

[77] Dones R., Bauer C., Bolliger R., Burger B., Faist Emmenegger M., Frischknecht R., Heck T., Jungbluth N. and Röder A. (2004a) Life Cycle Inventories of Energy Systems: Results for Current Systems in Switzerland and other UCTE Countries. Final report ecoinvent 2000 No. 5. Paul Scherrer Institut Villigen, Swiss Centre for Life Cycle Inventories, Dübendorf, CH. Retrieved from: www.ecoinvent.ch

[78] FthenakisV. M. and Kim H. C. (2007) Greenhouse-gas Emissions from Solar Electric- and Nuclear Power: A Life-cycle Study. Energy Policy, Vol. 35, pp. 2549-2557

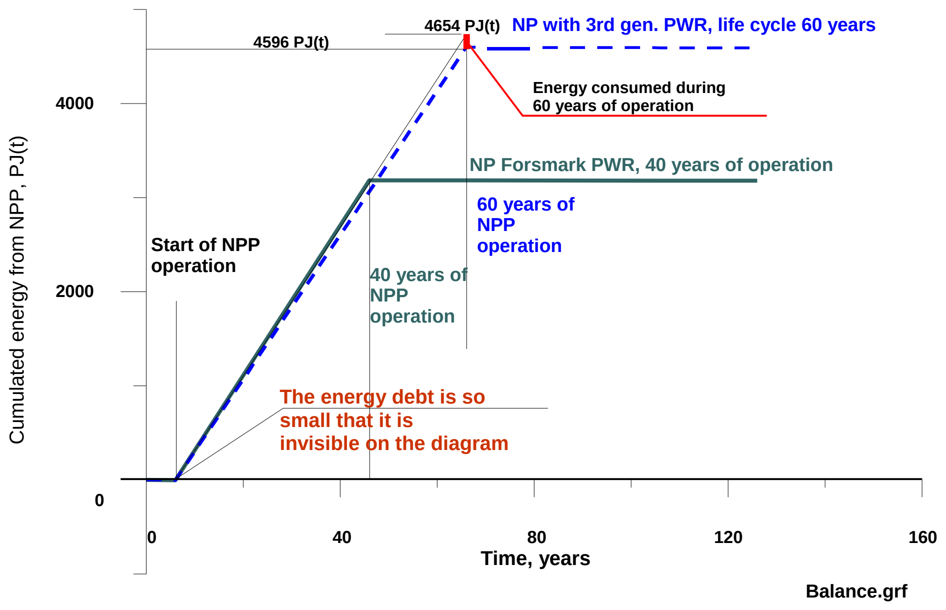


Figure 70. Energy balance in the life cycle of a nuclear power plant

Technical documents, and in particular the NPP Environment Product Declaration from Sweden[79] and the United Kingdom[80], provide the amounts of CO_2 emissions between 4 and 40 g corresponding to CO_2/kWh, whereas the bottom limit corresponds to centrifugation of uranium, and the top limit—to diffusion enrichment. Usage of a lean ore has minor influence on the energy balance of the whole cycle, and therefore, for the CO_2 emission balance.

It was demonstrated that figures provided by SLS are several times higher than the actual data. The assertion that NPPs will emit more$_2$ than gas plants is based on wrong assumptions. Errors in estimation of energy necessary to extract and purify the uranium are discussed below.

Significantly overestimated figures occur also in the estimations of energy needed to build a plant or dispose it, published by SLS. Technical documents of various origins, verified by independent auditors, confirm that energy inputs for construction and decommissioning of power plants are significantly lower than energy generated in the whole life cycle of a NPP, and greenhouse gas emissions in the nuclear cycle are among the lowest of all energy sources.

Therefore, the issue of energy balance—determining the amount of CO_2 emissions—is one of the essential arguments in discussions on nuclear energy. Main elements of this argument are provided below[81].

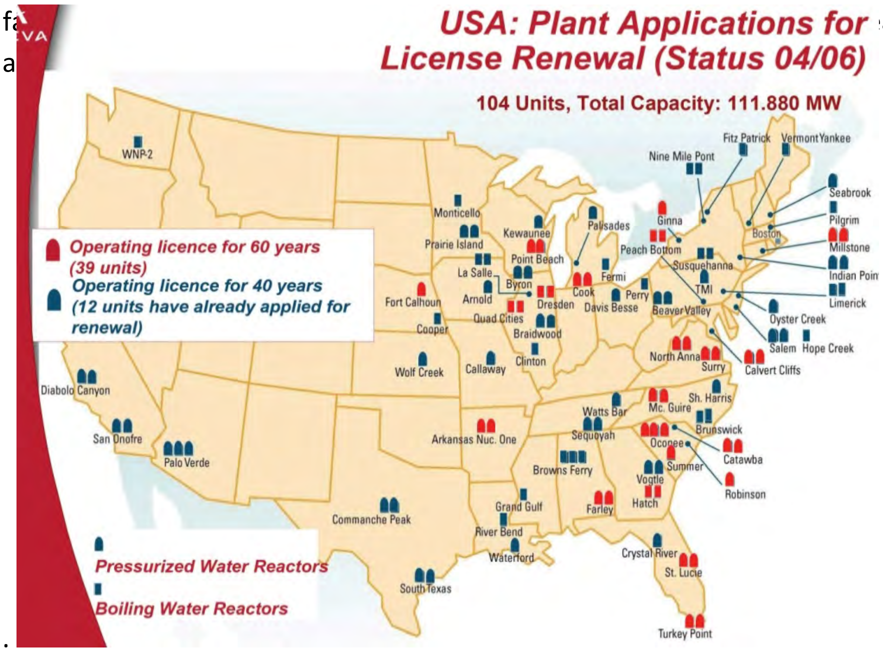
[79] Vattenfall (2005) Vattenfall AB Generation Nordic Countries – Certified Environmental Product Declaration of Electricity from Forsmarks Kraftgrupp AB (FKA). S-P-00021, June, 2004. Updated 2005. http://www.vattenfall.de/www/vf_com/vf_com/Gemeinsame_Inhalte/DOCUMENT/360168vatt/386246envi/2005-EPD-FKA.pdf

[80] BE (2005) British Energy, "Carbon footprint of the nuclear fuel cycle – Environmental Product Declaration of Electricity from Torness Nuclear Power Station – Technical Report". AEA Technology Environment, London, UK. Retrieved from http://www.british-energy.com/pagetemplate.php?pid=251

[81] http://www.cire.pl/pliki/2/czywystarczyuranu.pdf

2.5.1.2. Energy generated during the whole life cycle of the nuclear power plant

Because assessments are conducted for the whole life cycle of the nuclear power plant, it is important to determine, what period of useful operation we should expect. SLS postulate 30 years with a load factor (installed capacity utilisation factor) of 0.82, which gives 24 years of effective continuous work. In fa ... ars, and many of them were a ...



.

Figure 71. NPPs in the USA with operating licences for 60 years.

The load factor achieved in the world at the average—together with nuclear power plants in Third World countries—is currently 0.85, and in the USA, it exceeds 0.9. For 3rd generation nuclear power plants which are to be built in Poland, the guaranteed operation time totals 60 years with the expected load factor of 0.9, which gives 54 years of effective continuous operation. New 3rd generation power plants shall feature a higher capacity utilisation factor, because they are designed so as the repairs and maintenance of security system be performed during the reactor's operation. It means shortening of renovation periods—and therefore a higher full capacity operation time factor.

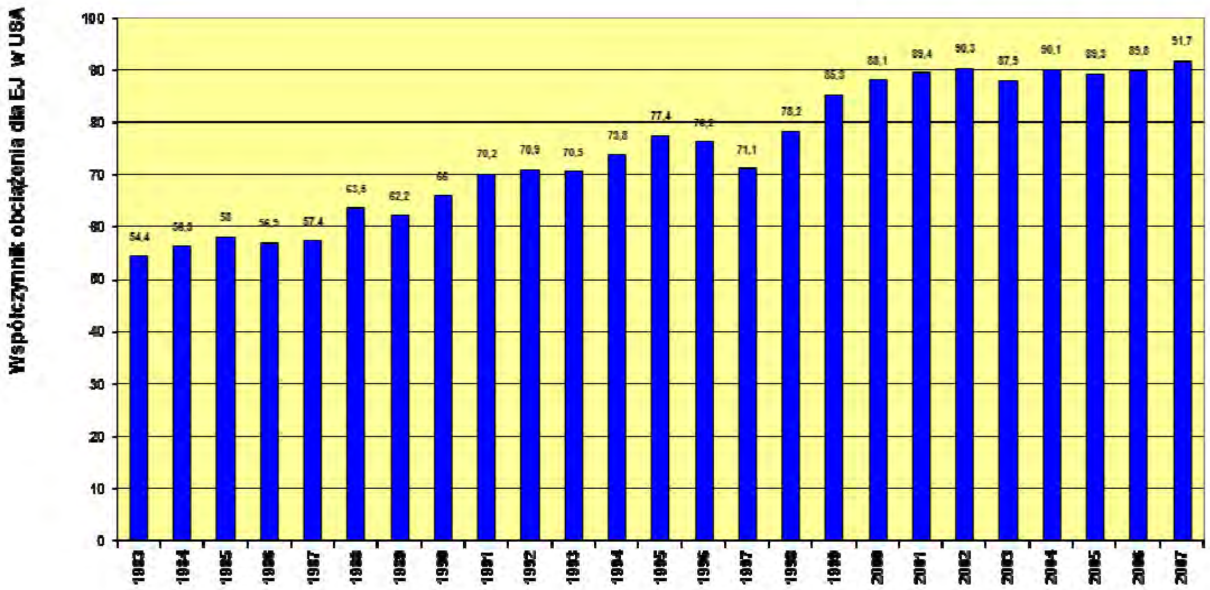


Figure 72. Average installed capacity utilisation factors of NPPs in the USA.

Współczynnik obciążenia dla EJ w USA	Load factor for NPPs in the USA

Since the analyses are conducted for new NPPs, the 3rd generation NPPs to be constructed in Poland, a 60-year life cycle is adopted in the assumptions, and the installed capacity utilisation factor of 0.85, which is achieved at average throughout the world. Also, a comparison with 2nd generation nuclear power plants shall be presented, given a 40-year life cycle and pessimised performance parameters.

SLS say that a reference reactor consumes 162.35 of natural uranium annually[82], which given the load factor of 0.82 and the thermal efficiency coefficient of 0.33, which gives the gross electricity of:

Egross = 25,86 PJ/year = 25,86 PJ/year/3600 s/h = 7,183

TWh/year, or per one ton of natural uranium 159,3 TJ(el)/t(Unat).

Due to the fact that energy balances include thermal energy (TJ(t) and electricity TJ(el), and to generate 1 TJ(el) it is necessary to use 3 TJ(t) at the average, SLS adopted a principle that when summing up, the electricity is multiplied by 3 and added to the thermal energy. In order to ensure comparability of results, a similar methodology was maintained. Hence, electricity generation from a NPP was multiplied by 3 and provided in thermal energy units. Therefore, thermal energy obtained from a reactor during one year shall be 77.58 PJ/a, and from one ton of natural uranium—478 TJ/t(Unat).

With generation of the NPP totalling 7.183 TWh yearly, over a period of 40 years it would give:

7.183 TWh/year x 40 years = 287

TWh or, in thermal energy units:

287 TWh x 3600 s/h= 1,034 10_6 TJ = 1034 PJ el = 3103 PJ,

For 3rd generation reactors, ensuring thermal efficiency of 0.37 and 60 years of operation, given the

[82] J.W. Storm van Leeuwen : Nuclear power- the energy balance, Uranium, October 2007

capacity utilisation factor of 0.85, we arrive at:

7,183 x 0,37/0,33 x 0,85/0,82 x 60 = 500,9 TWh

or, in thermal energy units:

500,9 TWh x 3600 s/h x 3 = 5,4 10^6 TJ= 5400 PJ.

The parameters adopted above correspond to the values which were obtained during operation of NPPs more than 20 years age, with a burnup of 45,000 MWd/t. Presently, burnup values for nuclear fuel reach 60,000 MWd/t, and the amount of energy generated with a mass unit of uranium is higher. SLS data were adopted in order to obtain a common reference points for further evaluations and to provide realistically possible generation of energy for nuclear power plants, so as not to be accused for excessive optimism.

2.5.1.3. Energy necessary to extract and purify uranium (taking into account mine reclamation)

2.5.1.3.1. Energy necessary to extract uranium in the Ranger mine

SLS write that CO_2 emissions caused by nuclear power shall grow in the decades to come in result of depletion of rich ores of uranium and dependence on the leaner ore. A leaner ore requires more energy to extract a unit of uranium and causes correspondingly greater CO_2 emissions. In the opinion of SLS, if no new, substantial resources of high quality ore are discovered, then already in the life cycle of existing nuclear power plants, fuel cycle emissions shall exceed those related to firing organic fuels.[83] Further on, Storm van Leeuven says that if a lean ore, containing less than 200 grams of uranium per ton, (0.2 kg/1000kg—0.02%), are used, emissions of a nuclear plant will be as high as of a coal plant. But in fact, the energy input connected with the extraction and purification of the ore and reclamation of the mine is small.

According to WNA data, in the Ranger mine, where in 2004 ore with quite high uranium content of 0,234% U was extracted, the energy used locally (in the mine and the area surrounding it, including for production of sulphuric acid, but without accounting for the energy in materials purchased externally[84]) for extraction and purification of uranium totalled 165 GJ/t U_3O_8, which is 195 GJ/tU (The same data are provided by Prof. Sevior[85] [86]in his polemics with SLS). In accordance with the principles of analyses of a whole NPP life cycle, it is necessary to add the energy contained in the explosive and chemicals purchased by the mine to the energy used locally, as these materials required energy earlier, before they were delivered to the mine. Data on the amounts of these chemicals and their energy content are provided in the table below.

Table 15. Energy contained in chemicals (data of SLS).

Material	Energy contents per mass unit	Amount	Electricity	Thermal energy
	GJ(t)/t	Thousands	TJ_{th}	TJ_{el}
Explosives	72	2300	2	160
Sulfur S	40.26	29.8		1200

[83] http://www.stormsmith.nl/Media/downloads/insights.pdf str.23
[84] WNA Energy Analysis of Power Systems, March 2006
[85] J.Hore Lacy, personal communication, e-mail of 28 January 2008
[86] Sevior M, http://nuclearinfo.net/Nuclearpower/SSRebuttalResp

Sodium chlorate NaClO3	87	2.75	58	66
Ammonia NH3	158	1.08	39	54
Calcium oxide CaO	8.6	26.04	1.8	219
Total			101	1699

Yearly production of U_3O_8 in the Ranger mine totalled 5910 tons. Thus, the energy of explosives and chemicals supplied to the Ranger mine per one ton of U_3O_8 , totalled (after conversion of electricity into the equivalent thermal energy)

$$(101 \times 3 + 1699)\ TJ/5910\ tons(U_3O_8) = 338\ GJ/t(U_3O_8)$$

In total, the demand for energy used locally and contained in the materials supplied amounted to 165 + 338 = 503 GJ/t(U_3O_8), and after accounting for the U_3O_8 uranium contents coefficient totalling 0,848:

$$503\ GJ/t(U_3O_8) / 0{,}848\ t(U)/t(U_3O_8) = 593\ GJ/t(U)$$

Therefore, the proportion of energy generated to the energy input at the stage of extraction and purification of uranium, is 478 TJ(t)/593 GJ(t) = 80. As the above discussion concerns the full life cycle of a NPP, then apart from the energy necessary to exploit uranium deposits also the energy needed for mine reclamation after the extraction is completed should be taken into account.

2.5.1.3.2. Energy for the Ranger mine reclamation

It is worth noting that gangue and waste from the process of ore purification contain the same minerals which were contained in them when these materials were in the ground. The difference consists in the fact that uranium ore was removed from them, so their radioactivity is lower. If gangue is placed back in the ground and covered with a layer of soil, it shall not pose a radiological risk higher than the initial one, before the extraction was started. Usually, this method is applied when reclaiming mine terrains. In the Ranger mine, gangue and waste from the uranium purification process shall be placed in excavations remaining after ore extraction and covered with a layer of soil, on which grass shall be sown and trees planted. It shall prevent erosion on the surface of the reclaimed terrain.

It is assumed that the amount of energy necessary to fill an exploited excavation with gangue as part of reclamation shall be similar to the energy used for shipment of excavated material from the deposit to the surface during the exploitation. When compared to the energy used for shipment of excavated material, energy consumption during reclamation shall be reduced by the energy of explosives used in excavation works and the energy of chemical processes as part of uranium ore enrichment. In such a way, the energy input per mass unit of gangue shall be obtained in the same amount as during the extraction of uranium, although the transport of gangue back to excavations requires less energy than extracting it. With a certain margin of error and underestimation, this value shall be equal to 195 GJ/t(U), which specifies the energy costs in the Ranger mine during uranium extraction. It is a higher value than it follows from the data of Storm van Leeuwena (SL) relating to the energy necessary for transportation, published on his webpage[87]. In chapter D7, the author writes that assuming a minimal distance for rock and ore transport s = 10 km, the minimal energy input for extraction of 1 ton of rock (ore or overburden) shall be E(transport) = 66.0 MJ/t. Assuming the proportion of the overburden mass to the ore mass S = 3, and uranium contents equal to 0.234 %U, when we apply the energy input adopted by Strom van Leeuwen, we shall arrive at the following value of energy consumption:

[87] J.W. Storm van Leeuven: Nuclear power - the energy balance, Uranium, October 2007

66 MJ/t(rock) x (3+1) /0.00234 t(U)/t(rock) = 112.8 GJ/t(U),

therefore a significantly lower figure than provided above. Applying the higher value in the analysis in order to ensure a relevant margin of underestimation,

Finally, the total energy inputs for extraction and purification of uranium along with mine terrain reclamation are, with a large reserve margin, as follows:

593 GJ/t(U) + 195 GJ/tU = 788 GJ/t(U),

which constitutes only 0.0016, namely 0.16% of the energy generated with 1 ton of natural uranium, totalling 478 TJ(t)/t(U).

2.5.1.3.3. Comparisons of the energy necessary to extract uranium in the Ranger mine

According to the estimations of Storm van Leeuwen, the energy necessary to extract and purify uranium in the Ranger mine is 1280 GJ/t(U). Moreover, the energy "necessary for reclamation is estimates at four time the energy needed to extract a mass unit from the mine deposits", which totals, according to Storm Van Leeuwen, E(exctraction) = 1.06 GJ/t of ore. The mass of waste, including limestone and bentonite, which—according to SL—should be added to stabilise the waste, he estimates at "two times the mass of the extracted ore". Such assumption leads to the conclusion that energy necessary for reclamation is 8 times higher than the energy necessary for ore extraction, namely 8.4 GJ/t(of ore).

For the Ranger mine, for which the extracted ore mass totals 2293 000 t/a, the reclamation energy would be, according to SLS:

2293 000 t/a x 2 x 4,2 GJ/t = 19,26 10_6 GJ/a

When translated into the mass of uranium, the energy necessary for reclamation,

according to him, would total: E(reclam) = 19,26 10_6 GJ/a / 5910 t(U_3O_8) =

3260 GJ/t(U_3O_8) = 3840 GJ/t(U)

Along with the energy necessary for extraction and purification of uranium, we would arrive in such case at 4920 GJ/t(U).

This value is significantly higher than 788 GJ/t(U) determined above. As it can be seen, already for the ore with 0,234% of uranium contents, the calculations by SLS are overestimated more than 6 times when compared to the actual data. The lower the uranium contents, the bigger the error in SLS estmiates.

2.5.1.3.4. Rossing mine—ore uranium content below 0.03%

In order to get closer to the "energy cliff" postulated by SLS, it is necessary to consider the actual data for the Rossing mine in Namibia, where an ore with uranium contents of 0.0276%U was extracted. The annual report of the mine for 2006 states[88] that in 2006, the mine produced 3,617 tons of U_3O_8, and the

[88] Rossing: Rossing working for Namibia, Report to Stakeholders, 2004

energy consumption at the mine totalled 1366 TJ (without chemicals). Specific energy consumption per one ton of ore was 113.7 MJ/t. It corresponds to thermal energy consumption per one ton of uranium equal to:

113.6 MJ/t(of ore)/0,000276 t(U)/t(of ore) = 411 GJ/t(U) (without chemicals).

It is twice as much as in the Ranger mine, where the consumption of thermal energy per one ton of uranium at the mine (chemicals excluded) was 195 GJ/t(U).

As can be seen, the amount of necessary energy strongly depends on local conditions, and the proportion of the overburden weight to the ore weight is one of crucial parameters. The leaner the ore, the lower the proportion. In Ranger workings, the proportion was S =3. But at Rossing, it assumed values between 0.7 and 1.43. Given a 10 times smaller uranium contents in the ore, the energy inputs were only two times higher, approximately.

So assuming roughly that the total energy consumption shall grow proportionally to the energy used for extraction, the energy consumption for Rossing shall be equal to:

411/195 x 0,79 TJ/tU = 1,66 TJ/tU. While in

the opinion of SLS, the necessary energy is 17 TJ/tU, which is 10 times more.

The estimates prepared by SLS are characterized by glaring upward bias for the energy cost of uranium extraction, with the simultaneous underestimation of the efficiency of extraction of uranium from the ore with uranium contents below 0.05% Application of SLS formulas leads e.g. to the conclusion, that in order to obtain yearly output of 4600 tons of uranium from the Olympic Dam, it would be necessary to supply an energy equivalent of 2 plants working with capacity of 1000 WMe each for one year. It is an amount of energy an order of magnitude higher than the whole electricity consumed by the Northern Australia, where the Olympic Dam is located. In the case of Rossing, SLS anticipates the amount of energy necessary for extraction and milling of uranium to be 2,6 GW·years. Meanwhile, the total energy consumption in all forms in the whole Namibia is 1.5 GW·years, which is less than SLS estimates assume for one mine.

2.5.1.3.5. Valencia mine—uranium contents in the ore of approx. 0.015% U_3O_8

The Valencia uranium mine, opened in 2008, uses a very lean uranium ore, containing between 0.13 and 0.15 kg of U_3O_8 per ton[89] [90]. The uranium resources of this mine are estimated at 33 million kg of U_3O_8 with uranium contents of 156 ppm, with the tails assay of 67 ppm, which shall enable 17 years of exploitation of the mine. This value corresponds to one provided by SLS as the "cliff" (0,013%), at which the amount of energy used for uranium production is to be equal to the amount of energy generated with the use of the uranium in a reactor.

As practice indicates, contrary to SLS assertion, the energy input for the extraction of an ore which is so lean is not that high. The capacity necessary for the mine is 20 MW[91], which means the following energy:

[89] Valencia Uranium project, ENVIRONMENTAL ASSESSMENT AND ENVIRONMENTAL MANAGEMENT PLAN, SCOPING REPORT July 2007

[90] http://forsysmetals.com/?page_id=420

[91] Ibid

20 x 360 x 24 x 3600 MW·s = 20 x 31,1 106 MJ = 622 106 MJ.

Given the uranium production of 18 million tons, with the uranium contents of 0.13 kg/t, it is 2.34 million kg of U_3O_8, which gives the electricity consumption of:

622/ 2,34 = 265,8 MJ/kg U_3O_8 = 313,4 MJ/ kgU= 313,4 GJ/tU

As a reminder, according to SLS, the energy needed for extraction and purification of a lean ore of a U_3O_8 grade below 0,013% was approx. 92,000 GJ/tU.

The amount provided by SLS is 293 times higher than the actual one.

2.5.1.3.6. Summary of estimates and facts related to energy demand in uranium extraction.

The comparison of pessimistic, repeatedly overestimated evaluations presented by SLS with practical values shows that the anticipated rapid growth of energy consumption for uranium extraction from a lean ore is not borne out in reality.

2.5.1.4. Conversion of U_3O_8 into UF_6

After obtaining the uranium oxide U_3O_8 it is converted into gaseous UF_6, to enable its enrichment by way of increasing the fraction of fissile U-235 isotope in the uranium. According to SLS, energy needed for the conversion E(conv) is:

E (conv) = 1,478 TJ/tU.

The work by Dones[92], on the basis of technical data, provides the conservative value of energy necessary for conversion equal to 1 TJ/tU. The works by renewable energy specialists, Fthenakis and Kim[93], indicate, on the other hand, that the energy input for conversion and production of fuel have been omitted in the discussion as small when compared to other energy expenditures in the whole cycle.

2.5.1.5. Enrichment

Enrichment of uranium constitutes the biggest part of energy inputs in the energy balance of the nuclear fuel cycle. The enrichment workload depends on the tails assay below which the uranium is considered to be waste. For example, in order to produce 1 kg of uranium with a 3% U-235 enrichment, it is necessary to provide 3.8 (separation work units, SWU) if the tails assay used is 0.25%, while in the case of a tails assay equal to 0.15%, the necessary workload is 5.0 SW. When the tails assay is lower, we save uranium, as the charge needs only 5.1 kg instead of 6.0 kg of natural uranium, but the necessary separation work grows.

At present, to enrich the fuel used every year in a light water reactor (LWR) with capacity of 1000 MWe, approx. 100-120 thousand SWU are necessary. Gaseous diffusion consumes approx. 2500 kWh (9

[92] Dones R. Critical note on the estimation by Storm van Leeuwen J.W. and Smith P. of the energy uses and corresponding CO2 emissions from the complete nuclear energy chain, PSI. 00.04.2006

[93] FthenakisV. M. and Kim H. C. (2007) Greenhouse-gas Emissions from Solar Electric- and Nuclear Power: A Life-cycle Study. Energy Policy, Vol. 35, pp. 2549-2557

GJ) per SWU. In turn, the modern centrifugation plants need (according to Dones) only 40 kWh,[94] which is 0.144 GJ/SWU.

In his analyses, SLS used data from before 30 years for the gaseous diffusion (ERDA-76-1)[95], according to which the energy input for enrichment is E(dif) = 11 GJ/SWU.

To assess the centrifugation method, SLS adopted Kistemaker's data of 1975 concerning the energy inputs for the construction of enrichment plants, assuming arbitrarily that the energy needed to operate the centrifuges shall be equal to E(cen) = 1,76 GJ/SWU, which is more than 10 time higher than it stems from technical specifications. The authors summed up the necessary energy postulated in the analyses for the construction and operation of enrichment facilities, arriving at the value of a postulated specific amount of energy input for centrifugation at the level of 3.1 GJ/SWU. After accounting for the actual input provided on the basis of the World Nuclear Association (WNA) technical data, in turns out that the value provided by SLS is overestimated many times (3/0.18 = 17.2). On the assumption that 30% of the enriched uranium is obtained in diffusion plants, and 70% of it is enriched by centrifugation, the SLS analysis estimated the average energy expenditure for enrichment equal to 5.47 GJ/SWU.

The World Nuclear Association (WNA) provides the energy consumption in centrifugation plants in the amount of 63 kWh/SWU, so it is a very prudent estimation with a large overestimation margin. This value is based on the data on the energy inputs in centrifugation plants of Urenco in Capenhurst from the period when the plants were converted and modernised, so it includes not only the current needs of enrichment processes, but also expenditures for the construction of installations, counted with a margin.

Taking into account a NPP life cycle of 40 years, WNA obtained the amount of energy necessary to enrich uranium, equal to 3,26 PJ(t) = 1,08 PJ(el). The said value, as the higher among Dones' estimates and the one taking into account the whole life cycle of enrichment plants together with their construction, was adopted in further discussion.

For a 60-year NPP life cycle, according to the assumptions of WNA, the workload for uranium enrichment was obtained amounting to 1,62 PJ(el) = 4,89 PJ(t).

Greenhouse gases leakage during enrichment

During centrifugation of uranium, a leakage of chlorofluorocarbons (CFC) and hydroflurocarbons (HFC) occurs.[96][97] The negative impact of CFC gases on the environment is twofold—they destroy ozone in the stratosphere and act as greenhouse gases in the troposphere. Opponents of nuclear power claim that leakage of these gases is "concealed" by the nuclear industry. The fact is, however, that the phenomenon of leakage of these substances is known, and its size is taken into account and disclosed in detailed accounts. In Capenhurst plants, CFC and HCF leakage totalled annually 630 and 710 kg,

[94] Dones R. Critical note on the estimation by Storm van Leeuwen J.W. and Smith P. of the energy uses and corresponding CO2 emissions from the complete nuclear energy chain, PSI, 10.04.2006

[95] ERDA 1976, A national plan for energy research, development and demonstration: creating energy choices for the future, Appendix B: Net energy analysis of nuclear power production, ERDA 76/1

[96] CFCs are greenhouse gases with a very high greenhouse effect potential, and a very long life time in the atmosphere. In result of such a long lifetime, they can slowly penetrate to the stratosphere. http://www.atmosphere.mpg.de/enid/20a.html

[97] The life time of HFC gases in the atmosphere is significantly shorter than CFCs. They break down in the troposphere and the probability of penetration to the stratosphere and destroying ozone is significantly lower in their case. But they also are strong greenhouse gases. http://www.atmosphere.mpg.de/enid/20a.html

correspondingly, which given the yearly production of 850 t SWU gives 7.4 10^{-4} kg/SWU and 8.4 10^{-4} kg/SWU.

Dones has assumed pessimistically, that CFC emissions are released as the most harmful CFC-114 or115, and HFC emissions—as HFC-134a, as a result of which greenhouse gases are emitted that are equivalent to emission of 118 kg (CO_2 ekw)/GWh. This value corresponds to approx. 2% of CO_2 emissions calculated for the nuclear cycle without these gases included (Dones, GABE)[98].

In the opinion of SLS, uranium enrichment plants in the USA emits nearly 5 grams of CO_2/ kWh in the form of CFC- 114. It is approx. 25 times more than provided by Dones. The difference between this figures can result from various enrichment processes—centrifugation in Capenhurst, diffusion in the USA. In the face of the fact that centrifugation already dominates on the market and in a couple of years, diffusion methods of uranium enrichment shall be abandoned, it is reasonable to use the Dones' data for Capenhurst in analyses of emissions in the mid-21st century.

2.5.1.6. Nuclear fuel production

Energy input for nuclear fuel production postulated by SLS on the basis of ERDA 76-1[99]
totals:

E (fuel prod.) = 3,79 TJ/tU (enriched) in fuel.

On the other hand, Dones indicates that the energy input necessary per one ton of enriched nuclear fuel is 700 GJ/tU (enriched) in fuel[100]. Assuming that fuel is enriched up to 3.5%, so per 1 kg of enriched uranium 7.49 kg of natural uranium is used, we arrive at the energy of 506 or 93,45 GJ/t of natural uranium, according to SLS and Dones, correspondingly. Thus, the difference between SLS assessments and technical data is more than fivefold.

2.5.1.7. Construction of nuclear power plant

An estimation of the amount of energy needed to construct and dispose a NPP was presented by Vattenfal dla EJ Forsmark, British Energy for Torness NP[101][102], and the Swiss Team at the Paul Scherrer Institute working on behalf of the Swiss government. Results of these analyses indicated that the energy for construction of a NPP totals between 4 and 6 PJ(t), while for decommissioning of the plant, between 3.5 and 4 PJ9(t).

It should be noted, that the study by Jan Willem Storm van Leeuwen and Philip Smith (SLS), widely quoted by the opponents of nuclear power, assumes that the amount of energy necessary for construction and decommissioning of a NPP is much higher. According to SLS, it is not 8 PJ (as provided by Vattenfall), but 240 PJ(t). The difference stems from the fact, that Vattenfall measured energy inputs directly on the basis of technical data, while the analysis of SLS are based on the plant price with all the

[98]Dones R et al GABE: Environmental Inventories for future electricity supply systems for Switzerland, PSI report 96-07, February 1996

[99]ERDA 1976, A national plan for energy research, development and demonstration: creating energy choices for the future, Appendix B: Net energy analysis of nuclear power production, ERDA 76/1

[100]Dones R et al GABE: Environmental Inventories for future electricity supply systems for Switzerland, PSI report 96-07, February 1996

[101]Vattenfall (2005) Vattenfall AB Generation Nordic Countries – Certified Environmental Product Declaration of Electricity from Forsmarks Kraftgrupp AB (FKA). S-P-00021, June, 2004. Updated 2005. http://www.vattenfall.de/www/vf_com/vf_com/Gemeinsame_Inhalte/DOCUMENT/360168vatt/386246envi/2005-EPD- FKA.pdf

[102]BE (2005) British Energy, "Carbon footprint of the nuclear fuel cycle – Environmental Product Declaration of Electricity from Torness Nuclear Power Station – Technical Report". AEA Technology Environment, London, UK. Retrieved from http://www.british-energy.com/pagetemplate.php?pid=251

overheads (including the interest on capital during the construction) converted into the equivalent amount of energy with the use of an energy-intensity coefficient for the economy of a given country. A simple method, but rather imprecise. It gives strongly overestimated results especially in the case of construction of a nuclear power plant, for which the costs of human labour at the engineering stage and the costs of ensuring quality are very high but do not entail such energy outlays as production of steel pipes or chemicals. Interest on capital during construction also strongly influences the costs of the plant, however with no energy inputs.

Such method of calculation of energy input for the construction of a NPP is criticised but specialists, also in renewable energy (ISA[103]). According to the ISA Study of the University of Sydney, the analyses based on conversion of the total financial costs into energy should be rejected. The ISA indicates that both the process of construction as well as decommissioning of a NPP cover great costs connected with the site to be obtained and land costs, court proceedings, permits, licencing, delays, fees, taxes, insurance, interest on capital, and remote demolition of the NPP at decommissioning.

In the case of power plants commissioned in the USA in the 90's, the results in consideration are additionally distorted because of long periods of suspension of the construction during court proceedings and administrative procedures withholding the startup, and interest on the capital invested in the construction needed to be repaid month after month. Not accounting for the above conditions when converting the NPP costs, the values of energy inputs will be highly overestimated, as in analyses by SLS. The results obtained by SLS indicate energy cost of construction amounting to 25,000 GWh/GWe, which means that the period of repayment of the energy debt incurrent for the construction would be 25000/7200 = 3.5 years. On the other hand, Vattenfall, in the Environment Product Declaration for Forsmark NPP published that the energy needed to construct a 1000 MWe unit totalled 4 PJ(t), which means that the energy dent will be repaid during approx. 1.5 months.

Dones give the range of CO emission for a NPP as 5-12 g(CO -eq)/kWh[104], whereby the bottom limit corresponds to centrifugation, and the top one to gaseous diffusion in enrichment. Energy necessary for construction and decommissioning of a NPP according to Dones totals 7.6 PJ(t) /GWe. This value is very close to the one provided by Vattenfall for Forsmark NPP. The British government, in the White Paper of January 2008, stated: "Our life cycle assessments for CO_2 emissions based on such documents as Vattenfall and Torness NPP reports are conducted with a large safety margin, prudent and easy to defend".

2.5.2. Decommissioning of a nuclear power plant

According to ISA, at the end of the life cycle, a typical power reactor contains approx. 10,000 tons of intermediate and high-level radioactive waste, approx. 10,000 tons of low-level and intermediate radioactive waste, and approx. 100,000 tons of inactive waste[105]. Radioactive materials must be disposed as enrichment waste, spent fuel and fission products, in accordance with the radioactivity level. Most activity, because as much as 99% is contained in high-level waste[106]. According to the ISA

[103]University of Sydney, Australia Life-Cycle Energy Balance and Greenhouse Gas Emissions of Nuclear Energy in Australia, Integrated Sustainability Analysis 3 November 2006

[104]Dones R. Critical note on the estimation by Storm van Leeuwen J.W. and Smith P. of the energy uses and corresponding CO2 emissions from the complete nuclear energy chain, PSI, 10.04.2006

[105]Thierfeldt S. Freigabegrenzwerte für Reststoffe. atw 1995; 40(4) 257-261

[106]International Atomic Energy Agency. Nuclear power: An overview in the context of alleviating greenhouse gas emissions. Supporting document to the Second Assessment Report of the Intergovernmental Panel on Climate Change, Life- Cycle Energy

study, the energy input for decommissioning of a nuclear power plant may be based on the pessimistic assumption of WNA[107] as equal to 35% of the energy input necessary for the construction of the reactor.

For the commercial HTR in Hamm-Uentrop, construction costs with inflation included totalled 7000 thousand DM, and costs of disassembly—642 thousand DM. For the commercial SNR-300 fast breeder in Kalkar, the costs of decommissioning amounted to 3% of the investment outlays. ISA authors admit that in large NPP, decommissioning costs shall constitute approx. 10% of the construction costs. This opinion is in line with the technical assessments prepared as part of IAEA works for a number of WWERs with capacity of 440 MWe and 1000 MWe. WNA presents five figures describing energy outlays for decommissioning of a NPP, between 4.3 PJ and 6.2 PJ[108]. With the energy inputs assumed at the level of 4,100 GWh_{th} ≈ 15 PJ, decommissioning shall constitute approx. 35% of the construction outlays.

In the opinion of SLS, the NPP decommissioning costs ratio totals 200% of the construction costs, and it should be multiplied by the average national energy-intensity in order to obtain the energy input. ISA authors reject such approach.

2.5.3. Disposal of radioactive waste

SLS argued that Vattenfall's declaration on the energy input for NPP decommissioning lack figures defining the input of energy necessary to carry out process which were not implemented so far, e.g. deep storage of radioactive waste. This is false, as Sweden developed a project of deep radioactive waste repository, which is a results of 20 years of work. Energy inputs in consideration were provided in a spreadsheet posted on http://nuclearinfo.net, and their value is based on the results of these works. Similar figures are provided by Dones on the basis of the data contained in a Swiss study on the anticipated costs of underground storage of high-level waste from Swiss NPPs.

The amount of energy, 92 GJ/t, used to dispose high-level waste, i.e. storage of fuel and storage and transport of radioactive waste, was determined on the basis of cumulated demand for energy for temporary storage, given the amount of waste of 5700_3 (high-level), and 28300 m_3 (intermediate level and low-level), whereby the volumes already include waste storage containers. Dones' data[109] were taken from a Swiss project study for temporary radioactive waste storage facilities. SLS postulate that the energy needed for disposal shall reach 1300 GJ/t of high-level waste, which is many times more.

In the case of disposal of intermediate level waste, SLS say that the energy amount necessary to dispose waste is 4300 GJ/m_3, while according to Dones, it is 22 $GJ(t)/m_3$. The energy necessary to dispose high-level waste according to SLS is 5000 GJ/m_3 of high-level waste, whereby according to Dones it is 260 GJ/m_3.

The amount of waste after centrifugation was assumed by SLS as significantly higher than after diffusion (4 times higher), which is justified neither technically nor physically. In result of this approach, the value obtained is four times higher than the value provided by Urenco in the Environment Product

and Greenhouse, IAEA-TECDOC -793. Vienna, Austria: International Atomic Energy Agency, 1995.

[107]World Nuclear Association: Energy analysis of power systems. Information Paper 11, London, UK, 2006

[108]Storm van Leeuwen J.W. and Smith P., "Nuclear Power: the Energy Balance". Updates 2005. Retrieved from http://www.stormsmith.nl/

[109]Dones R. Critical note on the estimation by Storm van Leeuwen J.W. and Smith P. of the energy uses and corresponding CO2 emissions from the complete nuclear energy chain, PSI, 10.04.2006

Declaration[110]. In the work by SLS, [111] the volume of radioactive waste from decommissioning of a NPP was estimated at 93900 m^3. The official evaluations of the operators of Swiss NPPs, performed before 1985 and used as input data to determine the total weight of radioactive waste requiring perpetual storage resulted in the following amounts: 7000 m^3 for PWR and 14000 m^3 for BWR (containers included). The most recent evaluations resulted in volumes below 5000 m^3 for PWR and below 10000 m^3 for BWR. (Direct information from designers, unpublished,

published in the work by Dones of 2007), therefore the amount of waste created at decommissioning of a NPP, assumed in SLS evaluation, is overestimated an order of magnitude when compared to the actual assessments.

2.5.4. Summary

From the above accounts and comparisons it stems that estimates concerning NPPs provided by the opponents of nuclear power are based on estimation methodologies which are criticised by specialist, also those dealing with power industry based on renewable energy sources, and figures contained in these analyses are significantly overestimated when compared to actual values. These overestimations occur at every stage of the fuel cycle.

To confirm the above, diagrams prepared for the Swedish nuclear power plant Forsmark and confirmed by relevant state authorities of the Swedish government are presented below (Figure 73).

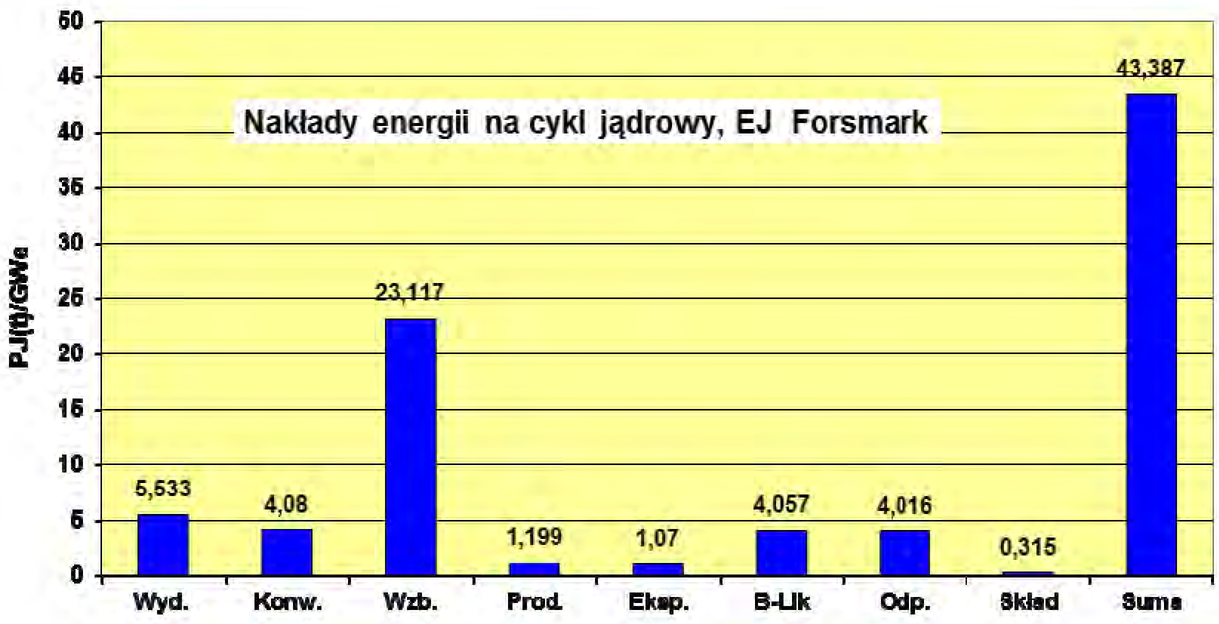


Figure 73. Energy input to the nuclear cycle, data according to the Environment Product Declaration for Forsmark NP[112].

---

[110] Dones R. (2003) Kernenergie. In Dones R. (Ed.) Sachbilanzen von Energiesystemen: Grundlagen für den ökologischen Vergleich von Energiesystemen und den Einbezug von Energiesystemen in Ökobilanzen für die Schweiz. Final report ecoinvent 2000 No. 6-VII. Paul Scherrer Institut Villigen, Swiss Centre for Life Cycle Inventories, Dübendorf, CH (2004). Retrieved from: www.ecoinvent.ch

[111] Storm van Leeuwen J.W. and Smith P., "Nuclear Power: the Energy Balance". Updates 2005. Retrieved from http://www.stormsmith.nl/

[112] http://www.nuclearinfo.net/ Nuclearpower/WebHomeEnergyLifecycleOfNuclear_Power/Energy per_lifecycle_phase_Ian_Martin_051124-1.xls

Abbreviations on the figure: **Wyd—extraction and purification of uranium, Konw—conversion into UF6, Wzb—enrichment, Prod—fuel production, Eksp—operation of NPP, B-Lik—construction and decommissioning of NPP, Odp—radioactive waste management, Skład—construction of waste repository.**

Emisje CO2 w cyklu życia dla EJ Forsmark
CO2 emissions in the life cycle for Forsmark NPP

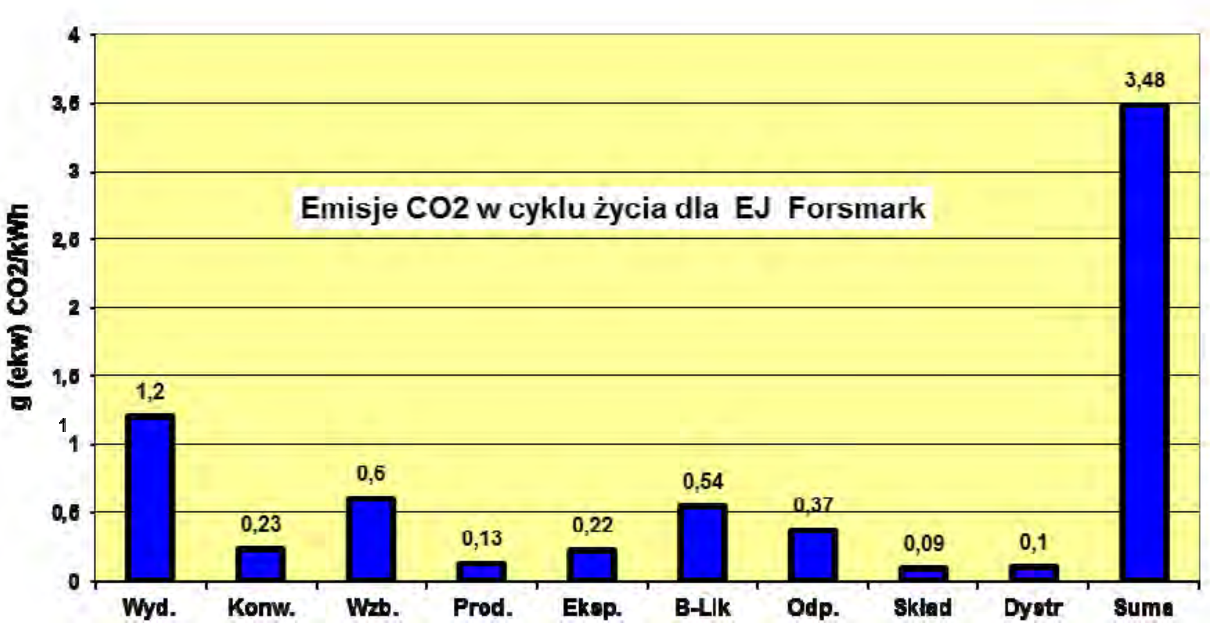


Figure 74CO_2 emissions in the life cycle for Forsmark NPP.

Emisje CO2 w cyklu życia dla EJ Forsmark
CO2 emissions in the life cycle for Forsmark NPP

The diagram showing the CO_2 emissions in the life cycle for Forsmark NPP (Figure 74) demonstrates that the highest CO_2 emissions occur in extraction of uranium, its enrichment, and construction and decommissioning of the nuclear plant. Under present operating conditions, these emissions in total are equal to only 3.5 grams CO_2 per hWh. It is a hundred times less than for gas plants. After the uranium ore deposits currently exploited are exhausted, the component connected with uranium extraction shall increase, but to a substantially lower level than suggested in works by Storm van Leeuven. While with no doubt one should expect a slight growth of CO_2emissions, nuclear power remains one of the energy sources with the lowest carbon dioxide emissions.

2.6. IMPACT RESULTING FROM THE OPERATION OF NUCLEAR POWER PLANTS

2.6.1. Discussion of concerns relating to possible radioactive contamination during standard operation and emergency states

During standard operation, 3rd generation reactors do not pose any threat. The amounts of radioactive emissions under standard operation conditions of various types of reactors (EPR, AP1000, ESBWR) are presented in sections 7.3.1 - 7.3.3 of the SEA Forecast, while the emissions were compared in section

7.3.4. Impacts connected with the emissions amounts discussed above, based on estimated doses of radiation for the exposed population under standard operation conditions of a NPP were also subject to a detailed analysis—the comparison of radiological impacts of reactors is contained in section 7.3.4.

The SEA Forecast mentions the possibility of accident in the nuclear industry outside Poland, as we must reckon with the possibility of failure of one of the old reactors. Even if radiation consequences of such an accident would be vanishingly small, they would induce an increased wave of social resistance. However, the effects of possible failures in reactors built in Poland would be very limited and local, because 3rd generation reactors do not pose a threat within a distance greater than 3 km, even in the case of accidents with core degradation.

Reactors built in Poland would have to meet the criteria provided for in the EUR, which limit the amount of emissions after an accident with core degradation to a level that does not have economic impact, so it does not result in suspension of cultivation and cattle grazing within any distance greater than the limited usage zone. For example, a UK EPR, in the event of a maximal design basis accident, with rupture of primary circuit, may cause releases of iodine I-131 totalling 1.2 10_{10} Bq and cesium Cs 137 totalling 2.1 10_{10} Bq within 168 hours after the accident (within a period of 7 days). These amounts are small and within a distance of 800 m from the reactor they will cause soil contamination on a significantly lower level than intervention levels for each it is necessary to undertake some actions to protect population or crops. The same applies to other design basis accidents—releases are small, e.g. after an accident with rupture of steam jet pipe, the release of iodine I-131 shall amount to 1.3 10_9 Bq and of cesium Cs-137 to 2.9 10_8 Bq. In the case of a severe accident with core degradation in an EPR, after the lapse of 720 hours (a month) from the accident, in line with section 14.6 PCSR[113] the release of iodine I-131 in three forms (aerosols, elemental form, and organic compounds) shall amount in total to 7.5 10_{12} Bq, and for cesium Cs 137 it shall reach 4.5 10_{11} Bq.

According to the resolution of the European Parliament, permitted levels of radioactive contamination of foodstuffs (Bq/kg) are as follows[114] (Table 11):

Table 16 Permitted levels of radioactive contamination of foodstuffs (Bq/kg) pursuant to the resolution of the European Parliament

Isotope	Food for children	Dairy products	Other	Liquid food
Sr-90	75	125	750	125
I-131	150	500	2 000	500
Cs-137	400	1 000	1 250	1 000

In accordance with the IAEA Derived Intervention Levels report[115], a 2000 Bq/l concentration of iodine I-131 in milk correspond to the dose of 5 mSv for children. Concentration of 150 Bq/kg, permitted according to the European Union standards, correspond to the dose of 5 x 150/2000 = 0,375 mSv.

Maximum daily effective doses in the case of design basis accidents at the boundaries of the limited usage zone shall occur in the case of accidents that occurred during manipulations with the fuel component with opened safety containment. In line with the safety report for EPR, within a distance

[113] UK EPR Pre-Construction Safety Report Chapter 16: Risk Reduction And Severe Accident Analyses Sub-Chapter : 16.2 Document ID.No. UKEPR-0002-162 Issue 04

[114] European Parliament legislative resolution of 15 February 2011 on the proposal for a Council regulation (Euratom) laying down maximum permitted levels of radioactive contamination of foodstuffs and of feedingstuffs following a nuclear accident or any other case of radiological emergency (recast) (COM(2010)0184 – C7-0137/2010 – 2010/0098(COD)), (2012/C 188 E/27)

[115] IAEA Derived Intervention Levels for Application in Controlling Radiation Doses to the Public inthe Event of a Nuclear Accident or Radiological Emergency, Safety Series No 81, IAEA Vienna 1986

of 500 m after a week from the accident, they shall be equal to 5.5 mSv, and within a distance of 5 km, 0.35 mSv.

In the case of a severe accident with core degradation, the effective dose for an adult or child, absorbed during 7 days is lower than 10 mSv already within a distance of 700 m from the reactor, and the effective dose absorbed within 50 years after the accident is lower than 10 msV within a distance of 1 km[116]. In both cases, reference is made to doses absorbed through all routes of exposure. While doses that can be important for agriculture shall be significantly lower (see figure below).

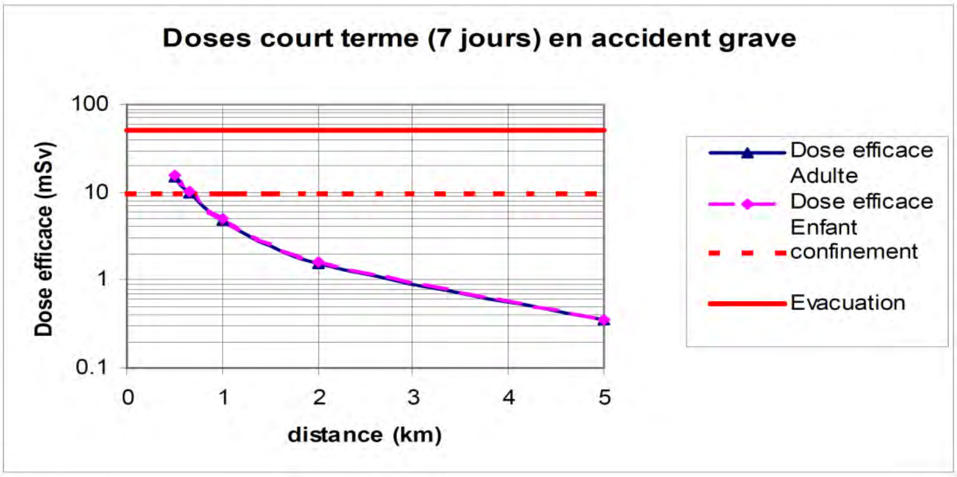


Figure 75. Doses absorbed during one week after a severe accident with core degradation in an EPR (description below).

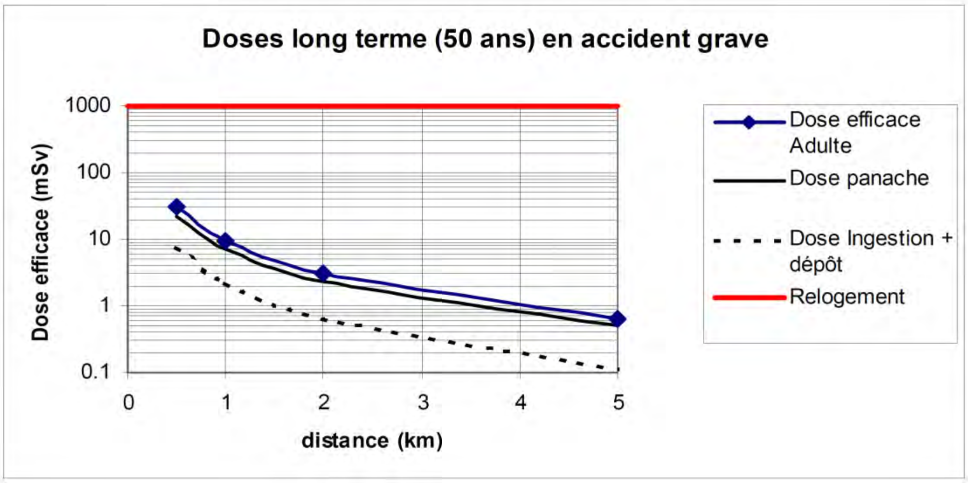


Figure 76. Doses after a severe accident with core degradation in a UK EPR[117] (description below).

Table 17. Key to figures:

Key	
Dose efficace adulte	*Effective dose for an adult*
Dose efficace enfant	*Effective dose for children*
Continement	*Containment*
Dose panache	*Dose from radiation cloud*
Dose ingestion + dépôt	*Dose from sediments and by ingestion*
Relogement	*Resettlement*
Distance	*Distance*

[116]UK-EPR Fundamental Safety Overview Volume 2: Design And Safety Chapter S: Risk Reduction Categories, Section S.2.3
[117] UK-EPR Fundamental Safety Overview Volume 2: Design And Safety Chapter S: Risk Reduction Categories, Section S.2.3

Doses efficaces (mSv)	*Effective doses (mSv)*

The size of doses caused after a severe accident with core degradation of a UK EPR by sediments and by ingestion decreases below 1 mSv already within a distance of 1.5 km from the reactor, and below 0,375 mSv within 3 km. As it can be seen, even a severe accident in an EPR will not cause a threat or restrictions in consumption of agricultural products in neighbouring countries.

The examination of ICRP guidelines, according to which doses for population should not exceed 1 mSv/year during standard operation of a reactor (Polish Supervision of Nuclear Safety established a significantly lower limit of 0.3 mSv/year—which is consistent with the current supervisory practices in the EU member states) confirms that neither standard operation of an EPR, nor design basis accidents, or even severe accidents with core degradation shall cause surface contamination resulting in any intervention in the neighbouring countries.

In the case of AP1000 reactor or boiling water reactors (ABWRs and ESBWRs), the doses would be somewhat different and the boundaries of the limited usage zone would run in slightly greater distance from the reactor, but full safety of terrain in neighbouring countries would be also ensured. Specific calculations of doses in the case of various types of accidents in the reactor type to be carried out shall be presented on the next stage, when the site for the first nuclear power plant will be defined and the reactor to be built in Poland will be chosen. At the present, quoting full estimates for all possible sites and reactors does not make sense, but the assessments for the reference reactor (EPR) show that 3rd generation reactors ensure general limitation of accident effects to the territory of the country where they are erected.

2.6.2. Discussion of the objection relating to the insufficient examination of radiation impact in the SEA Forecast

The Ministry of Economy does not agree with the opinion that the radiation impact was not sufficiently examined. The impact is described in the SEA Forecast in great detail and cover standard operation, design basis accidents, and severe accidents. The level of detail of the assessments presented in the SEA is markedly higher than applied usually at the so-called initial stage of works. It is possible thanks to safety reports for individual reactor types, submitted to nuclear safety committees in other countries. When a reactor type is selected, and the Polish Office for Nuclear Supervision receives a safety report for a specific location and selected reactor, the estimates contained presently in the SEA shall be complemented.

2.6.3. Discussion of the objection relating to not taking into account the critical opinions related to the impact of nuclear power plants

The assessment of safety of nuclear power plants is conducted by nuclear supervision offices on the basis of a safety report submitted by the investor and initially evaluated by independent experts. Such assessment process will be also conducted in Poland. It will take into account all critical remarks on the analysed reactor type. But as for now, without tender proposals submitted, or—more obvious—safety reports of 3rd generation to be installed in Poland—any criticism would be premature. Since safety requirements in Poland are more strict than in many other countries, it should be expected that the reactor solutions proposed will feature additional safety properties so as to meet the Polish requirements. At the present stage we may assure, however, that all critical remarks relating to the reactors under consideration shall be carefully analysed.

2.6.4. Discussion of controversies on the health impact assessment for small radiation doses, contained in the Forecast

The action of small radiation doses has been discussed for many years by, on the one hand, supporters of the theory of a linear, direct threat caused by radiation, and on the other hand—by scientists relying on numerous experiments and observations from various regions of the world, where despite elevated radiation doses no negative consequences for health were discovered, and even to the contrary—it was established that people in those regions have cancer less often. The Forecast presents a couple of examples of such results, but they are by no means the only data concerning actual populations. The observations collected relate to large groups of people and long time periods, e.g. in the case of China, approx. 100,000 citizens exposed to elevated radio-background are subject to studies, and the observations already cover 30 years. Although despite such a great amount of observations these results are not sufficient to prove statistically that the radiation does not negatively influence people, the results are in general below the level posing a threat of raising cancer incidence in control areas with lower radiation level. This was brought to attention already by UNSCEAR in 1994, and the Committee recommended further studies with the theory of hormesis taken into account.[118]

In December 2012, the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) presented, to the General Assembly of the UN, a conclusion from many years of work of the Committee: small radiation doses no not cause any detectable risk for human health, or for surrounding environment. UNSCEAR found that at doses below 100 mSv absorbed when the dose strength is small, it does not make sense to predict future health damages. The existing practice of conversion of small doses absorbed by many people to the number of health effects is not scientifically justifies and should not be applied. In accordance with a theorem of the famous medieval physician—Paracelsus—it is the dose that determines whether a thing is harmful for the organism or not[119].

A billion of years ago, when the cells developed of which our organisms are made today, doses were significantly higher than at present. The cells that came into being had to be equipped with defence mechanisms, or they would have perished long ago. Therefore one may expect that even our organisms are able to withstand natural radiation, even much higher than it is present today. Indeed, UNSCEAR reminds year after year that in many regions of our globe there are people who receive radiation doses from natural sources which are higher than average, and even higher than in areas contaminated after the Chernobyl accident. And those people do not suffer from cancer more frequently than people dwelling in areas of lower radiation.

The supporters of hormesis as an important factor of defence against radiation point out to many studies which show that radiation stimulates our defence skills. And these skills protect us not only from radiation, but also from effects of other harmful factors—and result in a strengthening of the body's resistance to carcinogenic processes.

[118]United Nations. Sources and Effects of Ionizing Radiation. United Nations Scientific Committee on the Effects of Atomic Radiation, 1994 Report to the General Assembly, with scientific annexes. United Nations sales publication E.94.IX.11. United Nations, New York, 1994

[119] „ Omnia sunt venena, nihil sine veneno. Solo dosis facit venenum", http://en.wikipedia.org/wiki/Paracelsus

The Forecast does not propose a position in this matter and the Ministry of Economy does not intend to name the true theory. The authors of PNPP are of the opinion that in order to obtain a full picture one cannot be blind to many studies that indicate harmlessness of small doses for people, but when selecting the reactor and setting the principles of its operation, the Ministry of Economy always adheres to the principle of maintaining the radiation doses as low as reasonably achievable –ALARA.

The main principle of radiological protection, ALARA, is adopted as the basis for radiological protection in Poland and when examining reactor designs for the first Polish nuclear power plant, doses caused by operation and possible accidents in nuclear plants are examined with the aim of making them as low as reasonably achievable. At present, ALARA is applied to compare technologies and protection options. On the other hand, the approach to LNT model and the concept of collective dose stemming therefrom has changed in the recent years. In the report entitled "Recommendations of ICRP – 103" of 2007 (which replaces earlier reports from the 90's), ICRP recommends refraining from any calculations related to the number of deaths in the scope of low doses with the use of "collective dose". The society of radiological protection experts responded to this with appreciation[120].

According to the report of UNSCEAR on the impact of Chernobyl accident, published in 2011,[121] more than 6 million of dwellers of the regions around Chernobyl that were considered contaminated received average doses of 9 mSv during 20 years in 1986-2005, and 98 million people in three countries received at the average a dose of 1.3 mSv. This is an insignificant increase when compared to doses absorbed in result of natural radio-background in this period, which is 50 mSv. UNSCEAR states that while there are signals that doses above 0.1 Sv under conditions of sudden irradiation of large population do cause a growth in cancer incidence and number of deaths of cancer, inasmuch neither the study of health of the persons who survived nuclear explosions, nor any other studies on adults provide evidence to any growth of carcinogenic effects at significantly lower doses. The models used to assess the impact of radiation, listed by UNSCEAR, include not only the LNT model, but also other ones, along with models that assume hormesis. The Committee states that "current epidemiological data provide no grounds to assume higher cancer incidence and cancer mortality rates in cohorts of residents in areas of the three republics and other European countries who received cumulated average doses below 30 mSv within 20 years. In "General conclusions", UNSCEAR writes about only 2 deaths during firefighting and 28 deaths resulting from severe irradiation of rescuers, adding that "*although further 19 rescuers died until 2006, their deaths resulted from various causes, usually without connection with radiation exposure*". In addition to the increased leukemia and cataract incidence in persons who received high doses, there are no other health effects which should be attributed to radiation.

Also the directive of the European Union, adopted on 29 September 2011[122] , mentions neither the collective does, nor the LNT concept. It should be clearly said that the SEA Forecast does not take a position as to whether the LNT hypothesis is true or false. It is a subject of scientific disputes which shall probably remain unsettled for many years. In practice, however, nuclear specialists in any country, and certainly in Poland, consistently apply the ALARA principle and this principle shall be the basis of

[120]Evolution of the System of Radiological Protection. Discussion of New ICRP Recommendations. Fourth Asian Conference, Tokyo, 13-14 December, 2007. OECD 2009, NEA No. 3636

[121]Sources and Effects of Ionizing radiation, UNSCEAR 2008 Report to the General Assembly with Scientific Annexes, Vol. II, Annex D, United Nations, New York 2011

[122] COUNCIL DIRECTIVE laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, Brussels, 29.9.2011, COM(2011) 593 adopted by the European Commission on 29 September 2011, http://ec.europa.eu/energy/nuclear/radiation_protection/doc/com_2011_0593.pdf

radiological protection also in Polish nuclear power plants.

Statements relating to the possible hormesis phenomenon, contained in the SEA, are made as part of the realistic assessment of the effects of small radiation doses on large populations, confirmed with hundreds of studies. These studies concerned an increased natural radio-background (e.g. in US regions with high radio-background[123] [124][125] [126] Yiang-jiang region in China[127], Kerala in India[128], Ramsar in Iran[129], Guarapari in Brazil), as well as additional doses absorbed by people exposed professionally (Shippingport yard employees[130], British radiologists[131], nuclear industry employees[132][133]), patients subjected to diagnostic irradiation or treated with the use of radiation[134][135] etc.

The studies conducted included also case-control studies e.g. studies on the impact of radon on lung cancer, as part of which 200 cases of incidence along with 397 control cases were examined, leading to results indicating significantly lower lung cancer mortality rates among people living in homes with radon concentration increased to approx. 75-100 Bq/m^3, given the reference level below 25 Bq/m^3 [136] (see figure below).

[123]FRIGERIO, N.A., STOWE, R.S., “Carcinogenic and genetic hazards from background radiation”, in: Proc. of a Symp. on Biological Effects of Low-Level Radiation Pertinent to Protection of Man and His Environment , (Chicago 3-7 Nov. 1975), IAEA, Vienna (1976)

[124]HICKEY, R.J. et al. Low level ionizing radiation and human mortality: multi-regional epidemiological studies, Health Physics, Vol. 40, (May 1981) 625-641

[125]Sandquist G.M. et al., Assessing Latent Health Effects from U.S. Background Radiation, Proc. of ANS Meeting, Nov. 1997

[126]JAGGER J. Natural Background Radiation and Cancer Death in Rocky Mountain States and Gulf Coast States, Health Physics, October 1998, Vol. 75, No 4, 428-430

[127]Sun Q, et al.:: Excess Relative Risk of Solid Cancer Mortality after Prolonged Exposure to Naturally Occurring High- Background Radiation in Yangjiang, China, Radiation Res. (Tokyo) 41, (2000) Suppl 433-52

[128]Nair MK, et al., Population study in the high natural background radiation area of Kerala, India. Radiat Res. 152, 145- 148S, 199

[129]S. M. J. Mortazavi1 and P. A. Karam High Levels of Natural Radiation in Ramsar, Iran: Should Regulatory Authorities Protect the Inhabitants? http://www.angelfire.com/mo/radioadaptive/ramsar.html

[130]MATANOSKI, G.M., “Health effects of low-level radiation in shipyard workers- final report”, DOE DE-AC02-79 EV 10095, US Dept. of Energy, (1991).

[131]Berrington A, Darby SC, Weiss HA, Doll R. 100 years of observation on British radiologists: mortality from cancer and other causes 1897- 1997. Br J Radiol 2001;74:507, 19

[132]CARDIS E. et al., “Combined analysis of cancer mortality among nuclear industry workers in Canada, UK and the USA”, IARC Techn. Report No. 25, Lyon, (1995).

[133]Fornalski, K. W. and Dobrzyński, L., Ionizing radiation and health of nuclear industry workers, Int. J. of Low Radiation, vol. 6, no 1, 2009, pp. 57-78 oraz Lagarde F.: Tiny excess relative risks hard to pin down, 5 August 2005, BMJ, http://www.bmj.com/cgi/eletters/bmj.38499.599861.E0v1#114265

[134]P., et al., Thyroid cancer after diagnostic administration of Iodine 131, Radiation Research,. 145 (1996) 86-92

[135]Howe G.R., 'Lung cancer mortality between 1950 and 1987 after exposure to fractionated moderate dose rate ionizing radiation in the Canadian fluoroscopy cohort study and a comparison with lung cancer mortality in the atomic bomb survivors study', Radiation Research, 142, p295—304, 1995

[136]Thompson RE, Nelson DF, Popkin JH, Popkin Z. Case-control study of lung cancer risk from residential radon exposure in Worcester county, Massachusetts. Source http://www.ncbi.nlm.nih.gov/pubmed/18301096

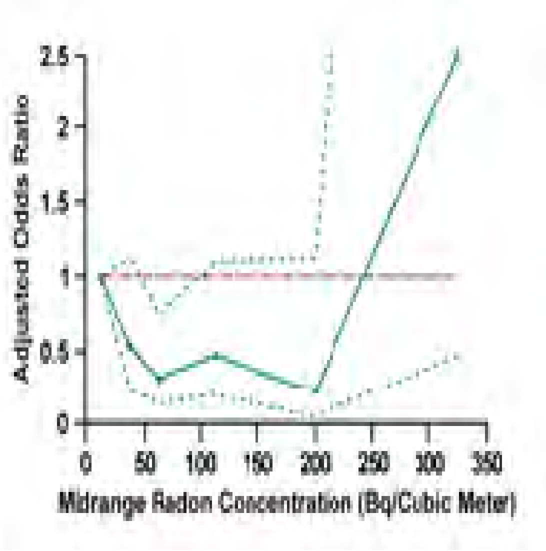


Figure 77. Relative probability of death in result of lung cancer depending on exposure to radon, Thompson's research in Worcester County.

There are many such results and they cannot be omitted in discussion of the effects of small radiation doses. When trying to limit as much as possible all radiation doses caused by power industry, it is at the same time reasonable to inform the population about the results of existing research on the effects of small radiation doses, which indicate that such radiation does not have any detectable negative health effects.

2.6.5. Leukemia incidence in the vicinity of nuclear power plants

Clusters of leukemia occur in areas with temporary higher density or high rotation rate of residents. They were also observed near some nuclear power plants and the nuclear fuel reprocessing plant in La Hague, France, and Sellafield, United Kingdom. In the case of Sellafield, very extensive studies have been conducted for many years without success in finding any connection of the cases of leukemia with radiation, and in May 2011, the COMARE scientific committee, established many years ago by the British government stated finally that radiation of nuclear facilities does not cause any increase in leukemia incidence [137].

In France, allegations aimed at nuclear fuel reprocessing plant COGEMA in La Hague were made by Prof. Viel who said that he detected growth in leukemia incidence among youth below 25 years of age, residing within a distance of up to 35 km from the facilities. He published a hypothesis that this growth is a result of radiation emitted by radioactive waste from La Hague plants. The incidence growth detected was minimal. The total number of cases confirmed in the population observed in 1979-96 was 4, whereas the number expected on the basis of average incidence in France was 2. This difference is not statistically significant, but since the allegation was aimed against nuclear power, it caused great concern. In response the minister of environment protection and the secretary of state for health matters in France created a scientific committee to examine this issue.

The Committee determined that the total number of leukemia cases which could be, in theory (based on the hypothesis that each dose is harmful—LNT), caused by liquid radioactive waste released in

[137]Nuclear power plants cleared of leukaemia link, Nature, 6 May 2011, http://www.nature.com/news/2011/110506/full/news.2011.275.html

standard conditions from the nuclear fuel reprocessing plant, is 0.0009 cases among the whole exposed population over the entire time period of operation of the facilities. Moreover, in the period from 1979 to 1996, emergency releases were noted which could cause an additional 0.0001 cases, and fire in a silo, which could cause 0.0001 cases. The total contribution of standard and emergency releases from the facilities could cause 0.0014 cases of leukemia. The results of works of the Committee show that radioactive releases from La Hague plant were not the reason for increased leukemia incidence in children near the plant.

The situation is similar in the area of the nuclear fuel reprocessing facilities in Sellafield. The cluster of increased leukemia incidence in children was detected in Seascale, near the facilities. A number of studies showed that the cases do not result from emissions of radioactive substances from Sellafield plant, and that similar clusters exist in various regions of the world. When in 1990–1992 a hypothesis was put forward that the leukemia incidence growth could be a result of a mutation of reproductive cells in fathers professionally exposed to irradiation, large-scale control examination were undertaken to verify it. The study included 35,949 children with cancer, and more than 120,000 employees registered in the British register of persons professionally exposed to irradiation.

The results demonstrated that there is no cause and effect connection between radiation doses received by parents and leukemia and non-Hodgkin's lymphoma in children. In particular, no evidence was found for the growth of risk among fathers who absorbed cumulated doses before the conception of a child, exceeding 100 mSv, or among those who received 10 mSv or more in the period of 6 months before the conception. The occurrence of leukemia clusters can result from lowered resistance and increased exposure to infection in result of population movements and mixing[138]. This hypothesis was supported by the British National Radiological Protection Board.

The growth in incidence of childhood leukemia and non-Hodgkin's lymphoma in regions where mixing of the population is significant was also observed by the eminent British physician and epidemiologist, sir Richard Doll[139]. He found that in new towns coming into being in former rural areas, in populations where parents had to commute to work leaving their existing place of residence, in new towns and cities coming into being on the North Sea coast, where oil industry and natural gas extraction facilities were built, similarly as around the new residence centre near Sellafield, the incidence of leukemia in children aged between 0 and 14 was higher than the national average. The average proportion of the number of confirmed cases to the expected number of cases in a given population (on the basis of known national average) was from 1.4 to 1.6, and in the highest-risk settlements, it reached 14. For comparison, within 10 km from Sellafield, the average number was 1.5, and the maximum value 11.5.

Also studies conducted in the USA confirm that in district characterised with substantial migration of population there are statistically significant elevated incidence levels of childhood leukemia.

Kinlen put forward a hypothesis that in high-inflow populations, the group resistance for infectious factors drops. This is confirmed by the results of studies conducted in a number of new British towns (Figure 78).

Professor Doll confirmed the Kinlen's hypothesis on the influence of population mixing on lowered

---

[138] Kinlen L. Epidemiological Evidence for an Infective Basis in Childhood Leukaemia: in "The Royal Society of Edinburgh's Symposium 'Leukaemia Clusters' 7 Dec. 1994.

[139] Doll R. The Seascale cluster: a probable explanation. Br J Cancer 1999; 81:1-3 [Medline]

resistance to individual leukemia types. The opponents of nuclear power attacked these observations saying that e.g. on the North Sea coast, the reason of growth of incidence among children was the exposure of parents to irradiation that occurred when welds were checked with the use of radiographic methods. However, this search for radiation roots of increased leukemia incidence in clusters of mixed population was definitely rejected when it turned out that the incidence of childhood leukemia had also increased by approx. 50% during the World War II in rural areas, where large number of people arrived, evacuated from towns in result of bombings.

Studies conducted in the United Kingdom in relation to the increased childhood leukemia incidence observed in various regions, Sellafield region among them, showed that the significant cause in to irradiation of parents, but mixing of municipal and rural population[140]. A significant increase in leukemia incidence was observed it such diverse situations connected with mixing of population as creation of new towns in rural areas[141], inflow of recruits to military camps in rural areas[142], in northern region of Scotland influenced by development of oil extraction from the North Sea[143], in regions of new construction projects (non-nuclear)[144], and even in rural areas where large numbers of children arrived, evacuated from regions at risk of bombardment during World War II[145]. A summary of ratios in the form of O/E proportion—(O: number of observed case; E: number of expected cases) is presented in (Table 18).

Table 18. The growth in incidence of childhood leukemia and non-Hodgkin's lymphoma (O/E) in regions where mixing of the population is significant[146]

Region	Whole area O/E (o_x)		Region of the highest risk	
New towns in rural areas	1.6	(23)	7.0	(3)
Commuting to work, growth	1.5	(79)	>7.0	(6)
Oil industry (North Sea)	1.5	(48)	14.4	(2)
Construction centres in rural areas	1.4	(130)	7.9	(5)
Sellafield region up to 10 km, 1950-83	1.5	(13)	11.5	(7)
Sellafield region up to 10 km, 1984-93	1.9	(5)	6.7	(1)

O_x Number of cases observed, aged 0-14, is provided in brackets

[140] Kinlen L. Epidemiological Evidence for an Infective Basis in Childhood Leukaemia: in "The Royal Society of Edinburgh's Symposium 'Leukaemia Clusters' 7 Dec. 1994

[141] Kinlen LJ, Clarke K, Hudson C. Evidence from population mixing in British New Towns 1946–85 of an infective basis for childhood leukaemia. Lancet. 1990;336:577–582. [PubMed]

[142] Kinlen LJ, Hudson C. Childhood leukaemia and poliomyelitis in relation to military encampments in England and Wales in the period of national military service, 1950–63. BMJ. 1991;303:1357–1362

[143] Kinlen LJ, O'Brien F, Clarke K, Balkwill A, Matthews F. Rural population mixing and childhood leukaemia: effects of the North Sea oil industry in Scotland, including the area near Dounreay nuclear site. BMJ. 1993;306:743–748

[144] Kinlen LJ. Epidemiological evidence for an infective basis in childhood leukaemia. Br J Cancer. 1995;71:1–5. [PMC free article] [PubMed]

[145] Kinlen LJ, John SM. Wartime evacuation and mortality from childhood leukaemia in England and Wales in 1945–9. BMJ. 1994;309:1197–1202

[146] Doll R. The Seascale cluster: a probable explanation. Br J Cancer 1999; 81:1-3[Medline].

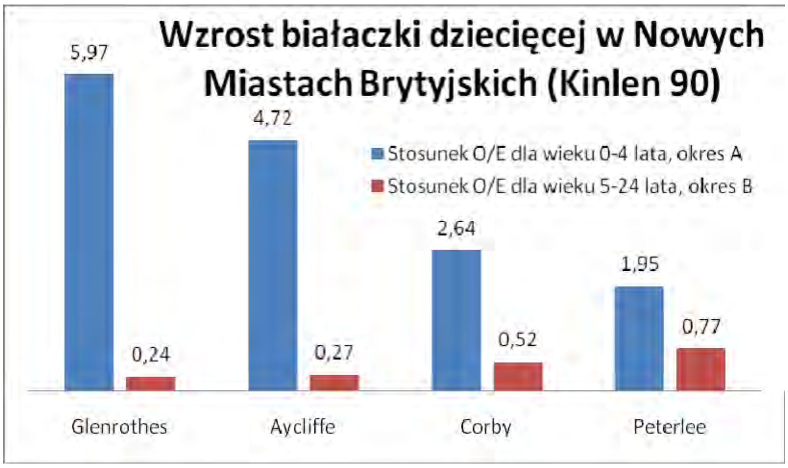


Figure 78. Results of British studies show the influence of population mixing in the emerging new towns [147]

Wzrost białaczki dziecięcej w nowych Miastach Brytyjskich (Kinlen 90)	
Growth in childhood leukemia incidence in new British towns (Kinlen 90)	
Stosunek O/E dla wieku 0-4 lata, okres A	O/E proportion for the age of 0-4 years, period A
Stosunek O/E dla wieku 5-24 lata, okres B	O/E proportion for the age of 5-24 years, period B

Another reason is social status of families in which leukemia occurs. Stiller and Boyle from the University of Oxford and from the University of Leeds[148] analysed in detail not only the impact of migration, but also the influence of social status of families. As measures of this status, they adopted three indicators—employment, owning a car, and owning a house. The studies covered more than 400 administrative regions, divided into three groups—with the lowest, average, and the highest migration intensity, and other socioeconomic indicators. It turned out that given the average incidence rate for ALL (acute lymphoblastic leukemia) of 48.7 cases per million among children aged 0-4 years, the average incidence in regions with the lowest migration totalled 43.4, in those with average migration—49.5, and in regions with the highest migration rate—56.1. Examination of migration ratios for children alone gave a similar result—the incidence totalled, correspondingly 41.3, 50.3, and 54.1 yearly/million. Other socioeconomic factors were of lesser significance, but the difference in leukemia incidence between the lowest and the average socioeconomic group was also significant. British observations are in accord with data from the USE, where clusters of childhood leukemia were observed in many towns inhabited by immigrant population, e.g. in Fallon, where the yearly number of new recruits in military base reaches 50,000[149][150]. Outside the United Kingdom, a number of studies confirmed the impact of population mixing on forming of leukemia clusters with no link with radiation, including studies in Ontario, Canada[151], Hong Kong[152], near La Hague, France[153], in Greece[154] and in the USA[155]).

[147]Kinlen L.J., Clarke K., Hudson C. Evidence from population mixing in British New Towns 1946-85 of an infective basis for childhood leukaemia, The Lancet, Vol. 336, p. 577-582, Sept. 8, 1990

[148]C.A.Stiller , O.J.Boyle Effect of population mixing and socioeconomic status in England and Wales, 979-85, on lymphoblastic leukaemia in children, BMJ 1996, 313: 1297-1300, /23 November

[149] Kinlen L, Doll R. Population mixing and childhood leukaemia: Fallon and other US clusters. Br J Cancer. 2004;91:1–3. [PMC free article] [PubMed]

[150] Probability Estimates for the Unique Childhood Leukemia Cluster in Fallon, Nevada, and Risks near Other U.S. Military Aviation Facilities Craig Steinmaus, Meng Lu, Randall L. Todd, Allan H. Smith Environmental Health Perspectives, Vol. 112, No. 6 (May, 2004), pp. 766-771

[151] Koushik A, King WD, McLaughlin JR. An ecologic study of childhood leukaemia and population mixing in Ontario, Canada. Br J Cancer. 2001;86:483–490

[152] Alexander FE, Chan LC, Lam TH, Yuen P, Leung NK, Ha SY, Yuen HL, Li CK, Li CK, Lau YL, Greaves MF. Clustering of childhood

The studies on childhood leukemia clusters listed above show that such clusters emerge in diverse regions, without connection to nuclear plants or other nuclear facilities. The work by Kinlen, published in 2011, contains full justification of this statement[156].

Therefore, the actual radiation exposure data for population in France and in the United Kingdom do not confirm the hypothesis about the radiation influencing the incidence of leukemia.

In Germany, studies were conducted three times. Two of them, focused on comparison between the incidence rate in the surrounding areas of NPPs, was conducted, in line with good scientific practices, by the German Childhood Cancer Registry. The first study accounted for the incidence of all cases diagnosed between 1980 and 1990 for persons living within a distance of 15 km from any of 20 NPPs in Germany in comparison with equivalent regions of similar demography. The main goal was to examine the incidence rate among children aged 0-14. No connection between proximity of residence to a NPP in an increased risk of leukemia was ascertained.

The second study covered data from 1991-1995. Its aim was the same. The results of the first study, concerning leukemia in children below 5 years of age, living within a distance of 5 km, were verified, and the incidence rates turned out to be somewhat lower than in the first study, and statistically insignificant[157].

The third study was conducted in the end of the 20th century. At its initial stage, a group of government experts excluded a number of facilities from the analysis, namely research reactors in Kahl, Jülich and Karlsuhe, high-temperature reactor in Hamm and NPP in Mühlheim-Kärlich. Further, instead of a two-tailed test—as part of which both the results that are higher as well as lower than the average are tested—a one-tailed test was applied, in which all results lower than the average are considered random errors and rejected. The results were compared with the average for the whole population in Germany.

Similarly as in the preceding studies, the examination of all cases of cancer in children below 5 years of age, living within a distance of 5 km, as part of a two-tailed test, did not indicate an increased risk, as the results were statistically insignificant. While with the use of a one-tailed test it was possible to demonstrate a growth of risk for a selected population of nuclear facilities.

It should be added, that—according to G. Dallal, the Head of Biostatistics Team at the Tufts University in Boston: "The property which causes most of the experts in statistics to reject the one-tailed test in the assumption underlying it, that all differences in unexpected direction—small and large—must be

leukaemia in Hong Kong: association with the childhood peak and common acute lymphoblastic leukaemia and with population mixing. Br J Cancer. 1997;75:457–763. [PMC free article] [PubMed]

153 Boutou O, Guizard AV, Slama R, Pottier D, Spira A. Population mixing and leukaemia in young people around the La Hague nuclear waste reprocessing plant. Br J Cancer. 2002;87:740–745. [PMC free article] [PubMed]

154 Kinlen LJ, Petridou E. Childhood leukaemia and rural population movements: Greece, Italy, and other countries. Cancer Causes Control. 1995;6:445–450. [PubMed]

155 Wartenberg D, Schneider D, Brown S. Childhood leukemia incidence and the population mixing hypothesis in US SEER data. Br J Cancer. 2004;90:1171–1776

156 L. Kinlen Childhood leukaemia, nuclear sites, and population mixing, Br J Cancer. 2011 January 4; 104(1): 12–18. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3039801/

157 Peter Kaatsch et al.: Epidemiologische Studie zu Kinderkrebs in der Umgebung von Kernkraftwerken (KiKK Studie) UMWltforschungsplan des BundesuMWltministerium (UFOPLAN)N Reaktorsicherheit und Strahlenschutz Vorhaben Stsch 4334 2007 Bundesamt fur Strahlenschutz

treated as simply insignificant. I have never seen a situation—writes Dr Dallal—where scientists consented to that in practice... It is amazing when one sees one-tailed tests used in the 21st century."[158] It should be highlighted, that Dr Dallal has nothing to do with nuclear power, as he is an eminent specialist in epidemiology.

Specialists also underline that the study in consideration provided results for the area surrounding a NPP that were compared with the average for population, and with the average for similar towns. Nuclear power plants are usually placed near industrial areas with many factories, plants, refineries, etc. Therefore, not it the richest parts of the country, and without clean country air. Therefore, living near a nuclear plant in Germany means also living near an industrial centre, near high chimneys releasing all the pollutants. No wonder then, that the comparison of health condition of people in such places with the average for Germany brings results unfavourable for these centres.

The German committee confirmed that a slight growth in incident rates is observed for selected regions, when using a one-tailed test. On the same time, the committee said that radiation from nuclear power plants could not be the cause of this growth. It was confirmed also by German Minister of Environment Sigmar Gabriel[159]. Moreover, in the summary, the committee reminded of the results of the two preceding studies conducted for all NPPs in German with the use of two-tailed test, which did not show any growth in incidence. Also, the committee did not considered the impact of migration, which—as it was established earlier in other countries (United Kingdom, USA, France) causes increased incidence rates.

The report by COMARE (Committee on Medical Aspects of Radiation in the Environment) published in May 2011 calls the results of the German studies in question. Alex Elliott, President of COMARE and physician at the clinic of Glasgow University, says that one should look for other causes of leukemia apart from radiation. The most recent COMARE report examined the incidence rate for leukemia in children below 5 years of age, living near 13 British nuclear power plants. Results of the report did not indicate "significant connections" between the incidence and impact of NPPs.

In the United Kingdom, there are approx. 50 cases of leukemia in children every year. As 35 years of studies enabled to find only 20 cases of leukemia within a distance of 5 km of any plant, a reliable

statistical study on such a small sample is very difficult. Since the number of cases is very small, it is possible that either the impact of NPPs is too small to be measured, or the whole phenomenon of leukemia is too small to be statistically significant. These results are inconsistent with the conclusions of the German study, according to which children living in the vicinity of nuclear plants suffer from leukemia twice often than in general population.

The COMARE report criticises the KiKK study, confirming that authors of this study did not assessed the impact of factors other than radiation. In the case of leukemia, there is a recongised relationship between leukemia incidence and socioeconomic status. The COMARE did analyse such factors, while KiKK study did not.

To illustrate the influence of population mixing on leukemia incidence we may refer to a case from the

[158] G. E. Dallal, One Sided Tests http://www.tufts.edu/~gdallal/onesided.htm, in The Little Handbook of Statistical Practice.
[159] http://www.dw-world.de/dw/article/0,2144,2994904,00.html

USA, from little town of Sierra Vista. The town was created thanks to the inflow of highly specialised technical workers and its population is 44,000. 91.5% of people above 18 years has at least secondary education, and 25% of them—university diploma. The environment is clean. Nevertheless, 7 childhood leukemia cases were noted in 1995-2001, and in 2003—three further cases. In total, there were 18 cases of leukemia between 1995 and 2007. Characteristic socioeconomic factors include low number of children in family and significant mixing of population that arrived to Sierra Vista from various US regions. An influence of chemical contaminations is also possible, e.g. wolfram, whose concentration in the area is above average. However such causal relationship has not been found so far[160].

It should be stressed that increased childhood leukemia incidence results from many various factors, including environmental and socioeconomic ones, and therefore the emergence of leukemia clusters should not be attributed to radiation from nuclear power plants, as it is confirmed by many of the studies discussed above.

2.6.6. IMPACT OF NUCLEAR POWER PLANTS ON WATER

2.6.6.1. Impact of tritium contained in sewage from nuclear plants

Tritium is a radioactive isotope of hydrogen occurring naturally, first of all in sea water, and in small amounts—also in the atmosphere. It emits low-energy beta radiation and its level of radiotoxicity is low. Tritium contained in water (in the form of HTO and T_2O) does not cause surface contamination in the form of sediments on the bottom of reservoirs—as opposite to heavy isotopes, such as Ra_{226} and Ra_{228} radium isotopes whose radiotoxicity is high (released in large amounts together with saline waters during drainage of deep mines, first of all hard coal mines).

In the case of nuclear industry, the largest amounts of tritium in the liquid form is created in the cooling circuits of Pressurized Water Reactors (PWR), mainly in result of using the boric acid—to compensate the reactivity margin and regulation, and lithium—to keep pH of the reactor coolant at a desired level.

However, in new generation reactors the production and emission of tritium (similarly as in the case of all liquid radioactive substances (Figure 79)) were significantly reduced—10 and more times when compared to older reactors, by way of:

- usage of burnable poisons in the nuclear fuel (with the use of gadolinium),
- usage of boron enriched in 30-40% with B-10 isotope in the boric acid,
- regulation of daily changes in reactor capacity without changing the concentration of boric acid—only with the use of control rods.

[160] http://www.familiesagainstcancer.org/?id=29

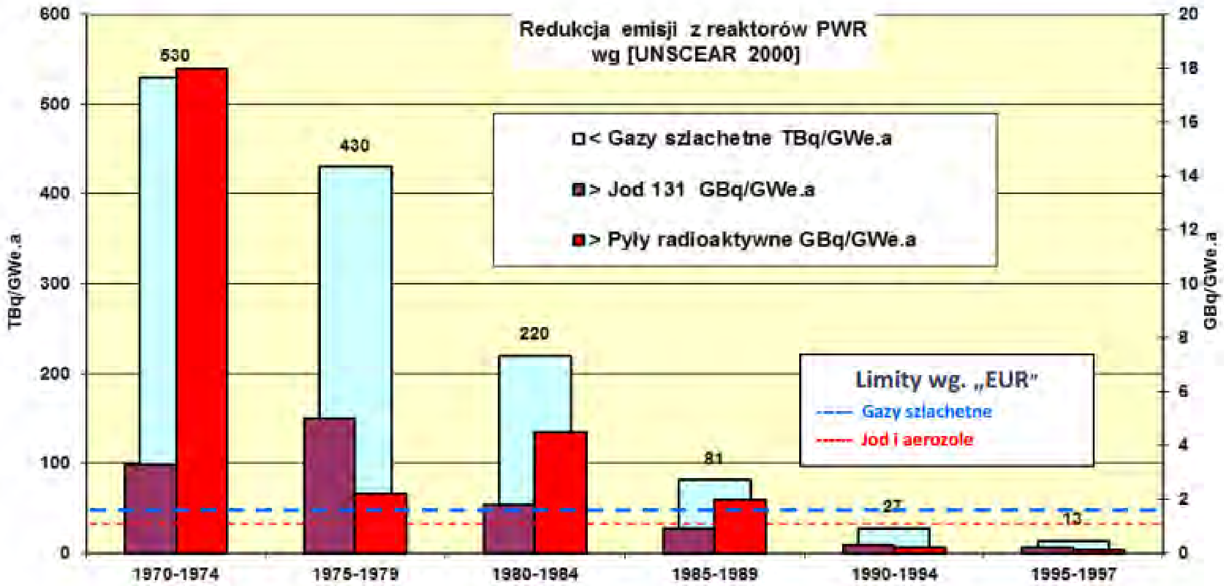


Figure 79. Reduction of emissions from PWRs, figures according to the UNSCEAR Report[161] [emissions provided in TBq (for noble gases) and GBq (for iodine and dust) per unit of electricity generated during a year at the continuous capacity of 1000 MWe.]

Redukcja emisji z reaktorów PWR wg [UNSCERAR 200]	
Reduction of emissions from PWR reactors according to [UNSCERAR 200]	
<Gazy szlachetne TBq/GWe.a	<Noble gases TBq/GWe.a
>Jod 131 GBq/GWe.a	>Iodine 131 GBq/GWe.a
>Pyły radioaktywne GBq/GWe.a	>Radioactive dust GBq/GWe.a

A comprehensive and detailed information about the expected tritium emissions has been provided in items 7.1.1.2.4.1, 7.1.1.3.4, and 7.1.1.5.2 of the SEA Forecast. The maximum forecast yearly tritium emissions, depending on the reactor type, range from 3 to 13 TBw, whereby for an EPR the expected value (based on operational experience of French nuclear plants and solutions applied in this reactor) it is only 0.5 TBq.

Tritium is released to water in very low concentrations, and in the case of location of nuclear power plants, it shall be discharged directly to the sea (all currently considered potential placements of the 1st Polish nuclear power plant are located by the Baltic Sea).

Tritium emissions from nuclear power plants—even those located by rivers—do not have a negative environmental impact (which was demonstrated both in environmental impact reports as well as by results of studies conducted). The more so it does not matter in the case of marine environment. It was demonstrated by off-shore inspections and measurements in the areas near nuclear power plants, especially French ones. Tritium tests did not indicate presence of radionuclides above the detection level (37 Bq/litre of water in 2003). Total beta activity was stable (approx. 11 Bw/litre of sea water, not more than 7 Bq/litre of subsoil water remaining in contact with sea water) and caused mainly by K-40 isotope. Comprehensive information about studies on marine environment contaminations is provided in item 7.7.1.3 of the SEA Forecast.

Tritium emissions during standard operation of nuclear power plants do not pose a risk to agriculture and subsoil water. In case of an accident—including severe accidents—with core degradation (even

[161] UNSCEAR Report 2000: Sources and Effects of Ionizing Radiation

total meltdown)—technical solutions applied in 3rd and 3rd+ generation reactors ensure protection of the safety containment of the reactor against damage, in particular against melting it through by the core material. Therefore, even in the case of a severe accident, direct contamination of ground water with any radioactive substances is practically impossible.

Environmental impact of tritium emissions is also completely insignificant when compared to emissions of radioactive substances from coal plants and hard coal mines. Coal plants emits to the environment [162] large amounts of radioactive substances contained in coal, while coal mines—substantial amounts of radium isotopes in water from mine drainage. These radionuclides—similarly as all other waste emitted by coal power and mining industry—disperse in the environment in an entirely uncontrolled way[163].

Therefore, the allegation of "substantial contamination of soil, vegetation, people and animals with ionising radiation" is ungrounded.

2.6.6.2. Impact assessment of nuclear power plant on water resources

In Poland, detailed and strict regulations on water protection, fully compliant with relevant EU regulations—including in particular the Framework Water Directive (2000/60/EC), are contained in Water Law[164] and Environment Protection Law acts, as well as in relevant implementing acts. It is worth noting in this context that Polish water law in particular forbids to introduce cooling waters whose temperature exceeds 26 °C to natural lakes, which makes it practically impossible to apply open cooling circuits with the use of lake water. The compliance with these regulations is enforced by relevant supervisory and controlling functions of the state, such as General Environment Inspection, as well as the National Water Management Authority and regional water management authorities.

As cooling water demand of nuclear power plants is approx. 20-30% higher than of conventional thermal plants with the same capacity, the cooling water demand scale is actually similar. When designing cooling systems for Polish nuclear plants, as well as during their operation, the best available techniques (BAT) shall be applied, in particular such as described in the report published by the European Commission[165]. Utilisation of modern solutions based on the best global examples and practices shall enable to minimise the adverse impact of nuclear plant cooling systems on the environment.

In relation to specific nuclear power plants, located on optimally selected sites and using a specific technology (both location as well as technology for the 1st Polish nuclear power plant shall be selected in the end 2014 at the earliest), a detailed environmental impact assessment shall be conducted as part of the proceedings for issuance of environmental decision for this project, with particular account of cooling issues. Also, a relevant environmental impact report shall be prepared, and the (specific) investment project shall be subjected to public consultation in the country as well as in the cross-

[162]Of course in addition to SO2, NOx, CO2, and carcinogenic dust—also containing toxic substances like arsenic or cadmium, and material amounts of toxic and carcinogenic mercury

[163]In the UNSCEAR Report (Sources and Effects of Ionising Radiation. United Nations Scientific Committee on the Effects of Atomic Radiation. 2000), the conventional power industry, which is based on firing of fossil materials, is mentioned as one of the most important and certainly most pervasive sources of waste containing significantly elevated amounts of natural radioactive isotopes.

[164]NOTICE OF THE MARSHALL OF THE SEJM OF THE REPUBLIC OF POLAND of 10 January 2012 on the promulgation of uniform text of the Water Law act (Dz. U. [Polish Journal of Laws] of 2012 , No. 0, item 145).

[165] European Commission: Integrated Pollution Prevention and Control (IPPC). Reference document for the best available techniques in industrial cooling systems. December 2001. Ministry of Environment. Warsaw, January 2004. (Original title: Document on the Application of Best Available Techniques to Industrial Cooling Systems).

border context[166].

Nuclear power plant may be placed only in a location where there are sufficient water resources for cooling, or otherwise the location is excluded. The requirement of sufficient water resources for cooling is contained in particular in the Polish "Placement Regulation"[167] (§2 item 4 letter e):

§ 2. A detailed scope of assessment with regard to land intended for a location of a nuclear facility shall include:

(…)

4) the following information from the field of hydrology and meteorology:

(…)

description of cooling systems of a nuclear facility including, depending on the envisaged cooling system, the consumption of cooling water, irretrievable losses, cooling area, hydrothermal conditions of the basin, water desalination and treatment systems, and also access to water in amounts which are sufficient for the purpose of cooling a nuclear facility,

The presentation of possible environmental impact of various types of cooling systems of nuclear plant, connected with discharged heat and chemical emissions in the "Forecast..." is sufficiently detailed for the present (initial) stage of planning and site selection.

2.6.6.2.1. Water body impact assessment for the Polish Nuclear Power Programme

In 2013-2014, detailed placement studies and analyses shall be conducted for possible locations (Choczewo and Żarnowiec, plus possibly 2 additional sites—Gąski and probably Kopań) in order to select the optimal location for the 1st Polish nuclear power plant. Results of these studies and analyses shall be subsequently used in preparation of the placement report and environmental impact report for the project for the selected NPP location. Environmental impact of a specific nuclear power plant (i.e. in s specific location and for a specific technology and configuration) shall be determined in detail in the environmental impact report for the project, which is necessary to obtain the environmental decision.

Analyses contained in the environmental impact report for a specific NPP shall include also its impact on ground water body, together with its endangered parts, as well as objectives defined in the Framework Water Directive (2000/60/CE) whose requirements were transposed to the Polish water law.

Each planned construction of a specific nuclear plant shall be subjected to separate national and cross-border consultation.

It should also be clearly emphasized that Polish legislature (EIA Act) guarantees that if the EIA arrives at a conclusion that a project can result in a non-fulfilment of environmental goals included in a river basin management plan, the authority responsible for environmental decision shall reject the consent to implementation of the project.

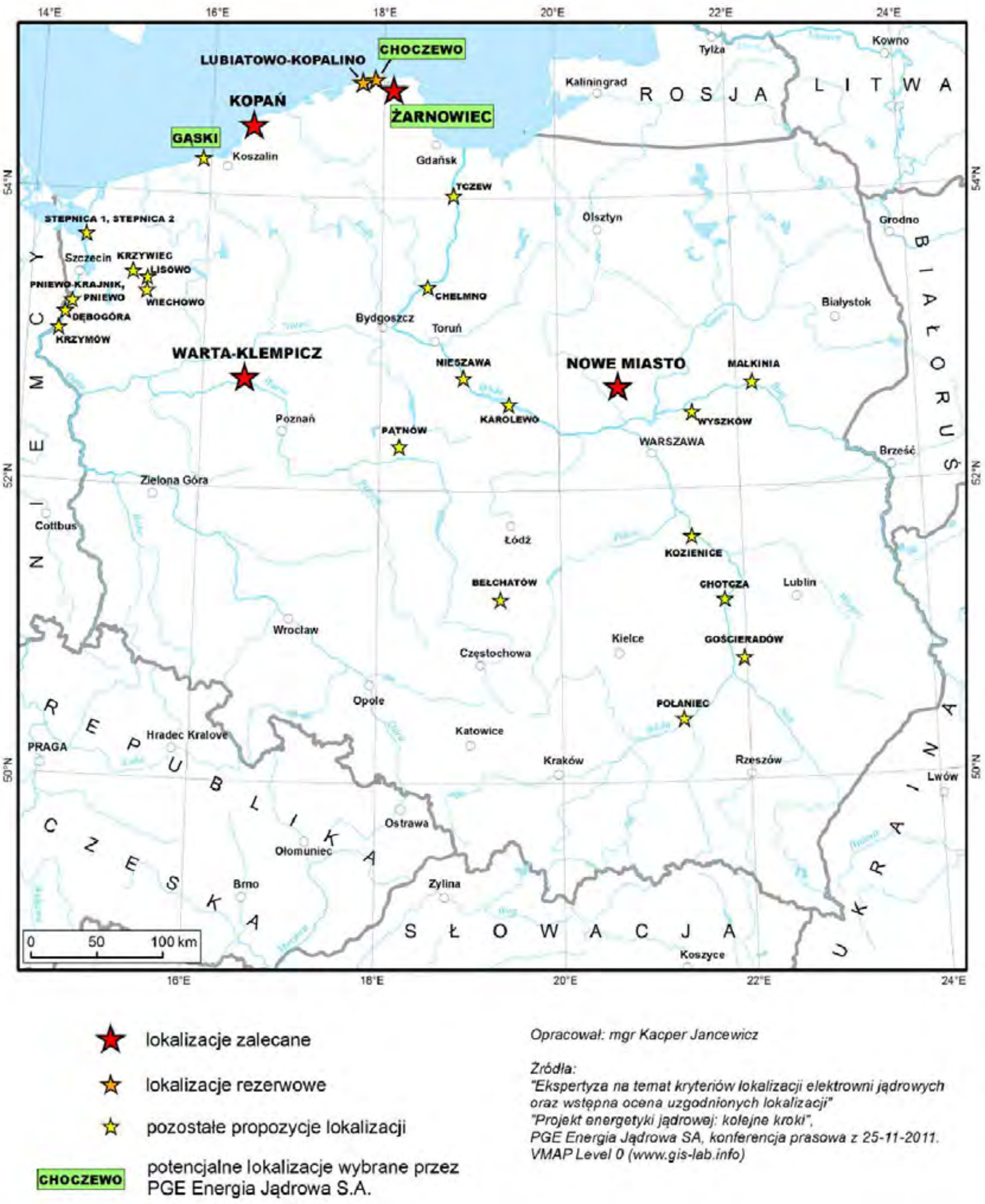
[166] Pursuant to the act of 3 October 2008 on the Provision of Information on the Environment and its Protection, Public Participation in Environmental Protection and Environmental Impact Assessments (Dz. U. [Polish Journal of Laws] of 2013, item 1235)

[167] Regulation by the Council of Ministers on detailed scope of assessment with regard to land intended for the location of a nuclear facility, cases excluding land to be considered eligible for the location of a nuclear facility and on requirements concerning location report for a nuclear facility "placement regulation") Dz. U. [Polish Journal of Laws] of 2012, item 1025).

For the purposes of this summary, an additional analysis was performed, identifying possible impact of potential nuclear plant locations stemming from the arrangements as part of the Nuclear Power Development Programme on the water body protection targets. The analysis was presented below and it supplements the information contained in the Forecast.

INTRODUCTION

The aim of this analysis is to diagnose possible impact in the scope of water protection for the bodies of water being possible locations for placement of a nuclear power plant. It should be emphasised that at the present, early stage of implementation of the Programme, it is possible to assess only potential impact on these goals. A detailed analysis shall be conducted within the environmental impact assessment procedure for locations indicated for further studies. Taking into account the conclusions stemming from the conducted from providing of the strategic environmental assessment, the information about bodies of water for all possible locations has been presented along with the more detailed information for seven main locations provided for in PNPP (recommended locations, reserve locations, and additional location—Gąski).



Recommended locations	Prepared by: Kacper Jancewicz, MSc
Reserve locations	*Sources:*
Other proposed locations	*"Expert assessment of placement criteria for nuclear power plants along with initial assessment of selected locations"*
Possible locations selected by PGE Energia Jądrowa S.A.	*"Nuclear power project: step after step", PGE Energia Jądrowa SA, press conference of 25-11-2011. VMAP Level 0 (WWW.gis-lab.info)*

Figure 80. NPP **locations in Poland (Source EIA Forecast for NPP)**

SPECIFICATION OF BODIES OF WATER IN THE REGIONS OF POSSIBLE NPP LOCATIONS

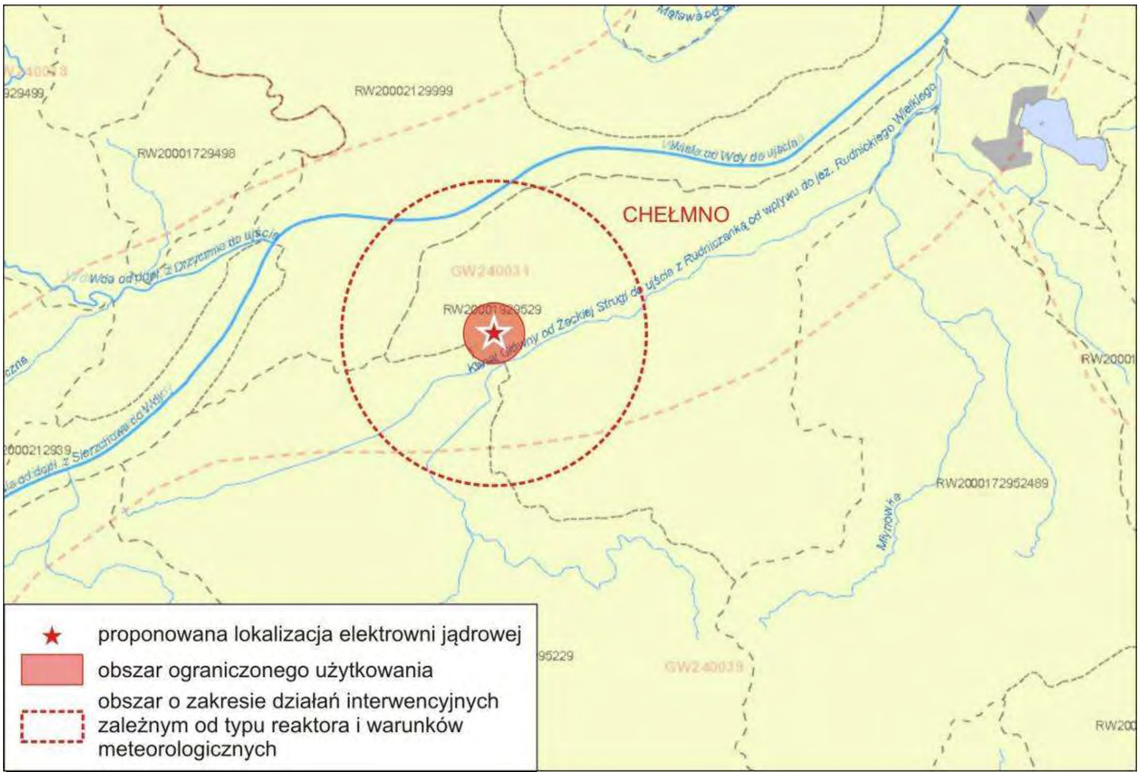
The table below presents bodies of water in regions in which possible nuclear power plants are to be placed. Both surface and bodies of ground water are presented.

Table 19 List of surface and ground water bodies in areas where possible NPPs are to be placed (more detailed locations are presented in grey).

No.	Name	Geographical data	Type of location	WB code	GWB code
1	Chełmno	Commune: Chełmno, District: Chełmno,	Riverside - Wisła	RW20001929529	GW240031
2	Nieszawa	Commune: Nieszawa, District: Aleksandrów Kujawski.	Riverside-Wisła	RW200017279329	GW240045
3	Gościeradów	Commune: Gościeradów, District: Kraśnik,	Hinterland (5 km from the Vistula River)	RW2000623269	GW2200127
4	Chotcza	Commune: Chotcza, Province:	Hinterland (5 km from the	RW2000212399	GW2300102
5	Bełchatów	Commune: Kleszczów, District: Bełchatów,	Hinterland	RW6000191825	GW650096
6	Karolewo	Commune: Nowy Duninów, District: Włocławek, Province: Kujawsko-	Riverside-Wisła	RW20000275999	GW230047
7	Kozienice	Commune: Kozienice, District: Kozienice,	Riverside-Wisła	RW2000212539	GW230099
8	Małkinia	Commune: Zaremby Kościelne, District: Ostrów Mazowiecka, Province:	Hinterland (2 km od Bugu)	RW200017266734/RW200017266729	GW230054
9	Nowe Miasto	Commune: Nowe Miasto, District: Płońsk,	Hinterland	RW200024268899	GW230049
10	Wyszków	Commune: Zabrodzie, District: Wyszków,	Hinterland	RW200017266949	GW230054
11	(podlaskie)	Identification pending	Bodies of surface and ground water cannot be identified.		
12	Choczewo	Commune: Choczewo, District: Wejherowo,	Nadmorska	CWDW1801	GW240013
13	Lubatowo-Kopalino	Commune: Choczewo, District: Wejherowo,	Nadmorska	CWDW1801	GW240011/GW240013

No.	Name	Geographical data	Type of location	WB code	GWB code
14	Tczew	Commune: Tczew, District: Tczew,	Riverside - Wisła	RW20002129999	GW240031
15	Żarnowiec	Commune: Krokowa, District: Wejherowo, Province: Pomorskie	Nadjeziorna – Jezioro Żarnowieckie	RW200017477259	GW240013
16	Połaniec	Commune: Połaniec, District: Staszów,	Riverside- Wisła	RW20002121799	GW2200122
17	Pątnów	Commune: Konin, District: Konin,	Nadjeziorna – Jezioro Pątnowskie	RW60002318345299	GW650064
18	Warta-Klempicz	Commune: Lubasz, District: Piła,	Hinterland	RW600017187329	GW650042
19	Kopań	Commune: Darłowo, District: Sławno,	Seaside	RW6000047149	GW680010
20	Krzywiec	Commune: Marianowo, District: Stargard Szczeciński, Province:	Hinterland	RW600016198869	GW69007
21	Lisowo	Commune: Marianowo, District: Stargard Szczeciński, Province:	Hinterland	RW600016198869	GW69007
22	Wiechowo	Commune: Marianowo, District: Stargard Szczeciński, Province:	Hinterland	RW600016198889	GW69007
23	Pniewo	Commune: Gryfino, District: Gryfino,	Riverside	RW6000211971	GW69004
24	Pniewo-Krajnik	Commune: Gryfino, District: Gryfino,	Riverside	RW60001719314	GW69004
25	Dębogóra	Commune: Widuchowa, District: Gryfino,	Riverside	RW6000211971	GW690024
26	Krzymów	Commune: Chojna, District: Gryfino,	Riverside	RW60002419189	GW690024
27	Stepnica 1	Commune: Stepnica, Province:	Bay	TWIWB8	GW67002
28	Stepnica 2	Commune: Stepnica, Province:	Bay	RW6000173148	GW67002
29	Gąski	Commune: Mielno, Province: Zachodniopomorskie	Seaside	CWDO1505	GW68009

All possible locations against the background of hydrographic network and division into bodies of water were shown in figures below (all figures are prepared by the Ministry of Economy on the basis of data from geoportal.kzgw.gov.pl).



Proposed location of nuclear power plant
Limited usage zone
Intervention area depending on reactor type and weather conditions

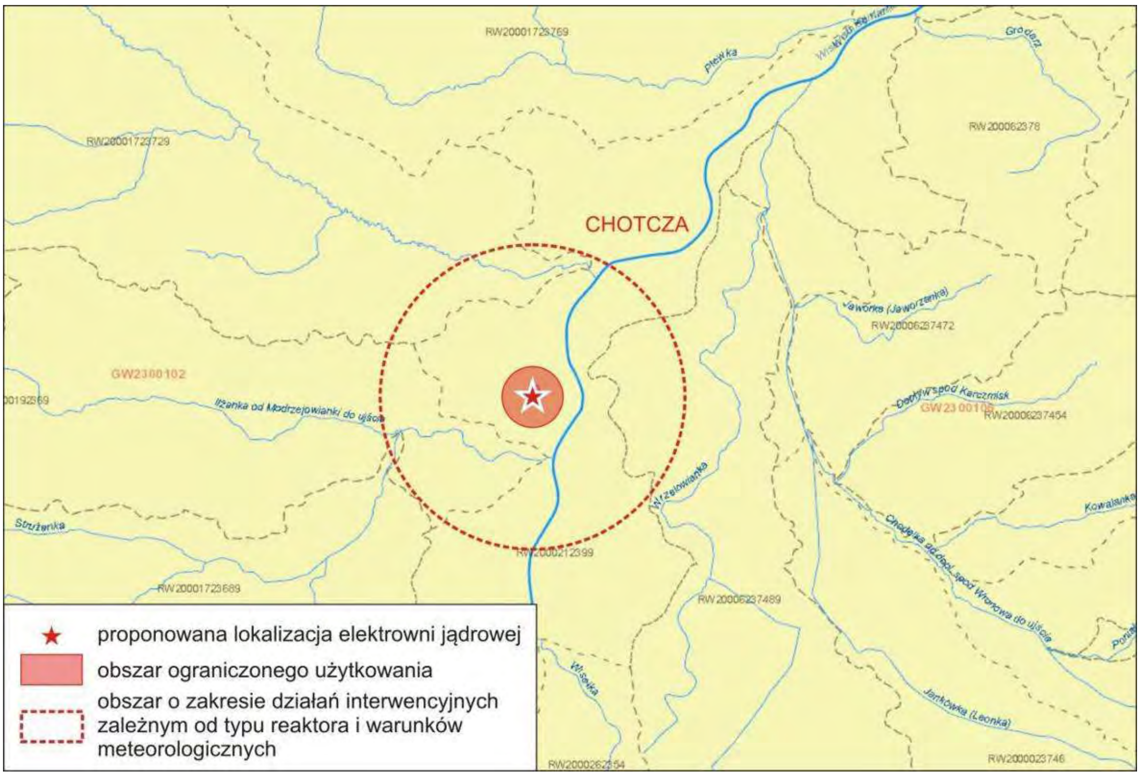
Figure 81. Possible location of NPP Chełmno against bodies of water

Proposed location of nuclear power plant
Limited usage zone
Intervention area depending on reactor type and weather conditions

Figure 82. Possible location of NPP Nieszawa against bodies of water

Proposed location of nuclear power plant
Limited usage zone
Intervention area depending on reactor type and weather conditions

Figure 83. Possible location of NPP Gościeradów against bodies of water



Proposed location of nuclear power plant
Limited usage zone
Intervention area depending on reactor type and weather conditions

Figure 84. Possible location of NPP Chotcza against bodies of water

Proposed location of nuclear power plant
Limited usage zone
Intervention area depending on reactor type and weather conditions

Figure 85. Possible location of NPP Bełchatów against bodies of water

Proposed location of nuclear power plant
Limited usage zone
Intervention area depending on reactor type and weather conditions

Figure 86. Possible location of NPP Karolewo against bodies of water

Proposed location of nuclear power plant

Limited usage zone
Intervention area depending on reactor type and weather conditions

Figure 87. Possible location of NPP Kozienice against bodies of water

Proposed location of nuclear power plant
Limited usage zone
Intervention area depending on reactor type and weather conditions

Figure 88. Possible location of NPP Małkinia against bodies of water

Proposed location of nuclear power plant
Limited usage zone
Intervention area depending on reactor type and weather conditions

Figure 89. Possible location of NPP Nowe Miasto against bodies of water

Proposed location of nuclear power plant

Limited usage zone
Intervention area depending on reactor type and weather conditions

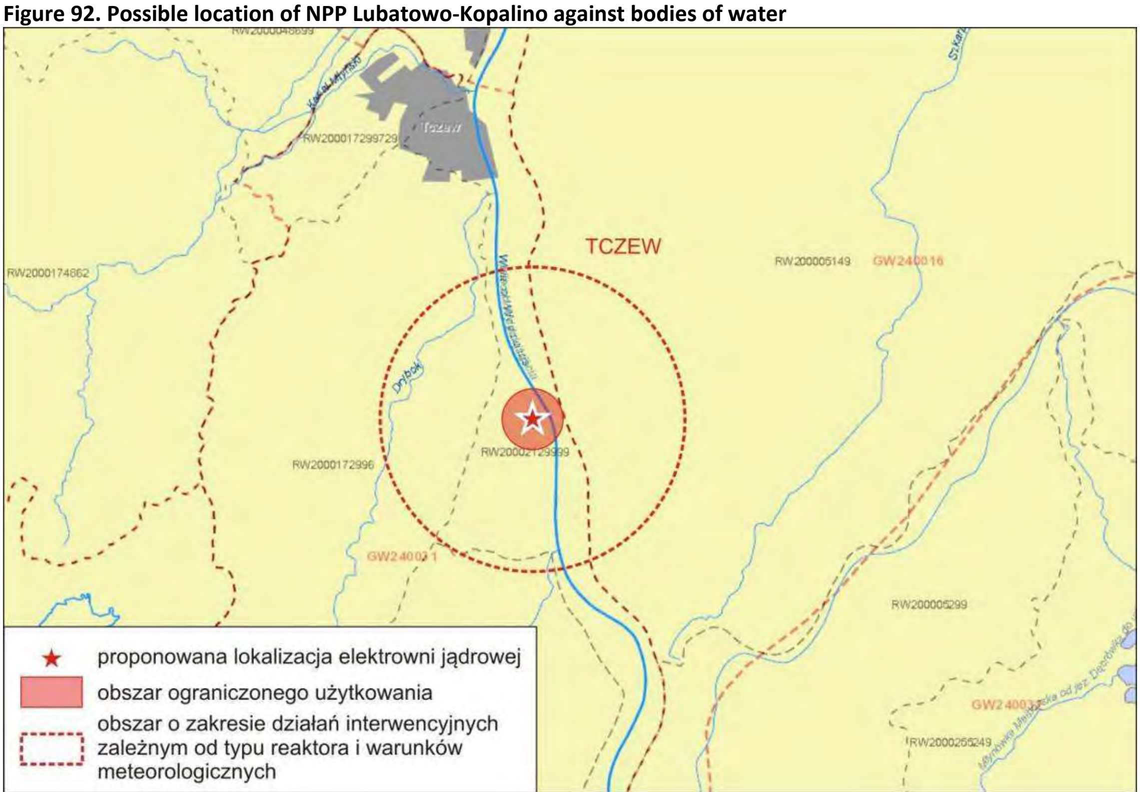
Figure 90. Possible location of NPP Wyszków against bodies of water

Proposed location of nuclear power plant
Limited usage zone
Intervention area depending on reactor type and weather conditions

Figure 91. Possible location of NPP Choczewo against bodies of water

Proposed location of nuclear power plant	
Limited usage zone	
Intervention area depending on reactor type and weather conditions	

Figure 92. Possible location of NPP Lubatowo-Kopalino against bodies of water



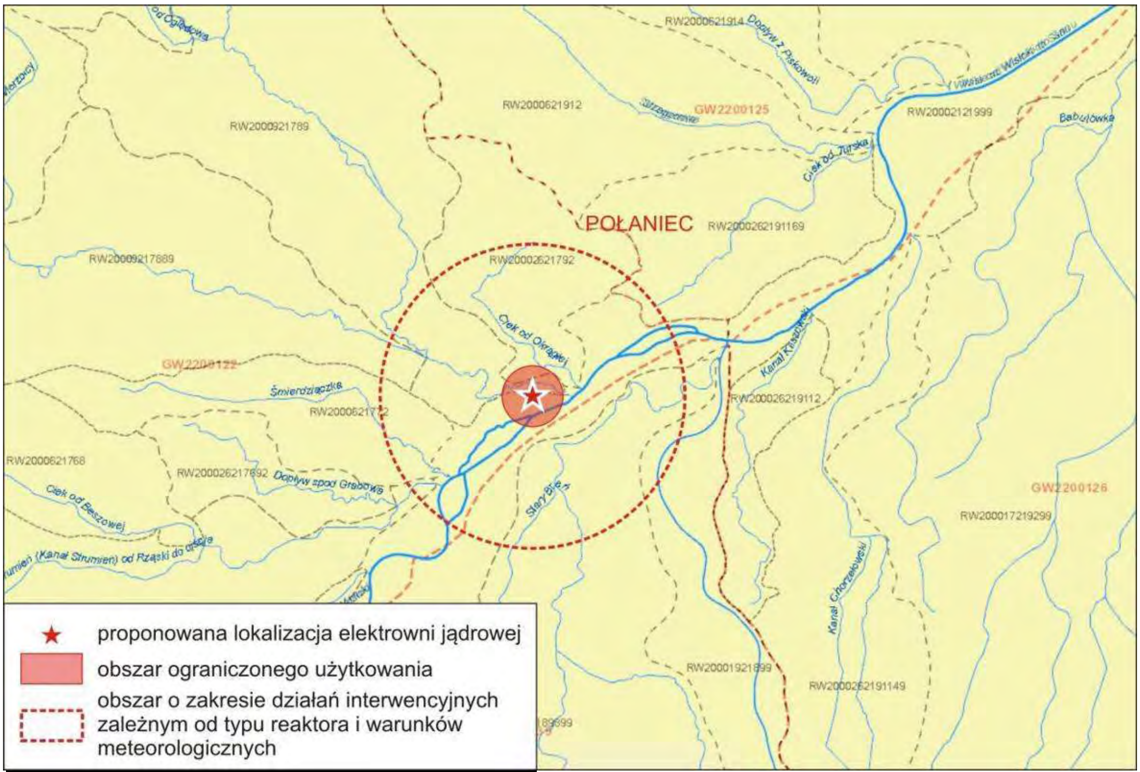
Proposed location of nuclear power plant	
Limited usage zone	

Intervention area depending on reactor type and weather conditions

Figure 93. Possible location of NPP Tczew against bodies of water

Proposed location of nuclear power plant
Limited usage zone
Intervention area depending on reactor type and weather conditions

Figure 94. Possible location of NPP Tczew against bodies of water



Proposed location of nuclear power plant
Limited usage zone
Intervention area depending on reactor type and weather conditions

Figure 95. Possible location of NPP Połaniec against bodies of water

Proposed location of nuclear power plant

Limited usage zone
Intervention area depending on reactor type and weather conditions

Figure 96. Possible location of NPP Pątnów against bodies of water

Proposed location of nuclear power plant
Limited usage zone
Intervention area depending on reactor type and weather conditions

Figure 97. Possible location of NPP Warta-Klempicz against bodies of water

Proposed location of nuclear power plant
Limited usage zone
Intervention area depending on reactor type and weather conditions

Figure 98. Possible location of NPP Kopań against bodies of water

Proposed location of nuclear power plant

Limited usage zone
Intervention area depending on reactor type and weather conditions

Figure 99. Possible location of NPP Krzywiec against bodies of water

Proposed location of nuclear power plant
Limited usage zone
Intervention area depending on reactor type and weather conditions

Figure 100. Possible location of NPP Lisowo against bodies of water

Proposed location of nuclear power plant
Limited usage zone
Intervention area depending on reactor type and weather conditions

Figure 101. Possible location of NPP Wiechowo against bodies of water

Proposed location of nuclear power plant

Limited usage zone
Intervention area depending on reactor type and weather conditions

Figure 102. Possible location of NPP Pniewo against bodies of water

Proposed location of nuclear power plant
Limited usage zone
Intervention area depending on reactor type and weather conditions

Figure 103. Possible location of NPP Pniewo-Krajnik against bodies of water

Proposed location of nuclear power plant
Limited usage zone
Intervention area depending on reactor type and weather conditions

Figure 104. Possible location of NPP Dębogóra against bodies of water

Proposed location of nuclear power plant

Limited usage zone
Intervention area depending on reactor type and weather conditions

Figure 105. Possible location of NPP Krzymów against bodies of water

Proposed location of nuclear power plant
Limited usage zone
Intervention area depending on reactor type and weather conditions

Figure 106. Possible location of NPP Stepnica against bodies of water

Proposed location of nuclear power plant
Limited usage zone
Intervention area depending on reactor type and weather conditions

Figure 107. Possible location of NPP Stepnica 2 against bodies of water

Proposed location of nuclear power plant
Limited usage zone
Intervention area depending on reactor type and

weather conditions

Figure 108. Possible location of NPP Gąski against bodies of water

POSSIBLE FACTORS OF NPP IMPACT ON BODIES OF WATER

The forecast EIA for NPP identifies the following possible impact on surface and ground water:

Surface water impact		
CONSTRUCTION		A significant adverse impact of the construction on surface water is not expected. Only local changes in water circulation can occur in connection with dewatering of work excavations and discharging the water to surface reservoirs.
OPERATION		**Heat emissions to surface water** causes their temperature to raise. There are legal restrictions as to the limits of heating for surface water. Heated water introduced cannot exceed 35 C for rivers and seas, and 26 C for lakes and lake tributaries. Excessive growth of surface water temperature can cause faster growth of aquatic organisms, and in consequence, overfertilisation of surface water. Water temperature directly influences all life forms and their physiological processes, and has an indirect impact on the amount of oxygen in water. Heated water has lower oxygen solubility and facilitates decay of organic matter, which results in faster oxygen consumption. The degree of heating of the waters to which heat is to be introduced can be calculated only for a specific investment location. Such detailed analysis shall be performed after the investment location is selected, and shall provide a basis for precise determination of the degree of heating in C. During operation of the nuclear power plant, the water reservoir used for cooling will be examined in detail in order determine the range and type of impact of discharged heat.
		Chemical contaminations are introduced to water in result of: sediment prevention on surfaces of water cooling system devices, disinfectants, and heat exchangers and pipelines corrosion products. In *riverside power plants* it is necessary to treat the water supplementing the cooling system, or the cooling water. Sediments formed in result of various treatment methods can contain certain heavy metals. The sediments are collected in special sedimentation tanks, compacted, dried and removed to piles. No adverse impact connected with storage of sediments on piles has been recorded. In result of calcium and magnesium removal in the form of a sediment, water returned to the reservoir shows lower contents of dissolved components than the collected water. In *seaside power plants* there is a specific necessity of chlorine usage in order to maintain relevant purity of water used in circuits. Chlorine, when reacting with organic compounds, can form harmful chemical substances. If concentrations of individual chemical substances in water returned to surface reservoirs do not exceed 1% of the limit, their impact can be considered negligible. The only substances exceeding the standard are oxidising agents which are highly unstable, decompose quickly, and the area in which the limit is exceeded shall be limited to direct surrounding of the water discharge location.
	Occurrence of an accident	Only in result of a severe accident a leakage of radioactive substances to water is possible. However the latest reactors are equipped with additional systems and appliances protecting the integrity of containment along with the foundation slab. Thus, the risk of radioactive leakage is, in principle, limited to zero. However in the case of release of radioactive substance to the atmosphere in result of an accident, radioactive particles shall slowly deposit on the surface or shall be quickly washed away by rain or snow falls, to finally reach surface reservoirs. Depending on local weather conditions, surface waters can be contaminated.
DECOMMISSIONING		No adverse impact on surface water is expected at the stage of decommissioning of a nuclear plant.

Impact on surface water		
CONSTRUCTION		**Water contamination** at the stage of construction is possible only in the areas where the high or very high sensitivity to ground water contamination, because ground waters are not separated from the land surface. The most favourable in terms of protection of the ground water against contamination shall be areas where ground waters are separated from the land surface with a layer of clays that prevents water penetration. Change of water relations can take place in results of ground works, especially if there are shallow ground waters locally. Deep excavations require intensive dewatering which can have a drying impact on adjacent terrains. However in the case of nuclear power plants, the depth of excavations is not particularly great—up to 14.00 m at most. Large areas of surface sealing through construction of a plant and adjacent infrastructure can induce local changes in the water level of shallow ground water, and therefore also local drying of land surface.
		Possible contamination of surface waters is unlikely, as structures, systems and devices of the plant shall be built in accordance with strict quality control standards, environment protection standards, and BAT standards, minimising thereby the possibility of unplanned releases of harmful substances to the ground. Storage tanks, depots of chemicals, fuel transshipment areas, and areas of other activities bearing the risk of environment contamination shall be located on hardened surfaces or confined within tight barriers preventing possible leakages. Therefore, should no unexpected accident occur, the operation of a power plant shall not influence the quality of land and ground water in any way. In order to control the quality of ground waters surrounding the power plant, samples of ground water shall be taken to detect any possible contamination. **Possible changes in ground water levels** can occur in result of sealing of large areas, which limits percolation. The level of ground waters shall be controlled and the impact of the structure on the local changes in ground water flows around the buildings shall be determined.
OPERATION	Occurrence of an accident	**Release of radioactive substances** can occur only in result of a severe accident. However the latest reactors are equipped with additional systems and appliances protecting the integrity of containment along with the foundation slab. Polish regulations do not allow to construct reactors without such systems of safety containment protection. Thus, the risk of radioactive leakage is, in principle, limited to zero. **Release of non-radioactive substances** can occur in relation with uncontrolled leakages. Therefore, designing of emergency water collection tanks and preparation of principles of conduct in case of accident will be extremely important element of the designing and construction stage. In the case of any release of pollutants in results of an accident, an emergency procedure shall be implemented to detect and neutralise the leakage and the contaminated land in order to prevent ground water contamination.
DECOMMISSIONING		Total decommissioning of buildings and accompanying infrastructure together with sealed areas shall positively influence water resources because of the increased surface seepage.

Thus, the most important factors impacting hydro-biological hydro-morphological and physicochemical elements of condition of bodies of water may include:

IMPLEMENTATION STAGE

- conversion of hydro-morphological elements of cooling water intake sources and its tank through construction of necessary intakes and discharges;
- conversion or destruction of macrolides, phytobenthos and zoobenthos, fish fauna, herpetofauna habitats etc.;
- possible emission of pollutants to waters in result of construction works;
- possible temporary disruption of water relations in result of deep ground works and dewatering.

OPERATION STAGE

- change of hydrological regime caused by water consumption for cooling purposes;
- change of thermal properties and chemistry of water in receiving reservoir resulting in a change of habitat characteristics for flora and fauna (the impact is important in the case of open cooling systems);
- impact on benthos and fish fauna consisting in intake of individuals to the cooling system, resulting in their increased mortality;
- radiological hazard in the case of technical accident which can result in contamination of water environment;

DECOMMISSIONING STAGE

- possible emission of pollutants to water in result of construction works;

POSSIBLE RECIPIENTS OF NPP IMPACT ON WATER CONDITION INDICATORS

The project impact factors can influence the following components of water quality:

BIOLOGICAL COMPONENTS

At the construction stage of a power plant, local habitats of aquatic organisms that determine the ecological condition or potential of water bodies (phytobenthos, zoobenthos, fish species, macrolides, etc.) can be converted, as well as habitats of dependent waters, including those which are possibly included to the protected zone network. Hydro-biological components can be also influenced in result of the passage of chemical pollutants produced in the course of construction works or trial run of the plant, to the water. At the operation stage, changes in habitat conditions in result of changed thermal properties and chemistry of water in the receiving reservoir can occur, which may influence its condition or ecological potential. An important impact factor can be constituted by intake of zoobenthos and phytobenthos as well as fish fauna to the cooling system, resulting in elevated mortality of protected species.

HYDRO-MORPHOLOGICAL COMPONENTS

At the construction stage, building of cooling water intakes and cooling water discharge routes can result in conversion of hydro-morphological components of the receiving reservoir. At the stage of operation, in result of the necessity of consumption of large water amounts, the hydrological regime of the receiving reservoir can change. The biggest impact of this type is generated by open cooling systems, while the impact of closed systems is proportionally smaller. Due to lack of specific decisions on the technology to be used, at this stage, it is difficult to draw conclusions about their range. A significant impact on hydro-morphological continuity of watercourses constituting the sources of cooling water can be exerted in result of the necessity of water impoundment in order to ensure relevant resources for cooling water intake.

PHYSICOCHEMICAL COMPONENTS

Apart from possible short-term impact on physicochemical parameters in result of passage of pollutants caused by construction works to the water (mainly suspensions; oil derivatives are also possible), the basic impact on these elements is exerted by changes in thermal properties of waters in receiving reservoir in result of cooling water discharge in open cooling systems. As water collected to the system is also treated, its chemical parameters are in terms of salinity, pH, and chlorine contents are changed. It can lead to changes in chemistry of receiving reservoir waters, and to deteriorate its chemical condition in result. During operation, also small doses of radiation may be released to water, however these amounts are well below admissible limits and should not endanger environmental targets.

IDENTIFICATION OF POSSIBLE IMPACT OF PLACEMENT ON THE CONDITION OF AND PROTECTION TARGETS FOR GROUND AND SURFACE WATERS

The tables below present possible impact of the analysed NPPs locations on the condition of and protection goals for bodies of ground water within their area.

Name of location	Body of water		Place					Status	Condition	Assessment of the failure risk in relation the environmental objectives	Derogations	Substantiation of derogations
	European ground water body code	Name of the ground	Combined body of	Water region	Basin area		Regional Water Manage					
					Code	Name						
Nowe Miasto	PLGW230049	49	-	Middle Vistula Water Region	2000	Vistula basin area	RWMA in Warsaw	Ground Water	good	not at risk	-	-
Choczewo	PLGW240013	13	-	Lower Vistula Water Region	2000	Vistula basin area	RWMA in Gdańsk	Ground Water	good	not at risk	-	-
Lubatowo-Kopalino	PLGW240011 / PLGW240013	11	-	Lower Vistula Water Region	2000	Vistula basin area	RWMA in Gdańsk	Ground Water	good	not at risk	-	-
Żarnowiec	PLGW240013	13	-	Lower Vistula Water Region	2000	Vistula basin area	RWMA in Gdańsk	Ground Water	good	not at risk	-	-
Warta-Klempicz	PLGW650042	42	-	Warta Water Region	6000	Oder basin area	RWMA in Poznań	Ground Water	good	not at risk	-	-
Kopań	PLGW680010	10	-	Lower Oder and Przymorze Zachodnie Water Region	6000	Oder basin area	RWMA in Szczecin	ground water	good	not at risk	-	-
Gąski	PLGW68009	9	-	Lower Oder and Przymorze Zachodnie Water Region	6000	Oder basin area	RWMA in Szczecin	ground water	good	not at risk	-	-

All listed possible locations are within bodies of ground waters whose condition was identified as good and not at risk in terms of environmental objectives to be achieved until 2015. In accordance with Art. 38e of the Water Law act, it is the environmental objective for bodies of ground water to:

- prevent or limit introduction of pollutants to them;

- prevent deterioration of their condition and improve their condition;
- protect them and undertake corrective measures, and also ensure equilibrium between the intake and recharge of these waters so as to achieve their good condition.

Because of no significant adverse impact of a NPP on ground water was diagnosed in relation to standard operation, no adverse impact on the protection objectives for bodies of ground water is expected. The objectives can be endangered only in the case of a severe accident entailing a radiological leakage. Local and temporary impacts can occur only at the construction stage, in result of ground and dewatering works.

Name of location	Groundwater body		Place					Status	Condition	Assessment of the failure risk in relation the environmental	Derogations	Substantiation of derogations
	European ground water	Name SWB	Combined body of water	Water region	Basin area		Regional Water					
					Code	Name						
Warta-Klempicz	PLRW600017187329	Smolnica	W1202	Warta Water Region Warty	6000	Oder basin area	RWMA in Poznań	Natural body of water	good	not at risk	-	-
Nowe Miasto	PLRW200024268899	Sona from Kraszewo tribute to the estuary	SW1614	Middle Vistula Water Region	2000	Vistula basin area	RWMA in Warsaw	Natural body of water	bad	at risk	4(4) - 1	The degree of water contamination caused by the type of land use in the water catchment area makes it impossible to achieve the assumed environmental objectives within the set timeframe. Technical measures
												restoration of a relevant water condition are missing.

Żarnowiec	PLRW20001 7477259	Piaśnica to the outflow from Żarnowieckie Lake	DW1801	Lower Vistula Water Region	2000	Vistula basin area	RWMA in Gdańsk	heavily modified water body	bad	at risk	4(5) - 1	Impact of anthropogenic activities on the condition of water bodies results in a necessity to postpone the achievement of environmental objectives due to a lack of technical solutions to be applied in order to improve the condition of water bodies.
Kopań	PLRW60000 47149	Głównica with Kopań and Wicko Lakes	DO1603	Lower Oder and Przymorze Zachodnie Water Region	6000	Oder basin area	RWMA in Szczecin	Natural body of water	good	not at risk	-	-

Seaside locations			
Name	**WB code**	**National Water Management Authority (NWMA) identification**	**Combined water body**
Gąski	CWDO1505	direct sea catchment	CWDO1504
Choczewo	CWDW1801	direct sea catchment	DW1801
Lubatowo-Kopalino	CWDW1801	direct sea catchment	DW1801

From among riverside locations, there are more natural water bodies (Kopań, Nowe Miasto, Warta-Klempicz) of which two are in good condition, without environmental objectives at risk. Pursuant to art. 38d sec. 1 of the Water Law act, the environmental objective for surface bodies of water not identified as artificial or heavily modified is to protect, improve, and restore the condition of surface bodies of water so as to achieve their good condition until 2015, subject to Art. 38g. In the perspective of implementation of the Nuclear Power Development Programme it is not expected that the objectives set would be threatened. In a later perspective, the influence of the condition of bodies of water is possible due to the forecast impact. However their range and significance will be assessed only at the designing stage of the project. Since the possible location in Nowe Miasto lays within bodies of water whose condition is bad and the achievement of environmental objectives there is threatened, it was covered with a temporary derogation until they are achieved. Due to the present status and the derogation applied, the NPP construction can deteriorate the possibilities to achieve the environmental objective for the bodies of water. The possible location in Żarnowiec lays within bodies of water considered heavily modified and the achievement of the environmental objective is threatened there. For that reason, a temporary derogation was applied to it. Pursuant to art. 38d sec. 2 of the Water Law act, the environmental objective for artificial and heavily modified surface bodies of water not is to protect, improve, and restore the condition of the bodies of water so as to achieve good ecological potential and chemical condition of artificial and heavily modified surface bodies of water. Due to the present status and the derogation applied, as well as the type of these bodies of water, the probability that the NPP construction will deteriorate the possibilities to achieve the environmental objective for the bodies of water, is lower.

In the case of water bodies identified as marine, Poland is still developing the methodology and principles of environmental impact assessment. In accordance with art. 1 of directive of the European Parliament and the Council 2008/56/EC of 17 June 2008, establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive), transposed into Polish law, the basic environmental objectives in relation to marine waters is retaining or improvement of their quality, in particular through:

- protecting and preserving the marine environment, preventing its deterioration or, where practicable, restoring marine ecosystems in areas where they have been adversely affected;
- preventing and reducing inputs in the marine environment, with a view to phasing out pollution, so as to ensure that there are no significant impacts on or risks to marine biodiversity, marine ecosystems, human health or legitimate uses of the sea.

As the application of open cooling systems in seaside locations is very probable, so also a significant impact on thermal properties and chemistry of water in the Baltic Sea, the environmental objectives for marine bodies of water can be substantially affected and therefore these issues should be analysed in detail at the stage of EIA, after the completion of work on the implementation of the methodology for defining and reviewing environmental objectives for marine waters.

2.7. IMPACT RESULTING FROM FUEL CYCLE

2.7.1. Discussion of the argument that uranium extraction is more harmful than coal extraction

Fuel consumption in a 3rd generation reactor is below 20 tons annually, for a reactor with capacity of 1000 MWe. This value was provided in the context of the easiness of shipment of such amount of fuel to the power plant. With no doubt such shipment is much easier, less energy-intensive, and it causes less pollutions than shipment of 3 million tons of coal. The Austrian side proposes to compare 3 million tons of coal not with the nuclear fuel, but with the uranium ore, however, such approach is wrong, because we do not transport uranium ore to the power plant; it stays where it is in the mine, contrary to coal. However, one may compare environment pollution and deterioration of human health during extraction of coal and uranium ore.

The analysis of conditions of the extraction of uranium ore in such locations as: Niger, where AREVA operates, Namibia, where Rossing mine is located, and Australia in the area of Northern Territory, where Ranger mine of ERA is situated, as well as Canada and the USA, provides a basis for the conclusion that both work conditions as well as environment protection are at an unquestionably high level, and the impact of this activity on human health and environment is comparable with the effects of coal extraction in the USA or in Poland.

2.7.1.1. Niger, Arlit and Akanani mines

This region is discussed by Greenpeace in its report (Greenpeace Report) ,the organisation does not provide specific allegations. The Report admits that a comprehensive assessment of impact of uranium mining on health has never been conducted, but examples are provided that evidence the radioactive influence of the local uranium ore on soil and water. Soil samples found near the mines showed elevated radioactivity, 100 times higher than the normal level of activity in the region, and on the Akonan streets, a dose rate was detected which was 500 times higher than the standard one. In 2003–2005, an elevated activity of water was detected in result of a high concentration of the uranium ore. AREVA has closed wells with that water. Therefore, it stems from the Report that radioactivity is elevated in the vicinity of uranium ore deposits.

According to the Greenpeace Report, the dose rate received by local population, inhabiting areas near the uranium ore deposits with 0,1% uranium contents, is approx. 0,005 MiliSv/h, which given 300 working days a year for 7 hours corresponds to the annual dose of 12 mSv.

According to ICRP recommendations, the dose for professionally exposed workers should not exceed 100 mSv during 5 years, which given an average rate of 20 mSv/year.

According to AREVA Report for 2010, the accident rate and radiation doses were as follows:

Table 20. Accident rate and radiation doses in Niger mines[168].

	2008	2009	2010
Accident rate with working time loss among direct and indirect employees per 1,000,000 work hours (FRI - frequency rate of industrial lost time accidents)	2.34	2.11	1.55
Number of fatal accidents	2	0	3

[168] Responsible Development of AREVA's Mining Activities, 2010 report

Fraction of unsecured work places that were granted OHSAS 18001 safety certificate	18%	22%	44%
Average radiation dose for professional exposed workers, mSv/year	3.28	3	3.47
Average radiation dose for contractors, mSv/year	2.22	1.95	2.63
Maximal dose received by one employee, mSv/year	15.25	16.15	17.15

The target set by AREVA for 2011 is to maintain the level of doses below 16 mSv/year. It should be reminded here that according to ICRP, the dose limit for an employee may not exceed 20 mSv/year at average, and within 5 years—100 mSv. The limit is observed.

Water consumption in uranium mines in Niger in 2010 totalled 906 m_3/tU, which means a decrease by 50% when compared to 2004, while energy consumption amounted to 110 MWh/tU, a reduction by 27% when compared to 2004.

Taking account of tightened requirements in the scope of radiation protection which resulted in lowering of the additional dose for population from 5 mSv/year (applicable to 2001[169]) to 1 mSv/year, AREVA leads the activity in the scope of population health protection in two directions:

- identification of regions where gangue was used for economic purposes, and introduction of countermeasures if the radiation level requires so, e.g. in the case of buildings erected with the use of radioactively contaminated materials, in cooperation with the residents,
- strict compliance with the rules of gangue management in ongoing operation of the mine.

Work conditions in the mine are strictly controlled, according to the same principles as those applicable in Canadian mines. Work safety results are very good—since October 2000 to December 2008, the FRI in SOMAIR facilities was 0, and for the whole activity of AREVA in Niger in 2009, 2.1 accidents (in France, there were 26 cases). The environment protection measures applied in uranium mines in Niger were assessed in 2004 and 2005 by IRSN, concluding that the environment management systems are in compliance with international requirements.[170]

2.7.1.2. Namibia

Industrial safety factors for Rossing mine in Namibia are presented in the table below.

Table 21. Summary of industrial safety factors in the Rossing mine[171]/

Safety parameters in the Rossing mine	2011 target	2010	2009	2008	2007	2006
Number of employees	1 580	1 592	1 415	1 307	1 175	939
Uranium oxide production (in tons)	3 203	3 628	4 150	4 108	3 046	3 617
Number of employees who received doses above 20 mSv/year	0	0	0	0	0	0
New cases of pneumoconiosis	0	0	0	0	1	1
New cases of dermatitis	0	0	0	0	0	1
New cases of hearing loss	0	0	0	0	0	0

[169] Responsible Development of AREVA's Mining Activities, 2010 report
[170] http://www.areva.com/EN/operations-592/a-lasting-partnership-with-niger.html
[171] Rössing Uranium Limited Working for Namibia, 2010 Report to Stakeholders, Enhancing our strength April 2011, http://www.riotinto.com/documents/Rossing2010SDreport.pdf

New cases of chronic bronchitis	0	0	0	0	0	0
All Injury Frequency Rate (AIFR)	0.74	0.89	0.73	0.91	0.71	0.59
FRI	0	14	6	8	9	6
Number of fatal accidents	0	0	0	0	0	0

Radiation exposure of Rossing employees in result of radon, external radiation, and inhaled dust is 1-4 mSv/year, which is well below the professional exposure limit of 20 mSv/year.

The impact of uranium extraction on the region can be seen from the comparison of health indicators for the whole Namibia with Erengo, a region where uranium is extracted. At the meetings devoted to health issues, population expresses concerns about the impact of dust on human health, cancer incidence and on lower respiratory tract. However, the comparison of female fertility, infant and children mortality, and the life expectancy in Erongo and in Namibia indicates that the indicators for the uranium extraction region are better than the national average.

Table 22. Fertility and mortality in the uranium extraction region (Erongo) in comparison with average values for Namibia[172].

Indicator		Erongo	Namibia		Erongo	Namibia
Average number of children per woman		5.1	4.1			
Infant deaths per 1000 life births:	F	43	49	M	40	55
Mortality among children up to 5 years of age	F	57	64	M	49	78
Life expectancy at birth, years	F	59	50	M	54	48

Health care in Erongo region is of relatively good quality. New hospitals and health care centres have been built, as well as numerous clinics in rural and municipal areas. 95.7% of Erongo population have access to drinking water. The UN Human Development Index shows that the situation in Erongo is much better than the average conditions in Namibia.

Table 23. Human Development Index, source[173].

Index for	2001-2004	1991-1994
Namibia	0.557	0.607
- Municipal areas	0.661	0.719
- Rural areas	0.473	0.530
- Men	0.556	0.609
- Women	0.545	0.580
Erongo	0.705	0.690

The most important uranium mine in this region is Rossing, owned by Rio Tinto. In 2010, the uranium output here totalled 52 million tons of rock containing 3,628 tons of uranium dioxide. The diagrams below present the full set of health characteristics defined over subsequent years of operation of the mine for its employees.

[172] http://aurecon.webfoundryza.com/assets/files/ROSSING/phase2/Annex%20n9%20Socio-Economic.pdf
[173] http://www.riotinto.com/documents/Rossing2010SDreport.pdf

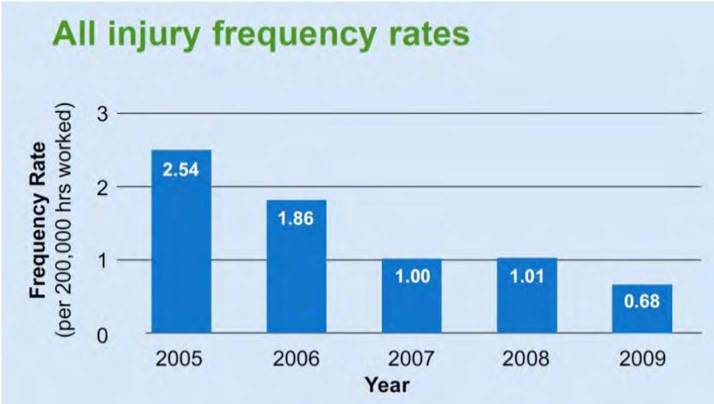


Figure 109. Work safety in uranium mines – Namibia, Rossing[174]

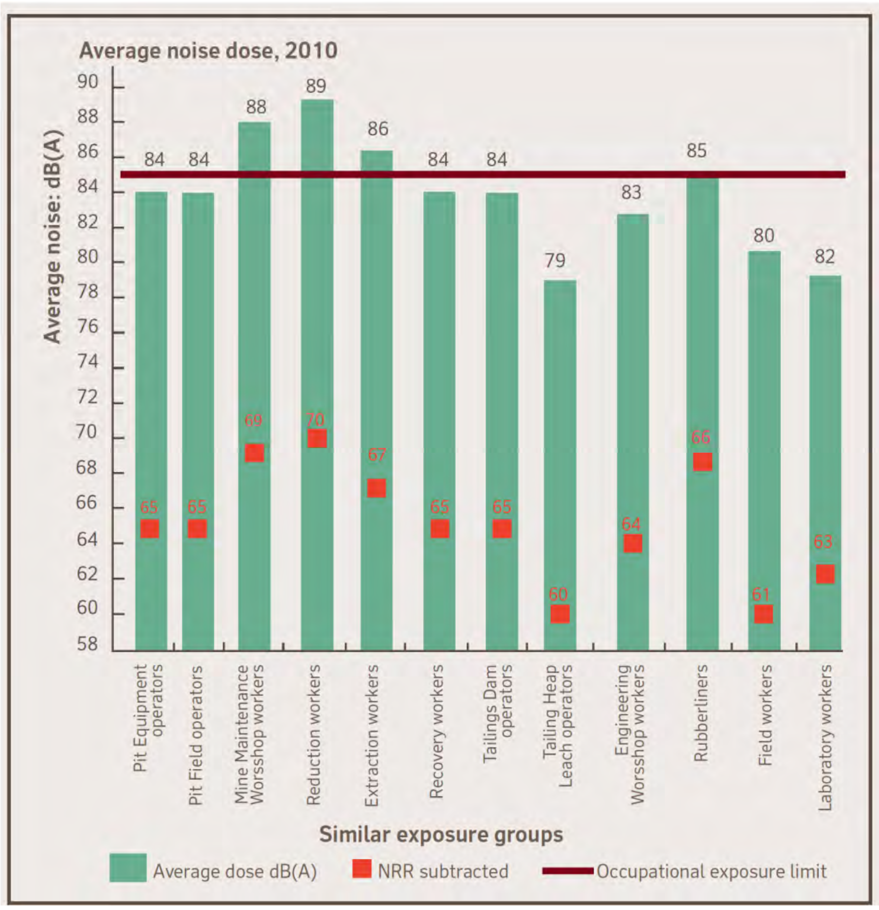


Figure 110. Noise level in Rossing mine compared to the limit for professionally employed (85 db). The values provided in green columns show the amount of noise perceptible without protection measures, and red squares—the Noise Reduction Rating (NRR)[175]

Dust The process of extraction, transport, crushing and grinding of uranium ore produces dust. From among 11 Similar Exposure Groups (SEG) in various work areas, two groups worked in areas where the dust concentration was above the levels. In both cases it was caused by faulty dust extraction systems, and in result, employees were equipped with masks reducing dust absorption 20 times.

[174] http://www.riotinto.com/documents/Rossing2010SDreport.pdf
[175] http://www.riotinto.com/documents/Rossing2010SDreport.pdf

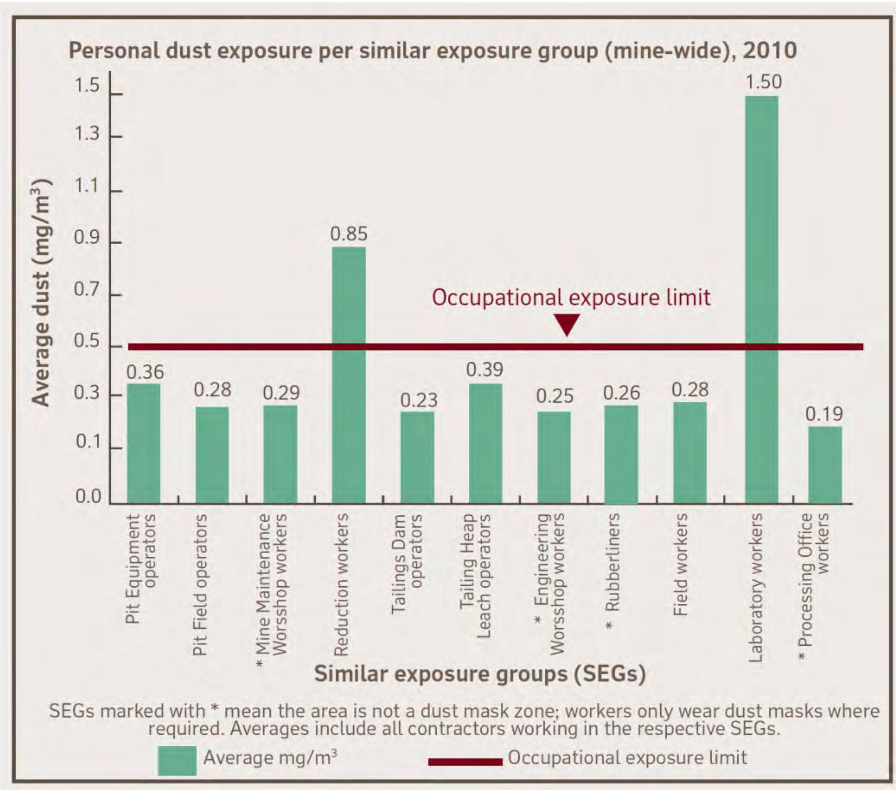


Figure 111. Industrial health protection in the Rossing mine[176].

Ionising radiation. Uranium is an element occurring naturally almost everywhere at an average concentration of 2.8 ppm. In the Rossing mine, uranium concentrated to 300 ppm at least, which is 0.03%, is extracted. Such a high uranium concentration causes an increased radio-background near the deposits.

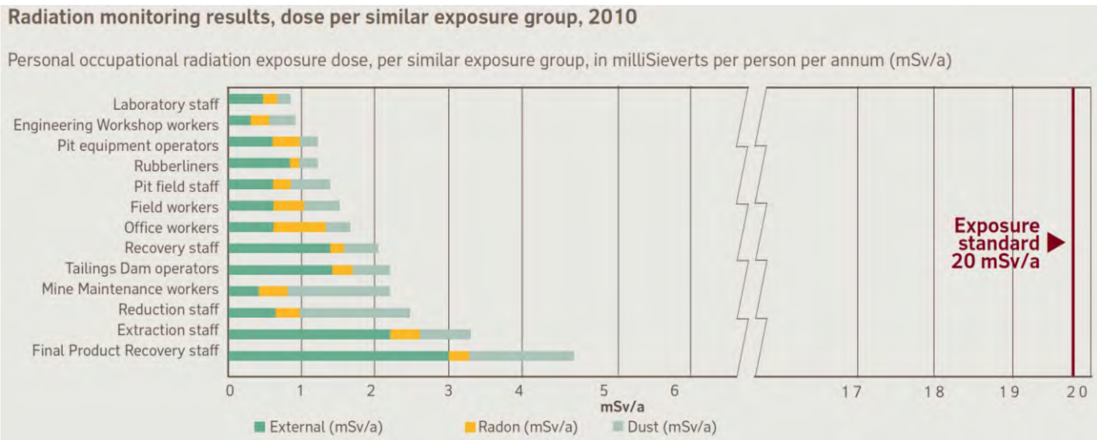


Figure 112. Radiation doses received by Rossing employees, mSv/year. As it can be seen, they are much lower than dose limits according to ICRP (20 mSv/year)[177].

[176] http://www.riotinto.com/documents/Rossing2010SDreport.pdf
[177] http://www.riotinto.com/documents/Rossing2010SDreport.pdf

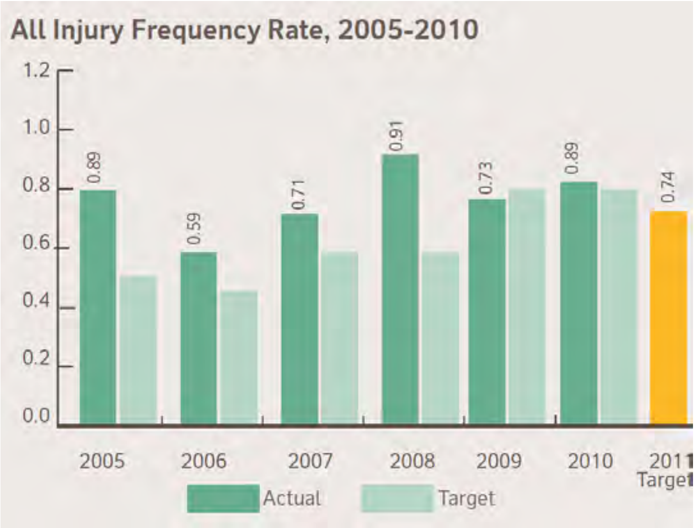


Figure 113. Total industrial exposure of Rossing employees[178]

2.7.1.3. Uranium mines in Australia – Ranger

ERA is one of the biggest uranium producers in the world and it supplies around 8% of uranium extracted globally. Since 1981, ERA has been extracting uranium ore in the Ranger mine, Australia.

For professionally exposed employees, ICRP recommends a dose limit of 20 mSv/year above the natural radiation background, averaged over 5 years (100 mSv during 5 years), but not higher than 50 mSv in one year. For population (people who are not professionally exposed to ionising radiation), ICRP recommends an additional dose not higher than 1 mSv a year.

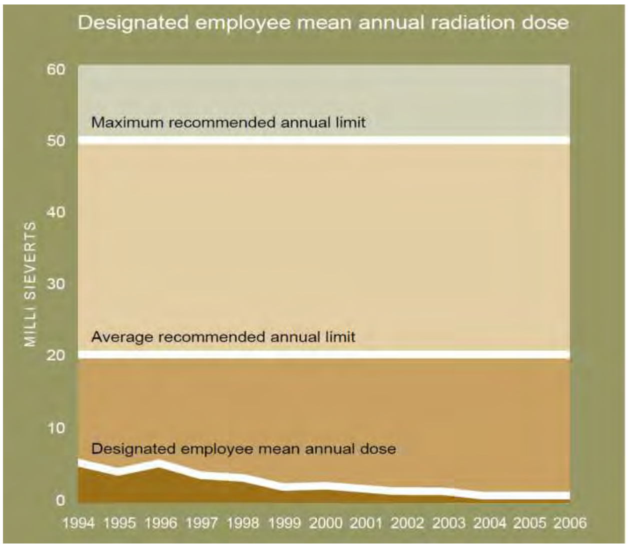


Figure 114. Radiation doses received by employees exposed to radiation in the Ranger mine. Source[179]. Dose limits set by the International Commission on Radiological Protection (ICRP) at 20 mSv/year in addition to radiation background and medical radiation. In 2006, Ranger employees received average doses of 1.1 mSv[180].

[178] http://www.riotinto.com/documents/Rossing2010SDreport.pdf
[179] (ERA Sustainable Development Report 2006) http://www.riotinto.com/documents/ReportsPublications/2009_ERA_Sustainable_Development_Report.pdf
[180] (ERA Sustainable Development Report 2006) http://www.riotinto.com/documents/ReportsPublications/2009_ERA_Sustainable_Development_Report.pdf

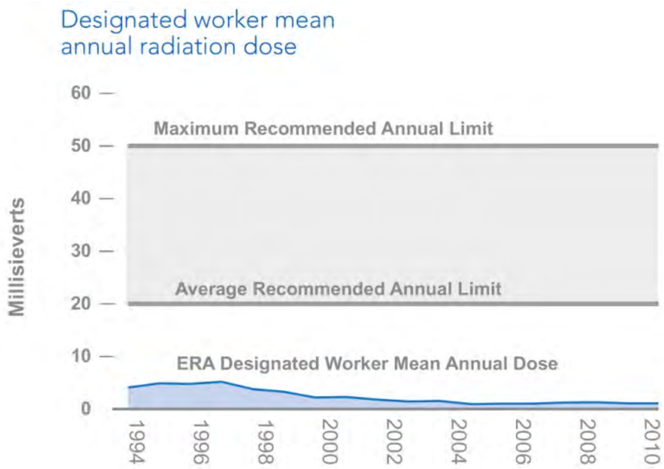


Figure 115. Radiation doses received by employees of ERA[181].

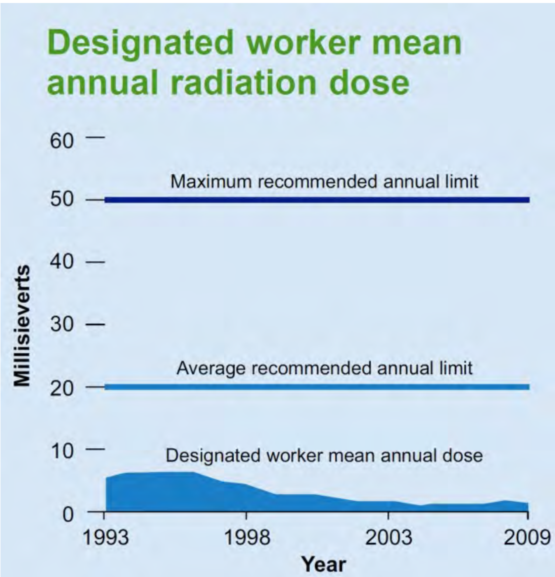


Figure 116. Doses received by Ranger employees, ERA, Australia.

The level of natural radiation background is between 2 and 3 mSv/year. ERA employees who may receive more than 5 mSv yearly are included to "designated" workers. During 2009, 319 designated workers received at the average 0.1 mSv with a maximal individual dose of 4.5 mSv, which is below the dose limit of 20 mSv recommended by ICRP. Other ERA employees are covered with the same ICRP limit, and their average yearly dose in 2009 amounted to 0.9 mSv. In 2009, the possible exposure of residents in regions neighbouring the mine totalled 0 mSv.

ERA measures industrial safety of its employees first of all with the use of the All Injury Frequency Rate (AIFR). It is the number of accidents at work covering the time loss, limited injuries and cases of medical intervention per 200,000 work hours. In 2010, ERA maintained the excellent result of 2009, with AIFR totalling 0.71 (2009: 0.68). Another indicator, Lost Time Injury Frequency Rate (LTIFR) per 200,000 hours totalled 0.20 in 2010, which was less than in 2009 (0.4).

181 http://www.riotinto.com/documents/ERA_Sustainable_Development_Report_2010.pdf

2.7.1.1. Coal extraction in the USA and Poland, impact on human health

Extraction of fossil fuels is always related with human health exposure and environmental burdens. Therefore, harmful effects of uranium ore extraction should be examined in the context of harmful effects caused by coal extraction. Coal extraction in the USA, where modern methods of health protection are applied, as well as Germany with its special focus on environment protection, were assumed as a reference point. In 2010 in the USA, according to the most recent data, 48 deaths of miners in result of accidents and disasters were registered, and approx. 1000 miners dies of pneumoconiosis every year[182]. The annual coal output in the USA totals 932 million tons[183], so it is 0.05 deaths in result of accidents per one million ton and 1.07 deaths because of pneumoconiosis. Not without significance is also the number of miners suffering of pneumoconiosis who are unable to work and everyday life many years before death, and there are more than 50% of them among smokers, and more than 20% among non-smokers[184]. In the case of the USA, where 130,000 people has been working underground recently[185], it means tens of thousands of ill. In developing countries, it is significantly worse.

In order to generate 48 TWh—which is how much Poland is planning to obtain yearly from nuclear power plants with capacity of 6000 MWe—approx. 18 million tons of coal is needed. It would mean approx. 1 death in result of an underground accident and 19 deaths in result of pneumoconiosis—20 deaths among miners yearly in total.

The uranium output in Rossing is 4000 tons/year—and to generate 8 TWh of electricity in a nuclear power plant, approx. 180 tons of natural uranium are needed. Thus, yearly production of uranium from Rossing provides electricity in the amount of 150 TWh—more than the total generation of coal plants—both on lignite and hard coal—in Poland (150 TWh).

In 2009, coal mines witnessed more than 3.5 thousand accidents, and claimed the lives of 38 people. Approximately 400 miners in hard coal mines contracts the dangerous pneumoconiosis every year[186].

To compare with the analyses in Rossing mine presented above, with uranium output sufficient to generate electricity at the level of 180 TWh, the number of cases was zero and there occurred 8 accidents in total resulting in work time loss, which means a markedly lesser adverse impact on human health and life.

2.7.1.2. Comparison of environmental hazard for uranium and coal extraction

The Greenpeace Report on the uranium mines in Niger criticises the amount of consumption of water for the purposes of uranium extraction. It should be borne in mind that coal extraction also involves water consumption. Another publication by Greenpeace says that even in Germany more than 500 million square meters of water is used every year for coal extraction. This number may be compared with 270 million m_3 of water during 40 years of operation of the uranium mine in Arlit, which means a consumption rate below 7 million m_3 a year, of which 35% of water extracted was used by the mine,

---

[182] Black lung on the rise among US coal miners, Samuel Davidson 11 January 2010 http://wsws.org/articles/2010/jan2010/blac-j11.shtml
[183] Top Ten Hard Coal Producers (2010e) http://www.worldcoal.org/coal/coal-mining/
[184] Coal Mine Dust Exposures and Associated Health Outcomes http://www.cdc.gov/niosh/docs/2011-172/pdfs/2011- 172.pdf tabela 2.
[185] http://en.wikipedia.org/wiki/Black_lung_disease#21st_century
[186] http://www.money.pl/archiwum/wiadomosci_agencyjne/pap/artykul/wug;ponad;75;proc;chorob;zawodowych;w;gorni ctwie;to;pylice;pluc,95,0,237151.html

and 65% for town supply. The extracted supplies constitute only a small part of 8 billion m^3 of ground water available in the area.[187]

Another environmental threat connected with coal extraction are coal fires—in Chine, from 15 to 20 million tons of coal is burnt uncontrollably every year, which contributes to higher CO_2 emissions to the atmosphere (ibid).

Disorders typical for the surroundings of coal mines are:

- Lung diseases, hypertension, renal disorders—an increased incidence among local residents was discovered in result of research in the USA.
- Toxic levels of arsenic, fluorine, mercury and selenium emitted during coal combustion, penetrate to the atmosphere and the food chain of local population.
- Cavings in mines and accidents result in thousands of deaths among miners all over the world every year. In China alone in 2006, 4,700 people were killed in accidents in coal mines.

2.7.2. Discussion of the objection relating to the missing or insufficient information about radioactive waste management

The Polish Nuclear Power Programme assumes that at least until 2050, the fuel spent shall be stored in reactor storage casks and on a temporary repository at the plant. The issue of necessary radioactive waste repository shall emerge in approx. 30-40 years after launching of the first nuclear power plant, around 2050 at the earliest. Until 2050, Poland does not plan other waste management. This solution, important from the rational point of view, was subject to EIA and is described both in PNPP as well as the SEA Forecast. The Forecast specifies the issue of radioactive waste and indicates its possible solutions (in the chapter describing the "fuel cycle") with the level of detail applied for such issues in the Programme.

It was also taken into account that the Ministry of Economy is presently developing *the management plan for radioactive waste and spent fuel* - appendix 1 - measure 5 of the Polish Nuclear Power Programme.

In line with the schedule, the draft *National Management Plan for Radioactive Waste and Spent fuel* was prepared.

KPPzOPiWPJ, as the Polish Nuclear Power Programme, shall be subject to the strategic environmental assessment in terms of its environmental impact and therefore, also environmental impact of transport, storage, and stockpiling of radioactive waste, inclusive of radioactive contamination removal and nuclear facility decommissioning. **The Programme shall detail issues related to the fuel cycle.**

Poland is at the stage of preparation of the Polish Nuclear Power Programme. It is a strategic implementing document including legal, organisational, and formal measures necessary to introduce nuclear energy in Poland. At this stage it is even not certain, what technology, site, cooling system,

[187] http://www.irinnews.org/Report/83706/NIGER-Desert-residents-pay-high-price-for-lucrative-uranium-mining

capacity etc. will be applied (apart from the fact that it shall be a generation III or III+ reactor). Specification of this information in the Programme itself, in view of its function and nature, is not reasonable.

At the present implementation stage of PNPP, Poland is oriented towards an open cycle. One cannot exclude, however, that with technological development of nuclear plants as well as methods of safe processing of spent nuclear fuel, it will be more suitable and reasonable for Poland to adopt a closed cycle in the future, also from the point of view of the environment. Nevertheless, it is impossible to resolve these issues at the present stage of implementation of nuclear power in Poland, and it is assumed that an open fuel cycle shall be implemented in Poland.

Costs of radioactive waste and nuclear plant decommissioning shall be covered from payments settled by each Polish nuclear power plant during its life cycle. The plant shall add these costs to the electricity charges. The funds collected shall be supervised by an independent environment protection body. This solution was contained in the regulation by the Council of Ministers of 10.10.1012 on the amount of payment to cover the costs of final management of spent nuclear fuel and radioactive waste and to cover the costs of nuclear power plant decommissioning performed by the organisational unit which has been granted operation licence for the plant (Dz. U. [Polish Journal of Laws] of 2012, item 1213). The payment was calculated in the amount of PLN 17.16 for 1 MWh of generated electricity. According to NEA OECD, costs of disposal of high-level radioactive waste was estimated in 2010 at 0.4-1.6 USD/MWh. As the payment determined in the above mentioned regulation by the Council of Ministers it two times higher than the required costs estimated up to now, it can be concluded that the financial side of waste disposal was taken account of to a sufficient extent in the Polish nuclear power programme. Still, it is necessary to consider the durability and reliability of waste maintenance for a long time and in separation from the human environment.

Issues related to spent nuclear fuel management were considered already for the purposes of the first nuclear programme in Poland (Żarnowiec NP). A number of studies connected with selection of the location for a deep spent fuel repository were conducted then, and were continued also after the completion of the first nuclear programme in 1997-1999, as part of the "Radioactive Waste and Spent Nuclear Fuel Management in Poland" Strategic Governmental Programme prepared by the National Atomic Energy Agency. One of the tasks of the programme was to choose the location and prepare the concept of a radioactive waste repository in deep geological formations.

In result of the works conducted as part of the Governmental Programme to choose the location for the radioactive waste repository in deep geological formations, 44 rock structures were identified in Poland, where such a repository could be located. The structures include magmatic and metamorphic rocks, clay formations, salt deposits. Regions considered as prospective included crystalline rocks in the bed of the East European Craton in the north-eastern Poland, clay rock formations on the Sudetic Monocline and the Łeba elevation, as well as some salt diapirs of the Zechstein saliniferous formation of the Polish Lowland.

A part of works, a negative assessment was also conducted in terms of the possibility to store radioactive waste in mining excavations and surface geological formations and undeveloped deep geological formations. Areas of ground water reservoirs, valuable minerals, seismically active, located in the area of mining works or attractive in terms of natural landscape have also been assessed negatively.

Therefore, Poland disposes of both studies as well as knowledge pointing out a possibility to handle the spent fuel and radioactive waste management at home.

2.7.3. Discussion of the argument that nuclear waste means irresponsible contamination of environment.

There is a recurring argument as part of both domestic as well as cross-border "public consultation" that actions aimed to creation of radioactive waste are irresponsible and that there is no effective and sound way of managing such waste.

The notion of radioactive waste covers a wide range of items and materials. Focusing only on the waste coming from the nuclear plants, it is possible to list: rubber gloves and protective covers for shoes (these are the so-called low-level waste); sewage from the cooling systems of the plant (intermediate waste), and waste from the processing of spent nuclear fuel, which is high-level waste. Poland has had nearly five decades of experience with low-level and intermediate level waste. It is also the case that the Central Repository of Radioactive Waste (CRRW) in Różan, which has been operating since 1960, did not cause any threat to health of local population and employees—to the contrary: the commune and city of Różan belong to the regions where cancer mortality level is one of the lowest, which is obviously influenced by the good condition of local environment.

Comments expressed within the opinion-giving process for the SEA Forecast were focused, however, mainly on high-level waste repositories created after fuel spending or containing fuel which has not been spent.

Radiation of radioactive waste has been well examined and there are shielding materials available these days able to stop it. Containers in which radioactive waste is shipped are equipped with shielding layers of iron and lead, which ensure full protection of the surroundings against radiation. The main possible threat is spill of radioactive waste on the surface, its penetration to drinking water and absorption by living organisms, in which radiation can directly influence cells and organic processes. Therefore, the radioactive waste management must employ an effective systems of barriers which shall ensure keeping the radioactive isotopes far from the human surroundings.

On should admit that many concerns are connected with doubts whether it is possible to store the fission products in a safe manner for a long time at one place. A good example which enables to understand that natural processes proceeded significantly lower than human activities is the example from before nearly 2 billion years. At that time, uranium fraction U-235 in natural uranium was much higher than today and constituted approx. 3% (U-235 decays naturally within a half-life period of approx. 700 million years, while for U-238, this period amounts to 4.5 billion years. This created a possibility of fission chain reaction, if rich uranium ore was in contain with water. Such event occurred in Oklo, Gabon, which caused a number of natural nuclear reactors to emerge, active for couple hundred thousand years with interruptions.

This fact was discovered by workers employed in the enterprise exploiting uranium ore, who noticed that there is "too little" fissionable uranium U-235 in the ore. It accounted for only approx. 0,717% instead of 0,72%, as usually in all samples of uranium ore from various locations on the globe[188]. The difference was small, which meant that the natural reactors operated with a small capacity and burned only approx. 1% of U-235, but further measurements revealed that there are also U-235 fractions in Oklo reduced to 0.621%, and in one sample it was only 0.440%. It meant that over a

[188] Meshik A.: The workings of an ancient nuclear reactor Scientific American November 2005

couple hundred thousand years of activity of these reactors, the burnt-out uranium fraction constituted around 26%. What is more, the minerals from Oklo turned out to contain fission products such as neodymium, and even xenon—a gas which was captured by aluminium phosphate grains under quagmires and lasted in this form for nearly two billion years![189]

Fission products from natural reactors in Oklo were not stored in rock deposits, closed in containers or vitrified—water influenced them (the presence of water was necessary for the reactors to become active), they were placed just beneath the ground level, exposed to any processes conducive to their migration—and they still remained on the spot until they naturally broke down. Only the most durable ones—with very long periods of decay and sufficiently low activity—evidence today that natural reactors were actually active, while at the same time they did not case radioactive contamination of the local surroundings.

The recently issued NEA OECD[190] Report presents a comparison of radioactive waste from nuclear power plants and hazardous waste from other sources. Every year, 8000-10,000 MT of waste is produced globally, of which 400 MT is hazardous, and 0.4 MT—radioactive. Generation in coal plants results in production of 1700 kt/TWh of waste, including 1600 kt /TWh of CO_2, and 3000 kt/TWh of mine waste. The corresponding values in nuclear power plants (together with waste anticipated in connection with plant decommissioning) are: below 0.2 kT/TWh of CO_2 , and below 8 kt/GTWh of mine waste. As opposite to the nuclear waste, coal cycle waste is disposed directly to the environment. It raises concerns about the CO_2 influencing climate change, and emissions of pollutants to the atmosphere result in human diseases and destruction of environment.

Capture and storage of CO_2 (CCS) consist in, similarly as nuclear waste storage, depositing the waste in deep geological repositories. The main difference between those two is that CCS waste is stored in a liquid form with supercritical parameters, kept in place only with natural barriers. Nuclear waste is stored instead in the form of a solid, vitrified and protected with the number of subsequent barriers. CO2 is not considered hazardous waste. However, substantial release of CO2, e.g. in result of a rupture of discharging pipe connecting the plant with the repository, constitutes a serious risk which can cause death of many people and animals. While possible damages to all subsequent barriers around radioactive waste can only lead to slow and small radioactive leakages.

Detailed discussion of durability of the radioactive waste repository shall be presented in the environmental impact assessment for the repository after its location is selected. But already today, it is possible to provide examples that such a repository will not affect the health of Polish citizens and citizens of other countries in any way whatsoever.

For comparative purposes, long term impact of waste produced in coal industry and nuclear industry is also worth addressing. This is all the more important because while there is a noticeable lack of social acceptation in the world for storage of radioactive waste, in the case of coal combustion waste this is not so. The activity of radioactive waste, however, decreases with time, while toxicity of coal combustion waste remains high. At the same time, the volumes of high-level waste produced by nuclear industry are relatively small, e.g. for French nuclear plants, 3 m_3 of radioactive waste corresponds to the annual operation of a 1000 MWe reactor, so approx. 3m_3 /GWe-yearly. Thanks to that it is possible to protect it very carefully to prevent their passage to the ecosphere.

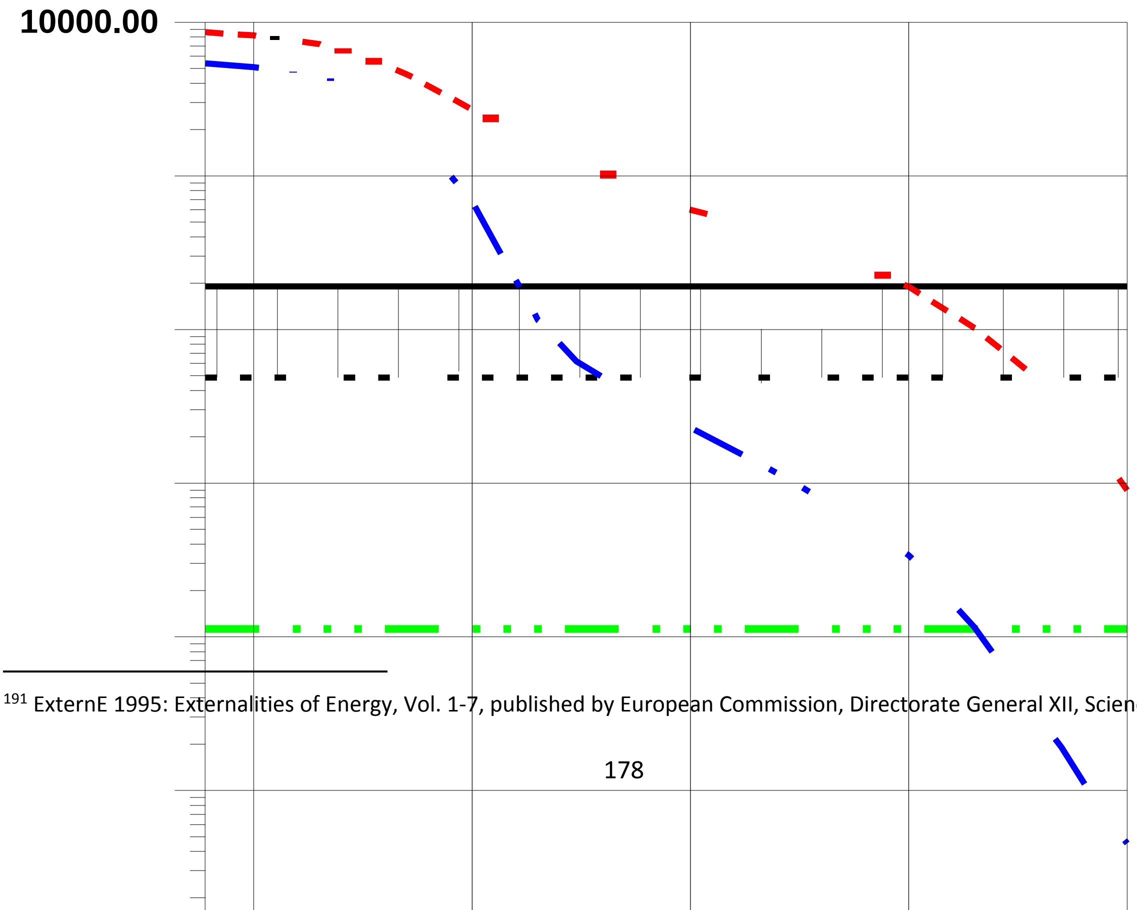
[189] Meshik A.: The workings of an ancient nuclear reactor Scientific American November 2005
[190] NEA-OECD Nuclear Waste in Perspective, 2010

For comparison, the amounts of waste produced every year by modern coal plants are enormous. For example, the table below (Table 24) provides data for German plants according to a study of the European Commission[191]. Data for Polish plants are similar.

Table 24. Amounts of solid waste from a hard coal (HC) or lignite (L) power plant).

Power plant	Lauffen, HC	Grevenbroich, L
	tons/GWe-year	tons/GWe-year
Ash	310 000	557 000
Gypsum	147 000	67 000
Sewage	11,500	2 230 000

A comparison of hazards generated by radioactive waste and waste from the process of coal combustion can be made for example on the assumption that in both cases, the waste is dissolved in drinking water. The measure of hazard in the radio-toxic hazard factor (RHF), defined as the amount of water necessary to dissolve the waste so as its concentration would not exceed the maximum allowed concentration in drinking water. A similar RHF indicator based on the maximum allowed concentration of toxins in drinking water serves as an indicator of exposure to toxic substances in coal combustion cycle waste. The RHF indicator is measured in km3 of water per unit of generated electricity, km3/GW-year. The relative hazards of radioactive waste and coal combustion waste are compared in the figure below.



[191] ExternE 1995: Externalities of Energy, Vol. 1-7, published by European Commission, Directorate General XII, Science

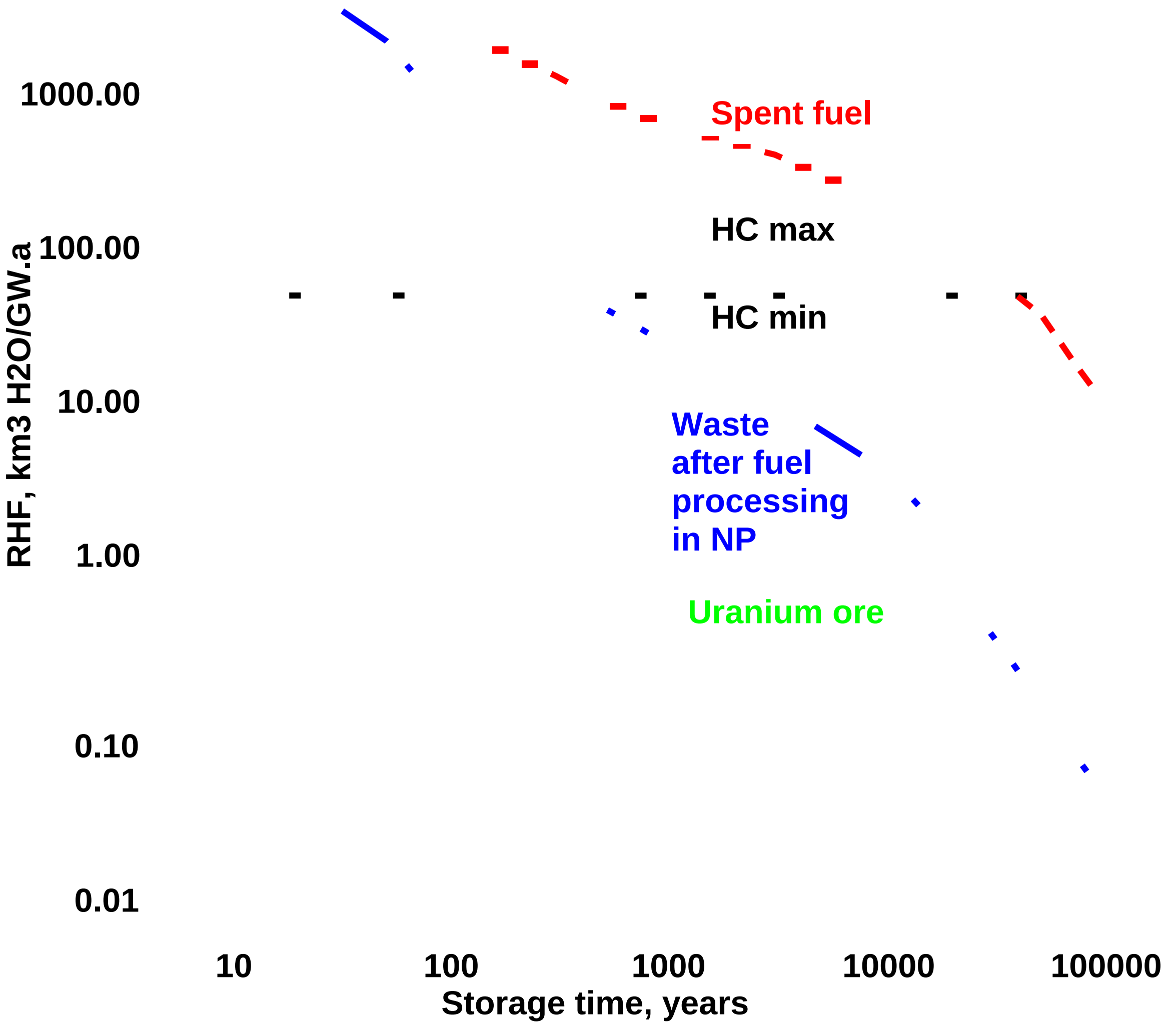

1000.00
100.00
10.00
1.00
0.10
0.01
RHF, km3 H2O/GW.a
Spent fuel
HC max
HC min
Waste
after fuel
processing
in NP
Uranium ore
10
100
1000
10000
100000
Storage time, years

Figure 117. Radio-toxic risk factor for waste produced during generation of electricity 1 GW-year, measured with the amount of water in which to dissolve the waste in order to reduce its concentration to the acceptable limit for drinking water, RRF (km^3 H_2O/GW-year).

- Spent fuel—nuclear fuel stored without processing, open cycle (USA)
- Waste after nuclear plant fuel processing, containing 0.5% of residual plutonium (e.g. from spent fuel processing facilities in France)
- HC max—slag and ash from coal combustion with maximum contents of pollutants (Poland)
- HC min—slag and ash from coal combustion with minimum contents of pollutants (Poland)
- Uranium ore—ore necessary to produce nuclear fuel providing 1GW.a (124,000 tons of ore with 0.17% uranium contents)[192]

Initially, the value of RRF in the nuclear cycle is defined by the activity of fission products both for the cycle with fuel processing (closed cycle), as well as without it (open cycle). However, the activity of fission products decreases faster than the activity of actinides. Therefore, their RRF becomes negligibly small when compared to the RRF of actinides already after 100 years in the open cycle, and after 300 years in the closed cycle (with fuel processing).

In the case of hard coal and lignite, the main contribution comes from cobalt (Co), copper (Cu), and vanadium (V). In lignite, also the contents of nickel (Ni) is important. The volumes of water necessary to dilute toxic elements to permissible concentration levels for drinking water are higher by an order of magnitude in the case of lignite (2100-3085 km^3/GW-year) than in the case of hard coal (48-190 km^3/GW-year).

A RRF curve for high-level waste in a closed cycle (in which uranium and plutonium are recovered for reuse in the reactor) decreases below that of lignite waste after 45-60 years, and after 200-500 years below the RRF curve for hard coal waste, depending on the initial contents of toxic elements in hard coal and lignite. The RRF for high-level waste drops below the RRF for uranium ore after 24,000 years.

It is actually correct, however, that when we do not recycle fuel, but store it along with radioactive waste, the hazard decreases much more slowly. Therefore fuel processing, criticised by anti-nuclear organisation, is an option preferred by the nuclear industry both in terms of uranium energy utilisation as well as easier protection of radioactive waste. The curves described above should be considered in connection with the minimal duration of a high-level waste container, assumed as amounting to 1000 years. Even assuming complete dissolution of radioactive waste in ground water, the danger related with high-level waste shall be lower than that connected with waste from coal plants already after 200 years. And on top of it, radioactive waste is carefully stored, so they shall remain separated from the biosphere not for 200, but for 20,000 years and longer.

In addition, at some point the level or radiation reaches a level characteristic for the natural uranium ore. The comparison with the initial danger caused by the uranium ore indicates that even if minimal radiation doses had posed risk of cancer, the operation of a NPP would have not resulted in growth of the general radiological hazard on Earth. Already when the RRF for high-level waste drops to the RRF level for ore, the radiological hazard is decreased, because ore is spread over open areas, often in contact with ground water, while high-level waste is stored in stable geological formations and separated from the environment. In the next years, the RRF for waste is lower than the initial RRF for ore and the difference between them constantly grows over time. So paradoxically, the operation of a NPP contributes to decreasing of the general radiation

[192] IAEA, Nuclear Power and Sustainable Development, 1998

background on Earth. In is not certain at all, whether we should aim for that, as there are many experiments showing that the existing radiation background is necessary for life of living organisms, but at least it can be said for sure that operation of NPPs and storage of radiation background do not increase the average radiological hazard for future generations.

2.7.4. Discussion of the argument that presently there is not a single high-level radioactive waste depository in the world

It is not true that there is not even a one radioactive waste repository in the world which would guarantee biosphere protection for a period in which the waste pose a risk. The United States already operate a radioactive waste repository in deep geological formation. This repository is called the Waste Isolation Pilot Plant and it is located in the desert in the State of New Mexico, and the waste is stored at a depth of 655 metres in a salt deposit. However, it is true that the repository is not intended for waste from commercial nuclear reactors, as it is a destination for waste which comes mainly from scientific centres and military facilities.

In the United States, also a commercial waste repository in Yucca Mountain, Nevada, was planned. However, after twenty years of research and spending a billion dollars, the project was abandoned. There were a couple of reasons, and among them: lack of clarification for certain doubts concerning geological suitability of the terrain; the fact that the nuclear energy in the USA is experiencing a renaissance and estimated waste volumes increased significantly; finally—substantial social resistance. Cancellation of the Yuca Mountain project does not change in any way, however, the fact that it is necessary to carry out this project somewhere else. Surveys are in the course.

European countries has also undertaken works on the location of a deep waste repository. First geological repositories are already being built in Sweden and Finland. Both countries chose granite formations almost 2 billion years old and unaffected with seismic activity during that time. In Finnish Eurajoki, the construction has already started (for now, as a research facility), and the licencing process is to be commenced this year. Waste storage shall start in 2020. In Sweden in turn, the process of site selection has been completed and finally a decision was taken to commence research works in Osthammar municipality. Also in France there are significantly advanced works under way to build a repository. In a couple of years, the construction of CIGEO repository in Lorraine shall be commenced. The geological formation selected there for this purpose was a deck of clay which is impenetrable for water.

These three repositories, as well as other in the course by Switzerland, the United Kingdom, are to accept waste in the next decade and operate for a hundred of years at least.

Certainly, the construction of a deep waste repository is a great challenge both in engineering, as well as in research-related and economic terms. However it should be highlighted that one of main obstacles for the construction of a repository is public support. One of the reasons for the "collapse" of the Yuca Mountain project described above was lack of public acceptance.

However, even the circles with anti-nuclear attitude admit that we cannot avoid the construction of such a repository, irrespectively of reasons of the nuclear power opponents, and whether the nuclear programs are going to be developed in various countries or not. At present, there are more than 300 thousand ton of high-level radioactive waste in the world. They are mostly stored in temporary repositories.

When comparing possible threats it is obvious that it is more safe to store such waste deeply underground, in special facilities and containers.

The repository currently constructed in Finland as well as repositories planned in Sweden and France guarantee full protection of the biosphere against ionising radiation of waste stored in the repositories. Alike, the finally chosen manner of radioactive waste and spent fuel management shall guarantee full protection of the biosphere against radiation effects. Also Poland disposes of relevant geological formations, which is confirmed by studies conducted as part of the first Polish Nuclear Power Programme. These issues shall be specified at the stage of development of **KPPzOPiWPJ** strategic document, at the proceedings of SEA related to it, as well as at the stage of EIA for the proposed target location. The works shall be carried out for the decade to come, and all stakeholders, as part of SEA procedures may participate in them.

2.7.5. Discussion of the argument that costs of disposal and storage of radioactive waste from NPPs have not been taken into account in Poland.

Costs of disposal of radioactive waste from nuclear power plants have been taken into account in Poland, as evidenced by regulation by the Council of Ministers on contributions to the nuclear power plant decommissioning and waste disposal fund. To calculate the amount of contribution defined in this regulation it was assumed that in the period of a 60-year operation of nuclear power plants of capacity of 6,000 MWe, 54,000 m^3 of radioactive waste shall be produced and 6,700 tons of heavy metals contained in spent nuclear power plant fuel. In turn, the volume of radioactive waste produced in result of decommissioning of a nuclear power plant with capacity of 6000 MWe was determined as 67,500 m^3.

After the analysis of historical data and assuming the development of nuclear technologies in health care, industry (in addition to nuclear power), and science, it was estimated that the amount of radioactive waste to be stored, coming from these applications, shall reach 100 m^3 annually. For the period of 120 years of repository operation (2021÷2140) it is about 12,000 m^3.

Summing up, the repository of low- and intermediate level radioactive waste should have capacity of at least 170,000 m^3. A repository of high-level radioactive waste and spent fuel should make it possible to store (with a reserve) spent nuclear fuel containing up to 6,800 tons of heavy metals. High-level radioactive waste will occupy a negligible part of the repository.

The estimation of total costs of repository per unit of volume of radioactive waste implies the averaged cost of storage of 1 m_3 of radioactive waste - PLN 33,200. The cost of railway shipment of radioactive waste over a distance of 500 km, estimated on the basis of current PKP CARGO tarrifs— with charges for shipment of hazardous materials included (radioactive materials) was estimated at 900 PLN m_3.

All in all, on the basis of prices of 2011, the costs of storage of 1 m_3 low- and intermediate level waste has been estimated at PLN 34,100.

The commencement of work on the high-level radioactive waste repository (also for spent fuel) is planned for 2025, while its operation shall start in 2064. From the analysis of costs of construction, operation, and decommissioning of the repository it follows that the specific cost of storage of spent nuclear fuel containing 1 ton of HMs totals PLN 2,250 million.

The commissioning costs for a nuclear power unit were estimated at PLN 3 billion, assuming that it shall be a power unit with an EPR using technology for which the greatest amount of radioactive waste is produced. The costs of storage of radioactive waste from decommissioning—PLN 812 million. In total, the commissioning costs for one nuclear power unit shall reach the level of approx. PLN 4 billion, in prices of 2011.

The analyses aimed at determination of the amount of contribution to the decommissioning fund, a 30-year decommissioning period for a NPP was assumed and a 20-year decommissioning for a nuclear fuel storage facility. The duration of decommissioning period shall have little influence on the amount of deductions to the fund.

To calculate the quarterly contribution for the decommissioning fund, a fixed inflation level of 2% annually was assumed as well as a fixed interest on bank deposits in the amount of 3% annual.

Taking these assumptions into account, the payment to cover the final costs of management of spent nuclear fuel and radioactive waste and to cover the costs of decommissioning of a nuclear power plant was determined in the amount of **PLN 17.16** for 1 MWh of electricity generated in nuclear power plant. It is more than e.g. in the USA (approx. 4 USD/MW).

The regulation under consideration belongs to the national legal supervisory framework for safety of nuclear facilities and management of spent nuclear fuel and radioactive waste, which member states of the European Union are obliged to establish pursuant to directive 2009/71/Euratom, and also regulations of directive 2011/70/Euratom. The selected items of the regulation were presented here to demonstrate that the Polish nuclear program does not ignore the problem of radioactive waste, and to the contrary, intends to solve it in line with the best global practices.

2.7.6. Discussion of concerns about the export of Polish waste

Export of radioactive waste or spent nuclear fuel produced in Poland for the final storage is inadmissible pursuant to EU legislation and it is not considered in the context of the nuclear industry development programme.

It is a fact, however, that spent fuel from Polish research reactors has been exported to Russia under a special agreement.

2.7.7. Discussion of the objection relating to the lack of description of risks related to shipment of nuclear fuel and radioactive waste

Contrary to the fears, shipment of spent fuel and radioactive waste does not cause any radiation hazard. At present, more than 20 million radioactive cargos are shipped every year, and the number of spent nuclear fuel shipments has already exceeded 80,000—with zero radiation accidents resulting in loss of health or life of people.

There are two possible sources of radiation in transport of spent fuel and radioactive waste:

- radiation emitted from the containers with waste in standard conditions during the shipment,
- possible growth or radiation and release of radioactive materials in the event of accidents severe enough to damage highly resistant containers applied in transport of high-level spent fuel.

The requirements aimed at ensuring safety of transport of radioactive materials have been determined for decades, they were agreed upon and published by IAEA[193] [194] , and—with small changes—they are applicable also today. Under normal transport conditions, standards adopted in all countries define the maximum applicable level of radiation in proximity of transport package and vehicle carrying radioactive waste, and also permissible radioactive contamination of container surface.

Successful shipments of radioactive materials have been made for 50 years. Most of the cargos is intended for hospitals, other for industry, research laboratories and NPPs. Approx. 1% of them are high-level materials. No one lost their health or life so far in result of releases or radiation of shipped radioactive materials.

Table 25. Radiation levels permissible under IAEA requirements in transport of radioactive materials.

Limitation type	Dose rate [mSv/h]
The radiation level at any point of the packaging surface (if it is not forwarded as a special shipment by land, sea, or air)	2
The radiation level at any point of the external surface of special shipment packaging	10
Packagings that were contaminated must be decontaminated to reduce the radiation level on the surface of the shipment caused by contamination below the dose rate limit	0.005
Radiation level at any point within a distance of 2 m from the vehicle surface	0.1

Containers with radioactive materials are designed in such a way so as to ensure safety not only during ordinary transport, but also after accidents, whereby design basis accidents are determined in a way making them more severe than accidents which can be expected on the basis of experience and pessimist analyses.

B type containers for spent fuel shipment by land or sea must be resistant to all possible transportation accidents. The tests of B and C type container includes the following:

[193] IAEA·Safety Standards. Publ. 1255. Safety Requirements TS-R-1, Regulations for the Safety Transport of Radioactive Material, 2005 Edition, IAEA, Vienna, 2005

[194] IAEA Safety of Transport of Radioactive Materials, Proc. of an Intern. Conf. Vienna, 7-11 July 2003, IAEA·Vienna 2004, Publ. 1200.

- Impact of a train traveling at full speed on a concrete barrier (Fig. 1)
- Impact of a train on the container side
- Fall of a B container from a level of 9 m onto a hard, concrete surface
- Resistance to perforation with a metal rod
- Fire
- Sinking of the container

Figure 118. Train carriage with a B type container of 74 tons impacts at the speed of 130 km/h on concrete block weighing 690 tons. Photographs of tests performed by Sandia National Laboratories, presented at the courtesy of the Nuclear Energy Institute (USA).

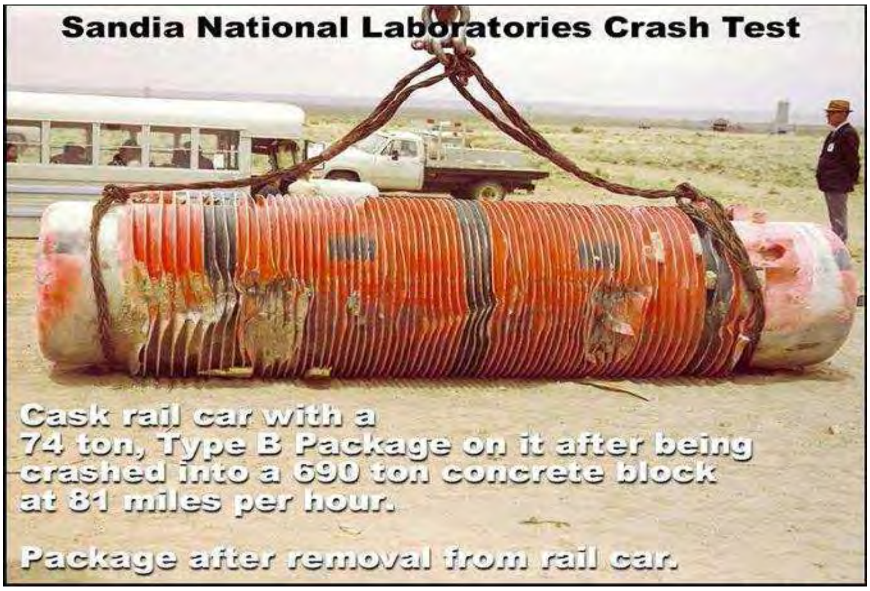


Figure 119. B container retained its protective properties after test of impact of a train on a concrete wall. Photograph of the test performed by Sandia National Laboratories, presented at the courtesy of the Nuclear Energy Institute (USA).

In the case of the test shown in Figure 63, the required design basis speed for the train is 60 km/h, but Sandia Laboratories have performed this test for a train moving at 130 km/h. The carriage was totally destroyed, but the container retained its shape, tightness, and protective properties, as it can be seen in Figure 64.

The fire test (Figure 120) includes exposing the packaging for 30 minutes to the influence of a surrounding which generates an inflow of heat equivalent to hydrocarbon fuel fire in air, under conditions sufficiently stabilised so that the average emission factor is 0.9, and the average temperature at least 800°C. The packaging must be entirely engulfed with fire, with the absorption ratio of 0.8, and the trial must be conducted up to the moment when the temperature in the whole container with contents imitating radioactive materials starts to decrease.

Tests for A type containers are performed at lower parameters, e.g. the level of fall onto a hard surface is selected depending on the container's weight.

Figure 120. Fire test. Photograph of the test performed by Sandia National Laboratories, presented at the courtesy of the Nuclear Energy Institute (USA).

2.7.7.1. Conclusions

The risk connected with accidents during transport of spent fuel and radioactive waste is well known and low. The high level of safety was ensured thanks to the following:

- Strict safety requirements for designing, construction, tests, and operation of transport containers set out in the international regulations universally recognised as valid.

- 1:1 container tests under conditions of the most sever accidents.
- Continuously improved calculation and computer models of behaviour of packages under conditions of an accident.
- Reconstructions of accident conditions for transport accidents not related to radioactive materials to learn about the behaviour of protective containers in such situations.

With these safety measures, no accidents have occurred so far in which release of radioactivity during transport would result in loss of life or health of staff or residents. Transport of spent fuel and radioactive waste from Polish nuclear power plants shall be subject to the same regulations and comply with the same safety requirements.

2.8 IMPACT OF EMERGENCY CONDITIONS IN NUCLEAR POWER PLANTS

2.8.1. Discussion of the argument on the lack of possibility to avoid accidents in nuclear power plants

The allegation concerns nuclear accidents and bases on examples of accidents in Chernobyl and Fukushima, arguing that similar disastrous accidents can occur at any time in any nuclear power plant, not excluding the most advanced 3rd and 3rd+ generation plants, and result in radioactive contamination of environment on a large scale and threat to health and life of people. The authors of the objection does not take account of technological advancement that took place in nuclear safety for new generation reactors, or of the fact that Chernobyl and Fukushima are not representative cases of possible accidents which can happen in the European nuclear power plants, including in particular new generation reactors. They demand categorically that the plans in the scope of nuclear power which is—according to the authors of the objection—very dangerous because one cannot exclude accidents in nuclear power plants, should be abandoned.

Meanwhile, the Chernobyl accident occurred in a LWGR-RBMK which is a reactor type designed originally to produce plutonium for military purposes, which was adapted in the USSR to generate electricity (these reactors are unstable in certain states), while the main reason behind the accident was an irresponsible, badly prepared and conducted experiment during which operators switched off all most important safety systems, one after another. Chernobyl-type reactors have not been used in power industry anywhere outside the USSR, and should similar mistakes be made by operators of a nuclear unit with a water reactor (some of these errors, however, are impossible to be be made), it would result in automatic reactor shut-down. An indirect, but very important reason behind the accident was also lack of "safety culture" and weakness of Soviet nuclear supervision.

The Fukushima accident in turn occurred in old BWRs of 2nd generation, with relatively weak safety containments (Mark-I) type. **The direct cause** of this accident was the disastrous magnitude 9 earthquake (one of the strongest in the history of Japan), which occurred under the bottom of the Pacific, within a distance of approx. 130 km east of Honsiu, and first and foremost the enormous tsunami caused by the earthquake. The earthquake and tsunami caused huge devastation in large areas of Miyagi and Fukushima prefectures, approx. 19,000 people were killed or missing, and 27,000 injured. In Fukushima Dai-ichi Nuclear Power Plant, a tsunami approximately 14-15 high broke through way too low breakwater (designed to stop a wave 5.7 m high), flooding the power plant area to a water level of 4-5 m, and destroying a number of systems and devices important for safety purposes, including safety systems. In particular, the tsunami destroyed the cooling water intake and pumping station (located behind the breakwater) and washed out a fuel oil storage, polluted water rushed into the engine room, flooding emergency Diesel aggregates (situated below the plant area), switchboard rooms of safety systems, battery rooms and other devices important in terms of safety. **Indirect causes** of this accident are errors and omissions of people and institutions responsible for safety of nuclear power plants. The site for the plant was chosen incorrectly—it was not only located in the area of substantial seismic risk, but first of all exposed to tsunami, and even worse—the maximal design basis tsunami height was estimated incorrectly.

Necessary improvements and safety measures were not introduced, and in particular:

- flood protection systems protecting the power plant area, as well as (additionally) other facilities of crucial importance for safety against inundation—including in particular by tsunami;
- additional (secondary) safety systems located in (bunker-type) buildings, protected against flooding (tight and situated sufficiently high)[195], which would ensure safety of the plant even in the case of extreme natural hazards;
- passive systems and devices—in particular for safety containment atmospheric mixing and hydrogen recombination.
- gas discharge systems of safety containment have not been adequately modernised so as to enable their trouble-free use under conditions of severe accident, power outage or lack of supply of pressurised air.

The negligence described above shall be attributed not only to the owner and operator of Fukushima NPP (TEPCO), but also the Japanese Nuclear Supervision Authority. Functions of nuclear supervision in Japan was divided into 3 organisational units, which were incorrectly subordinated in organisational terms, in particular the main supervision authority (NISA) reported to the Ministry of Economy, Commerce, and Industry. In such an organisational formula, Japanese supervision turned out to be insufficient in enforcement of nuclear safety requirements. In 2012, Japanese nuclear supervision was radically reorganised and it presently comprises two new units subordinated to the Minister of Environment: Nuclear Safety Advisory Committee and Nuclear Safety Agency.

It is true, however, that severe accidents in nuclear power plants, capable of causing radioactive contamination in their area, cannot be completely ruled out. However—especially in the case of 3rd and 3rd+ generation reactors, probability of such accidents is extremely low (lower than once a

[195] Such improvements have been applied in a number of NPs located in flood hazard areas.

million reactor years, which is approx. 100 times less than for 2nd generation reactors), while the size and range of possible contamination are limited to such an extent so as the intervention necessary to protect health of the population could be limited to the area within a distance of a couple of kilometres from the reactor (in accordance with EUR requirements[196] —3 km). At the same time, the key element of safety requirements for designs of new generation nuclear power plants is to practically rule out (in deterministic terms, with the use or relevant design basis solutions) of accidents with core degradation which could lead to early damage of safety containment of the reactor and very large releases of radioactive substances to the environment. Design basis solutions for 3rd and 3rd+ generation nuclear power plants are completely different from those of Chernobyl (RBMK), and significantly differ from those in Fukushima (old BWRs with poor safety containments and other faulty design basis solutions). Therefore, in no event the designs of RBMK units from Chernobyl or old BWR-3 and BWR-4 units from Fukushima could be considered representative for advanced, new generation nuclear units—and only such units will be allowed in Poland.

From among severe accidents of power reactors (with core degradation), which have occurred in the world, only the accident of a pressurised water reactor (PWR) of the 2nd unit of Three Mile Island (TMI-2) NPP in the USA may be considered representative for units to be built in Poland. However in this case, despite destruction of the reactor core, the defence-in-depth philosophy applied in design has proven its effectiveness and radiological effects of this accident in the NP's surrounding were very limited—millions of times smaller than in the case of Chernobyl, or even Fukushima. From the accident in TMI-2, nuclear industry learned an extensive and far-reaching lessons both in terms of technical solutions as well as training for operators, and technical support for NPP staff during accidents, which have been used also to define requirements for new generation reactors.

In Poland, the Nuclear Supervision reports to the Minister of Environment—so in our country, supervisory activities connected with nuclear safety supervision and control and radiological protection is separated from and independent of activities connected with promotion and development of nuclear energy. Moreover, Polish Nuclear Supervision has extensive statutory entitlements (extensive information on that topic is contained in section 14).

In Poland, there are no natural hazards such as in Japan—possible locations of nuclear power plants are in regions where seismic activity is low, there are no significant risk of tsunami (because of low seismic activity and the fact that the Baltic Sea is very shallow), extensive information about external threats is provided in chapter 5. What is more—stress tests allowed to determine resistance of the designs of new generation nuclear units even to such external threats as occurred in Fukushima.

To conclude, it should be said that accidents in Chernobyl and Fukushima are not representative in terms of the assessment of risk connected with the development of nuclear power in Poland, and that the risk remains at an acceptable level, especially having in mind that only state-of-the-art and most safe NPP technologies currently available commercially are planned to be used, and there are no significant external threats in possible location areas.

[196] European Utility Requirements for LWR Nuclear Power Plants. Revision C. April 2001.

2.8.2. Discussion of the argument that the SEA Forecast does not correctly assess the probability of accidents and their impact

The SEA Forecast (chapter 7), determines both the types and probability of occurrence and impact of possible nuclear accidents in nuclear units, equipped with 3rd+ LWR of the types taken into account (EPR, AP1000, ESBWR), on design basis as well as beyond-design-basis (extended design basis). In particular: amounts of emissions of radioactive substances in the case of design basis accidents and severe accidents are provided in item 7.1.2 and 7.1.3; while the probabilities of their occurrence and the radiological impact of various transient states (incidents) as well as design basis accidents and severe accidents—in items 7.4 and 7.5.

Impact of design basis accidents and severe accidents with core degradation are discussed in detail in the SEA Forecast, chapter 7, but some additional remarks are presented in this section, item 3. The diagrams presented clearly show that the impact of even severe accidents does not extend beyond a couple of kilometres from the nuclear plant. Should an EPR be built, the perimeter of the zone for which intervention shall be planned in the case of severe accident, would not exceed 3 km. In the case of locations currently preferred (Choczewo, Żarnowiec), the distance from the nearest country (Germany) is hundreds of kilometres, so any radiation impact is out of question, whether in standard operating conditions or in the case of an accident.

Therefore, Poland shall build 3rd generation reactors so as not to expose its own population, and the more so population of neighbouring countries, to an accident.

Safety of reactors shall be verified by competent and objective nuclear supervision authorities, not connected with electricity producers, and all safety analyses are available and may be reviewed by all interested. Many years of work aimed at improving safety of the reactors brought about solutions referred to as 3rd generation reactors whose safety properties ensure that radiation impact of an accidents are not perceptible within a longer distance than few kilometres, even in the case of an accident with core reactor degradation.

The Ministry of Economy disagrees with the argument that the Forecast incorrectly assesses the probability of occurrence of accidents. The data on accident occurrence probability presented in the "Forecast..." are based on results of probabilistic safety assessments verified by nuclear supervision authorities of many countries, and in particular: American (US NRC), French (ASN), British (HSE-ONR) and Finnish (STUK). Moreover, these assessments have been also verified by IAEA expert teams as part of the Generic Reactor Safety Review Project[197]. In addition, the methodology of probabilistic safety analyses for nuclear power plants has been developed and improved for tens of years, and there is a broad international consensus in this field, expressed in the form of guidelines of the International Atomic Energy Agency on probabilistic safety assessments.

The probability of occurrence of a severe accident (involving reactor core degradation) in a nuclear power plant with 3rd or 3rd+ generation reactor is lower than ones every million years of operation of the reactor, while the probability of a severe accident leading to substantial releases of radioactive substances to the environment is lower than once every 10 million years of operation

[197] Modro S.M. APPLICATION OF IAEA SAFETY STANDARDS: Insights from Generic Reactor Safety Review Projects (GRSR) Nuclear Power Summit, Warsaw, 25 – 26 November 2009 r.

of the reactors, so it is justified to say that the possibility of occurrence of a severe accident with significant environmental impact are close to zero.

In Particular, Polish regulations set out the highest standards of nuclear safety applicable currently in the world, complaint with the most recent international requirements (in particular safety objectives for new generation reactors contained in IAEA SSR-2/1 document and WENRA Declaration of 2010[198]), taking into account also the requirements of EUR document and lessons learned in result of the accident in Fukushima Dai-ichi NPP and stress testing of European nuclear power plants. Safety requirements contained in Polish regulations do not boil down to setting probabilistic criteria. The safety objectives for new generation reactors, referred to above and adopted in Polish regulations, include practical ruling out (in deterministic terms, with the use or relevant design basis solutions) of accidents with core degradation which could lead to early damage of safety containment of the reactor and very large releases of radioactive substances to the environment, and limiting the impact of accidents with core degradation which have not been ruled out, so as to significantly limit the necessity of intervention to protect health of the population to a limited area and time.

The requirements in this scope are contained in art. 35b section 2 of the Atomic Law (amended in 13.05.2011) and §9 and §32 of "Design Regulation" (it is a regulation by the Council of Ministers included to the secondary legislation of the Atomic Law); relevant requirements from these regulations are presented below.

Atomic Law[199]

Art. 36c.

(…)

2. Should any emergency arise that may lead to the degradation of the reactor core, the design of the nuclear facility shall have in place specific solutions that will be most likely to prevent:

1) a chain of incidents leading to premature release of radioactive substances, i.e. incidents that require intervention measures to be employed outside the nuclear facility, if no time is left to implement them;

2) a chain of incidents leading to considerable releases of radioactive substances, i.e. incidents that require general public protection measures to be employed which would be unlimited in time and space.

Design Regulation[200]

§ 9. Nuclear facility design shall ensure the limitation of releases of radioactive substances beyond the reactor containment in case of the occurrence of accident conditions so that in the event of:

1) *design basis accidents, there is no need to take any intervention measures beyond the limits of the restricted-use area;*

[198] WENRA Statement on Safety Objectives for New Nuclear Power Plants. November 2010.
[199] Dz. U. [Polish Journal of Laws] of 2012, items. 264 and 908.
[200] Dz. U. [Polish Journal of Laws] of 2012, item 1048.

2) extended design conditions, there is no need to take:

a) early intervention measures beyond the limits of the restricted-use area of the nuclear facility during the releases of radioactive substances from the nuclear facility,

b) medium-term intervention measures at any time whatsoever beyond the limits of the emergency planning zone,

c) long-term intervention measures beyond the limits of the restricted-use area of the nuclear facility.

§ 32. 1. The design of a nuclear power plant and research reactor shall take into account accident sequences which bypass the reactor containment, even without fuel melting, capable of leading to the direct release of radioactive substances beyond the primary reactor containment, by applying the following solutions:

1) appropriate safety reserves when designing systems connected to the reactor cooling circuit;

2) minimising the number of culverts located in the primary reactor containment;

3) isolating fittings which are appropriately reliable and which are duplicated on the pipelines connected to the reactor cooling circuit, passing through the primary reactor containment;

4) in case of a pressurized water reactor – safety measures in order to minimise the loss of reactor coolant and the releases of radioactive substances beyond the reactor containment if the pipes in the steam generator are ruptured.

2. Nuclear power plant and research reactor shall be designed so as to prevent the occurrence of severe accidents, which could lead to a premature failure of the primary reactor containment, or it shall be demonstrated that the probability of occurrence of such accidents is so small that it is not necessary to include it in the design.

3. The accidents, referred to in Section 2, shall cover in particular:

1) hydrogen explosion;

2) failure of the reactor vessel with pressure which could lead to:

a) ejection of the molten core material and direct heating of primary reactor containment or

b) generation of high-energy particles which could threaten the integrity of primary reactor containment;

3) steam explosion, which could threaten the integrity of primary reactor containment;

4) reactivity-initiated accidents, including – in pressurized water reactors – heterogenic dilution of boric acid.

4. The design of a nuclear power plant and research reactor shall provide for solutions ensuring limitation, by means of the reactor containment system, of the consequences of severe accidents involving reactor core degradation, in particular by:

1) *stopping and cooling the reactor molten core;*

2) *limiting the consequences of interaction between the reactor molten core and concrete;*

3) *limiting leakage from the reactor containment, taking into account stress resulting from the oxidisation of fuel claddings and hydrogen combustion and other strains which could occur during severe accidents;*

4) *extending the time after the lapse of which it will be required to use operator's intervention measures or other measures with the purpose of bringing the accident under control.*

2.8.3. Discussion of the objection that PNPP and SEA Forecast do not mention or take into account the impact of Fukushima accident

The final version of PNPP was published in September 2010, while the original text of the SEA Forecast in December 2010, before the Fukushima accident, so it is obvious that the accident is not described in the original SEA Forecast.

Currently, for the purposes of the SEA Forecast, after consultation, three studies have been prepared describing the causes, course, and results of Three Mile Island, Chernobyl and Fukushima accidents. The studies demonstrate that the Chernobyl accident occurred in a reactor substantially different from 3rd generation reactors considered for nuclear power plants in Poland, and external threats, which caused the accident in Fukushima—earthquake and tsunami—shall not occur in Poland in a similar size. To lesser seismic shocks—which can be expected once every 10,000 years in Poland, and also stronger ones, the reactors proposed for Poland are prepared and resistant.

2.8.3.1. Radiological impact of TMI accident

On 28 March 1979, the core of the second reactor of Three Mile Island NPP was partially degraded. The direct cause of core damage was switching off the emergency core cooling system by the operators. The decision was taken on the basis of readings of measuring equipment which were misleading to the operator and did not indicate that a valve was open, releasing coolant from the primary circuit. The operator was sure that the primary circuit is tight and suspended the inflow of cooling water in order not to overfill the primary circuit. In result, the coolant was in the core was depleted, and then—overheated, which led to melting of fuel elements. The molten fuel fell to the bottom of the reactors vessel, but the vessel remained tight, similarly as the safety containment. The "defence-in-depth" system proved to be effective, despite errors made by the operators[201]. The reactor was strongly contaminated and permanently taken out of operation, but fission product releases beyond the containment were minimal, no one was killed or hurt, and the only health impact was limited to the stress caused by concerns and contradictory information about the possible consequences.

[201] Strupczewski A. Awarie reaktorowe a bezpieczeństwa energetyki jądrowej, WNT Warsaw, 1990

The consequences of the TMI accident were very far-reaching. On the basis of the analysis of errors in measurement equipment and other design-basis defects detected during the accident, the US Nuclear Regulatory Commission issued a number of orders, requiring the power industry to introduce necessary improvements, and the reactor industry undertook a number of actions to ensure that accidents such as TMI will never happen again. One of important results of the analysis of operators' behaviour was preparation of procedures of conduct in case of accidents, based on the accident symptoms, namely readings of measurement equipment available in the control room, without guessing what damage caused the accident. Such procedures were implemented for the first time in nuclear power plants of Westinghouse (design and/or delivery), and then all over the world. To a large extent, they reduce the risk of operator's error. At the same time, improvements of measurement systems were introduced, ensuring *inter alia* that devices in the power plant control room show the actual state of all components necessary for safety.

Although the TMI accident was a financial failure of the plant's owner, it turned out to be a success of safety philosophy governing the power industry. Neither the health of operators, nor of population was impaired, and the surroundings of TMI was not contaminated. Because iodine did not escape from the safety containment and thyroid risk was not involved, pills of stable iodine were not distributed among the population.

Releases of fission products from the power plant were limited to approx. 370 PBq of noble gases (released —although in a far smaller amount—also during standard operation[202]) which do not chemically bind with other elements and therefore fly with the wind, "dissolves" quite quickly to permissible concentration levels and are not deposited in human organism or earth surface. The collective doses received around the plant, caused by emissions of these gases[203] and iodine was so small that remained below the click threshold of devices, in spite of involving the best measurement teams in the USA to work around TMI, and equipping them with the best measurement systems then available in the United States. Specialist assessing the accident results estimate that the iodine fraction which escaped the safety containment was lower than one ten-millionth of the iodine amount in the reactor core.

After the accident, the average dose for people residing within 80 km was lower than 0,015 mSv, and for those living within 16 km—0,08 mSv. The maximum individual dose was calculated below 1 mSv[204].

Contamination of milk with fission products was negligibly small. The highest concentration occurred in goat milk used to feed goatlings. According to NRC estimates, infants fed with goat milk with maximum contamination for 2 months after the accident would hypothetically receive a dose of only 0.02 mSv.

The reports asserting negative health impact are most often groundless. Many organisation specialising in protection against radiation conducted a number of epidemiological surveys and did not find any negative health effects[205]. Moreover, the objections connected with health loss, put forward by some residents, were considered by a court. Both regional courts as well as court of

[202] average releases of noble gases during NPs operation in 1997-99 according to UNSCEAR data totalled 13 TBq/Gwe-year

[203] Eisenbud M., Exposure of the General Public near Three Mile Island, Nuclear Technology, vol. 87, Oc 1989, s 514-519
[204] Good B.A. et al: Three Mile island and the Environment, Nuclear Technology, vol. 87, Oc 1989, s. 395-405
[205] Cantelon P.L., Williams R.C., Crisis Contained, The Department of Energy at Three Mile Island," 1982

appeal decided that despite reviewing all files and documents with the aim of justifying the claims of the residents, no grounds were found to confirm the impact of the accident on health of the population, and the full consistence of different measurements and calculation models analysed by various teams indicates that they are accurate. Assertions about the harmful impact of TMI accident on the health of the residents were rejected[206], [207],[208].

In June 1996, 17 years after the TMI accident, a District Judge of the District Court of Harrisburg, Ms. Sylvia Rambo, dismissed the suit of a plaintiff who claimed that the accident caused health results. The Judge relied on the following facts:

- The Consistence of radiation exposure maps prepared on the basis of computer models fed with data collected with thermoluminescent dosimeters (TLD), operating during the accident, which indicates that the devices fulfilled their role and correctly measured the dose rates.
- The maximum dose outside the power plant not exceeded 1 mSv, which means that the total collective impact of all radioactive releases could cause less than 1 death of cancer in the whole time span after the accident.
- The plaintiff did not manage to demonstrate their claim that hydrogen explosions in the reactor system caused radiation releases after which compact, but highly concentrated strips of radioactive gases were formed.

The Judge concluded:

"*Although the plaintiff claims that they received a 1 Sv dose (the level of doses received by certain Hiroshima residents during nuclear explosion), the court observed that it would be sufficient to win the case to demonstrate that they received a 0.1 Sv dose. However the plaintiff was unable to demonstrate even such dose.*"

As the judge wrote in the reasons:

"The plaintiff has had more than 20 years to gather evidence of their claims. Lack of evidence is obvious. The court searched all the evidence to find circumstances which would put in favourable light the plaintiff's request and provide reasons for referring the case to court. The court's efforts, however, are fruitless—no such circumstances have been found.".

Lawyers of the plaintiff appealed to a higher instance. The appeal has been examined by the Third Court of Appeal of the United States, which sustained the decision of Ms. Rambo.

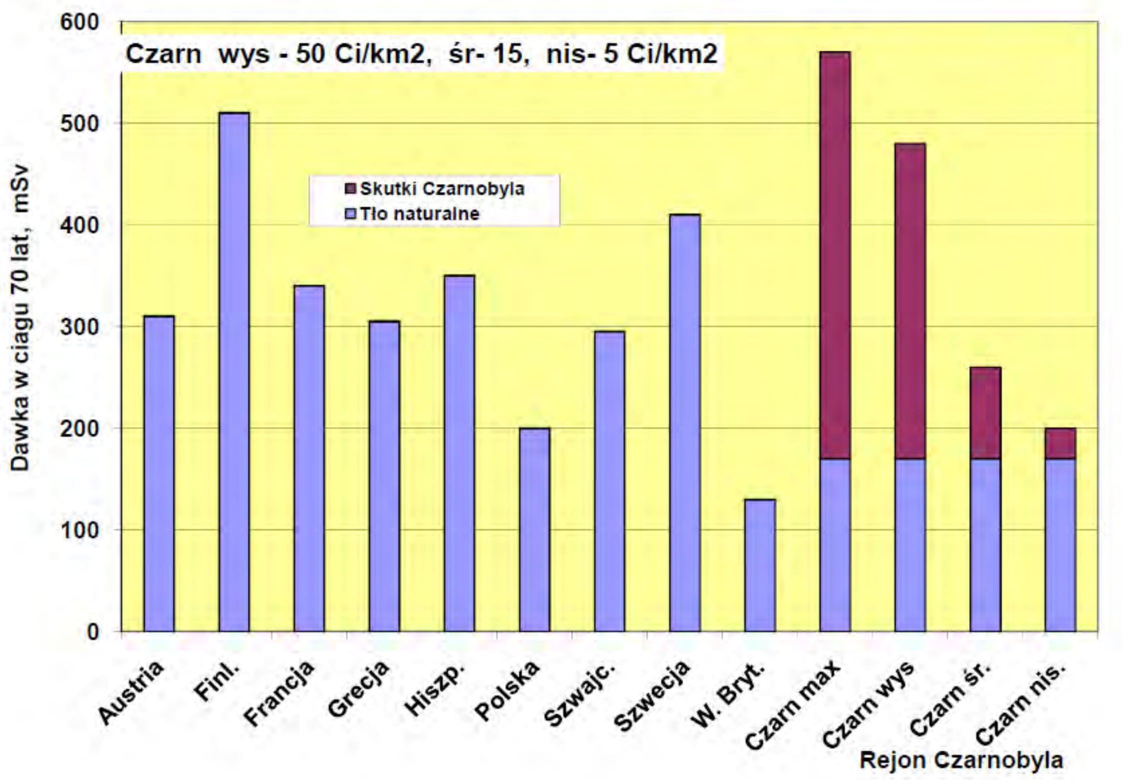
2.8.3.2. Radiological impact of Chernobyl accident

The Chernobyl reactor referred to tin Forecast, was built in a way incompliant with nuclear safety

[206] Holloway R. Killing Our Own - Did People Die from Three Mile Island? 1998 www.ntanet.net/threemile.html
[207] Samuel Walker: Three Mile Island – a nuclear crisis in historical perspective, Regents of the University of California, 2004
[208] Fox M., Miloy S. Fear and ignorance followed Three Mile island, News Tribune Tacoma March 28,1999, htpp://www.junkscience.com/mar99/tmi.htm

principles applicable in civil nuclear industry. Enabling a spontaneous increase of capacity in certain emergency situations in its design was inconsistent not only with the principles adopted in OECD countries, but even with regulations of the Soviet Union. Therefore, it was assumed in the PNPP that the results of this accident cannot be included in the balance of the civil nuclear industry on which the decision whether to build a 3rd generation reactor in Poland is to be based. A similar approach is applied also in other fields of the power industry. For example, the risk caused by hydroelectric plants does not include the victims of dam breaks, if a given dam was built before 1930 in line with the then available regulations, without appropriate supervision. The great analysis of threats related to accidents in various types of power industry, prepared by the Paul Scherrer Institute in Switzerland, in the balance for hydroelectric plants, does not include the victims of dam break in Vaiont, Italy. The ExternE study, Norway—preparing the study of threats related to dam breaks—relied first of all on its own positive experience, omitting dams constructed in non-OECD countries or long time ago in OECD countries. In general, the threats are assessed taking into account the current technological advancement and there are no reasons to abandon this principle in the case of nuclear power plants, which are intensely developing.

Reactors in Chernobyl were built inconsistently with safety principles applicable in civil nuclear industry. However, it is worth considering, whether the evacuation of hundreds of thousands people, carried out by Soviet authorities, was reasonable. Temporary evacuation of residents of the closest vicinities of Chernobyl was founded in concerns what will happen next. But after the situation was dealt with, when it became clear that doses for the population shall be small, keeping people away from their homes and creation of a closed, depopulated zone around the accident site, the-so called "closed zone", while unnecessary, was normal for Soviet authorities used to displace hundreds of thousands of people, but resulted in enormous economic and psychical damages. Even today five million of people who received doses many times lower than the population residing in regions of Finland, Sweden, or Massif Central in France are considered "Chernobyl victims". These people receive allowances, small, but strengthening their conviction that they are helpless victims of a great accident. But if such small doses were to actually affect they health, larger ones would have harm people in many world regions, and it would be necessary to displace—permanently evacuate—millions of the Finnish, Swedish, French, Indians, Chinese... And to prevent the USA senators from entering the Library of Congress, where there are walls of granite and their radiation is higher than in the depopulated zone around Chernobyl...



Dose during 70 years, mSv	Chern high – 50 Ci/km2, av-15, low-5 Ci/km2	Chernobyl area	Chernobyl impact
		Austria	Natural background
		Finland	
		France	
		Greece	
		Spain	
		Poland	
		Switzerland	
		Sweden	
		United Kingdom	
		HC max	
		HC high	
		HC average	
		HC low	

Figure 121. Comparison of life time doses from natural sources received in various countries of Europe and doses caused by the Chernobyl accident ("Chern" on the diagram), received by the residents of contaminated areas or avoided by the evacuated[209]

But neither in Finland, nor governments of other countries order evacuation of their population, and the Finnish and Swedish live long and healthy life, longer than Polish people, although exposed to a higher radiation. The Soviet decisions to evacuate people resulted from fear and not a reasonable assessment of the situation. In the end of the 90's, in order to prevent similar erroneous decisions in the future, international organisations determined that permanent displacement of population after an accident is justified only when the additional doses caused by the accident exceed 1000 mSv over a life span of 70 years[210]. It was confirmed by IEAE document of 2005.[211] Current UNSCEAR conclusions presented in the end of 2012 to the General Assembly of the UN[212] ultimately clarify this matter—Chernobyl evacuation was unnecessary.

[209] A.Strupczewski: Nie bójmy się energetyki jądrowej, COSiW, Warszawa, 2011,
[210] Nuclear and radiation safety: Guidance for emergency response Malcolm Crick, IAEA BULLETIN, 1/1996,
[211] Development of an extended framework for emergency response criteria, IAEA TECDOC 1432, Vienna 2005
[212] http://www.world-nuclear-news.org/RS_UN_approves_radiation_advice_1012121.html

Actually, it was asserted already earlier in the reports of the World Health Organisation, the International Atomic Energy Agency, UNSCEAR committee, and other international organisations, urging the Ukrainian, Belarussian and Russian authorities to allow re-population of the Chernobyl region. Two years ago, Belarussian government allowed the displaced to return to the old regions from which they had been once moved. So better not to be emotional about issues connected with the impact of Chernobyl accident, which is based on fear, but to rely on opinions of international organisations, consciously defining its consequences. However, irrespectively of their size, Poland does not intend to build Chernobyl-type reactors, and similar accident in 3rd generation reactors is out of question.

2.8.3.3. Impact of Fukushima NPP accident

On 11 March 2011, Japan was haunted by a large earthquake, the biggest one recorded in the history of the country, and in an hour, a tsunami 14 metres high caused by seismic activity hit the coast. The Fukushima power plant survived the earthquake and was cooled as planned, but the tsunami flooded it because the embankments were too low. Flooded generators stopped to work. Cooling the plant down turned out to be impossible, reactor cores melted and radioactivity was released. The reactors were lost, and Japanese government decided to evacuate the local population.

Radiation from the damaged reactors did not result in loss of life or health among the population and the plant's staff. Terrible devastation and death of 20,000 people were caused by the earthquake and tsunami, and not the Fukushima accident. On the basis of reports of World Health Organisation, and UN Committee for the Effects of Radiation, it can be said that the radiation impact was minimal. Adults and children were examined. It turned out that they are safe, and iodine was not administered because it was not necessary. The standard cancer incidence during 89 years of life among woman amounts to 29.04 per cent, and in Namie, where there was the highest radiation, the risk of cancer among female newborns which absorbed the highest doses, increased to 30.2 per cent. It was the result Japanese and international researchers arrived at applying the principle of linear no threshold dependence (LNT) referred to above, which gives highly pessimistic results.

For the same group of newborns in Litate, also with the use of the LNT principle, the impact was two times weaker, and for the other part of population of adults and children, risk changes were negligibly small. Throughout the rest of Japan—and in other countries—doses were to small to increase the risk of cancer.

2.8.3.4. Conclusions from severe reactor accidents.

The accidents in TMI and Fukushima showed that the safety philosophy followed in the nuclear industry is correct. Even in the case of severe accidents with core degradation, the risk to which people outside the plant are exposed is small. In the case of TMI, where mistakes of the operators and lack of complete knowledge of emergency processes caused core meltdown, releases of fission products outside the containment were negligibly small and intervention measures were not needed. In the case of Fukushima, the natural disaster had such a vast range that the power plant was deprived from all support from outside, and its own protective resources were designed for less risk, so the cores of the reactors were degraded. The evacuation of thousands of people from the area of the power plant was undoubtedly an ordeal, but health of these people was not deteriorated, while the toll of earthquake and tsunami outside the plant was horrifying and counted in tens of thousands of human lives. Meantime, the accidents in obsolete reactors which have not been modernised for many years, did not result in any deaths or illnesses in result of irradiation. Lessons learned in result of both these accidents were analysed and used to introduce many improvements to the reactors built currently, and also to improve the methods of dealing with accidents. The stress testing campaign conducted year after the Fukushima accident has shown that 2nd generation reactors are operated in accordance with licencing requirements and need only few modifications in order to meet the conditions of maximal external loads, and that 3rd generation reactors are generally resistant to all external threats. In the reactors to be built in Poland, stress testing conclusions shall be taken into account in full extent.

The Chernobyl reactors was built inconsistently with safety principles and regulations and will not be considered as a reference point to assess safety of future nuclear power plants in Poland.

2.8.4. Discussion of the objection that PNPP and SEA Forecast does not take account of stress testing conclusions

The stress testing peer review was attended by 3 Polish experts delegated by the National Atomic Energy Agency (NAEA). Conclusions based on the analyses of the stress tests have been already included in the final version of the draft "design regulation"[213], and relate in particular to: the manner of accounting for external threats, increasing the required autonomy of nuclear power plant (NPP) in terms of power supply and cooling water resources, application of additional or alternative power supply and residual heat discharge systems and devices, etc. PPA specialists also monitors the progress of works related with preparation and implementation of conclusions from the Fukushima Dai-ichi accident, in the International Atomic Energy Agency (IAEA), in countries-suppliers of NPP technologies, and certain other countries. Currently, IAEA prepares a document of "Requirements" series (DS462) which shall contain a collective supplementation and tightening of the requirements contained in safety standards of the "Requirements" level, in the context of conclusions from the Fukushima accident. In 27-31.08.2012, the 2nd Extraordinary Meeting of the Convention on Nuclear Safety was held in the IAEA headquarters, focused on the conclusions from the Fukushima accident, attended also by Polish experts. Possible new conclusions stemming from these works shall be used to further supplement and tighten Polish safety requirements applicable to nuclear power plants.

The results of stress testing of European nuclear power plants, including also newly built nuclear power units with EPRs (in Finland and France)[214], as well as analyses carried out in the USA in the

[213] The regulation was already adopted by the Council of Ministers (31.08.2012), issued (20.09.2012 r., Dz. U. [Polish Journal of Laws] of 2012, item 1048) entered into force.

[214] ENSREG. Fukushima accident. Stress tests performed on European nuclear power plants. Peer review country report. Finland.

ENSREG. Fukushima accident. Stress tests performed on European nuclear power plants. Peer review country report. France.

scope of the resistance of AP1000 unit to extreme external threats[215], did not indicate a necessity to incur substantial expenditures to improve the level of safety of 3rd+ generation reactors. In order to enhance the autonomy of nuclear power plants in terms of power supply, additional fuel oil tanks shall be added to Diesel generators, as well as batteries, additional Diesel aggregates with a relatively low capacity, and mobile and portable equipment such as: generators, motor pumps, etc.

2.8.5. Discussion of the argument that radioactive fission products from a NPP (such as I-131, Cs-137, Sr-90) are deposited in certain organs and tissues, causing an increased health risk

The fact that fission products and daughter products are deposited in certain organs and tissues is well known and accounted for in radiological protection. For each of radionuclides, the process of its depositing in human organism is determined, taking into account all the daughter products and on the basis of such a complete analysis, dose rate limits are determined. Activities of radionuclides reaching dose rate limits have been defined by the International Atomic Energy Agency in cooperation with all competent institutions, including the World Health Organisation[216], Food Agricultural Organisation, and other international organisations. In Poland, dose rate limits for people living outside the limited use zone have been set on a low level, both for standard operation and accidents. Since the radiological protection regulations clearly indicate additional dose rates caused by human activity, they secure a relevant level of safety requirements to be used when choosing the plant and during its operation.

In the case of Poland's population, the radiological impact of Chernobyl accident were particularly scrutinised, and the government even introduced a separate research programme aimed at careful collection of information about health risks caused by radiation after the Chernobyl accident.

Poland is a country where the iodine deficit in soil and water is diversified. Also the radioactive contamination after the Chernobyl accident was not distributed evenly. Therefore, in the main areas of endemic goitre, namely in Podkarpacie, Cracow region, Lower Silesia, or terrains of former Łódzkie and Piotrkowskie provinces, and also in the north eastern regions of the country, epidemiological surveys were conducted on thyroid cancer incidence.

The analyses used materials on the incidence, deaths, and hospitalisation rates resulting from thyroid cancer in Poland in 1980-2000. Incidence data were taken from cancer registers published by the National Cancer Registry of the Centre of Oncology – M. Skłodowska-Curie Institute, information on deaths come from the Central Statistical Office, and thyroid cancer-related hospitalisation data were taken from the All-Poland Survey of General Hospital Morbidity. The latter is conducted in all hospitals subject the Ministry of Health, and in railway hospitals. The study is supervised by the Department of Medical Statistics of the National Institute of Hygiene in

[215] Elektrownia jądrowa AP1000 wobec utraty zasilania elektrycznego. Jerzy Chrzanowski. Westinghouse Electric Company LLC.
AP1000 DESIGN ROBUSTNESS AGAINST EXTREME EXTERNAL EVENTS – SEISMIC, FLOODING, AND AIRCRAFT CRASH. Andrew Pfister, Christopher Goossen, Keith Coogler, Julie Gorgemans. Westinghouse Electric Company LLC. Westinghouse AP1000 Nuclear Power Plant. Coping with Station Blackout. April 2011. Westinghouse AP1000 Nuclear Power Plant. Spent Fuel Pool Cooling. May 2011. Westinghouse AP1000 Nuclear Power Plant. Response to External Hazards. August 2011.
[216] IAEA SS115 International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources Co-sponsorship: FAO, ILO, OECD/NEA, PAHO, WHO Supersedes Safety Series No. 9, 1982 Edition.

Warsaw, where its results are processed and prepared. The study has been conducted since 1979, and its subject is a periodically randomised 10-percent sample of cases treated in hospital.

From the beginning of the 90's, thyroid cancer incidence has been demonstrating a small but continuous growth, especially among women. However in both sexes, it is statistically significant. The mortality in result of thyroid cancer during the whole observation period remains on a stable, low level both in men as well as women.

All calculations relating to dose rates for the whole body and for the thyroid in people residing in various regions of Poland indicate that during the first year after the accident, the average dose for the whole body of a Polish citizen was approx. 0.3 mS, and the average rates absorbed by thyroid in children may be estimated at 8–10 mGy. In the next years, the doses significantly decreased. The yearly radiation dose received from all natural sources in Poland totals approx. 2.4 mSv. These data indicate that the risk of health consequences of the Chernobyl accident are insignificant and practically unmeasurable.

Over the years 1980-2000 in Poland, a growth in incidence was recorded—especially in 1991 among women, and in 1992–1993 and 1999–2000 among men. The growth is connected with suspension of iodine prophylaxis in Poland in 1980. The analyses of other risk factors related to thyroid cancer also indicate ionising radiation from medical exposure and the exposure after the Chernobyl accident in areas with higher radioactive contamination, and also genetic, environmental, and nutritional factors.

The incidence growth is also observed in other countries. In California, from the beginning of the epidemiological survey in 1972–1995, the average annual growth of incidence in men by 1.5% and by 1% in women was revealed. A similar increase occurs in the recent years in Germany. In Tasmania, a country which similarly to Poland is an endemic area in terms of goitre, the thyroid cancer incidence growth is also connected with the suspension of iodine prophylaxis in the 80's[217].

Doctors from the Medical University in Białystok, where radiation doses after the Chernobyl accident were the highest in Poland, arrive at a similar conclusion. In conclusions of their work summing up 20 years of research on thyroid cancer in children, they say:

"The growth in incidence of adenoma and thyroid tumours can result from many factors. The first among them is iodine deficiency. An approximately 10 times higher cancer incidence in endemic areas was found during autopsies. The observations from Belarus also revealed a growth of the number of tumour in children from the Chernobyl region, which can be a result of iodine deficiency. A decrease in the number of cases of follicular and anaplastic carcinoma was recorded, as well as an increase in the number of cases of papillary carcinoma, after the obligatory iodine prophylaxis was introduced. The fact of no such prophylaxis present in Poland in the 80's (iodination of salt was stopped in 1980) is also worth highlighting.

Only then they point out ionising radiation and change in diagnostic methods (namely dissemination of USG examination and the targeted fine-needle aspiration biopsy of thyroid) as possible causes.

[217] Hanna Roszkowska, Paweł Goryński: NOWOTWORY TARCZYCY W POLSCE W LATACH 1980–2000, PRZEGL EPIDEMIOL 2004;58:369–76

Because of the insignificant change in incidence of latent thyroid carcinoma in Poland, none of the works attempts to find a link between the number of cases and the average radiation doses in a given region. To the contrary, authors from various centres agree that the main cause of the growth in the number of cases of latent thyroid carcinoma is suspension of iodine prophylaxis in Poland in 1980.

2.8.6. Additional information about the national radiation monitoring system and applicable requirements in the scope of radiological protection—for intervention levels

Environmental monitoring shall be conducted by institutions independent from the investor/operator of the nuclear plant. They have not been selected yet, it will take place after power plant locations are selected. The monitoring will rely on the operational experience of the present monitoring network in Poland. At present, the radioactive waste repository in Różan, monitoring is monitored by institutions independent from the operator, the National Radioactive Waste Repository of the Radioactive Waste Disposal Center. These institutions are as follows:

- Polish Geological Institute,
- National Atomic Energy Agency (Nuclear Supervision),
- Board for Protection against Effects of Radiation of the National Centre for Nuclear Research.

The nuclear power plants may be also monitored by the Central Laboratory for Radiological Protection. Moreover, further organisations are involved in radiological measurements—the Institute of Meteorology and Water Management and the Ministry of National Defence. They participate in the currently operating system of stations for early detection of contaminations which is supervised and coordinated by the President of the National Atomic Energy Agency. The systems is comprised of a couple of subsystems of measurement stations, specified and described below.

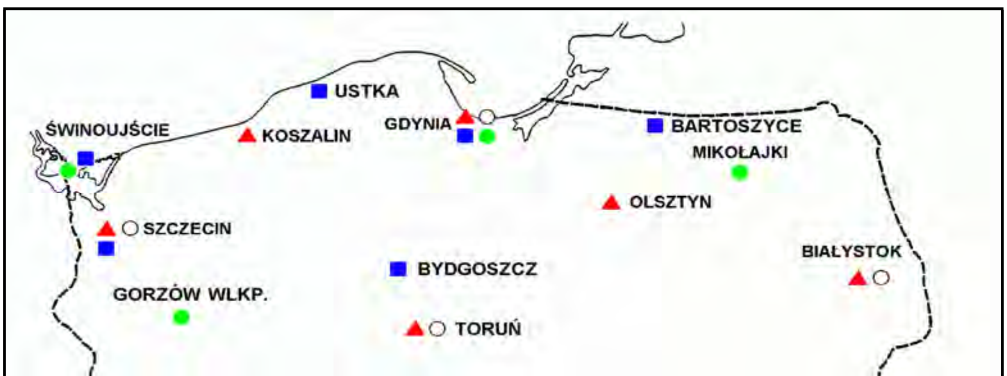
In Poland these days, there are quite advanced systems present for dose rate and radioactive contamination measurement, which monitor the radiation status of the country, and may and will be used also for monitoring in the case of an accident in a NPP. Below, concise information is provided about the system of stations for early detection of contamination currently operating in Poland. The system is supervised and coordinated by the President of the National Atomic Energy Agency. The systems is comprised of the following measurement station subsystems:

1) 12 ASS-500/NASS-500 stations (Aerosol Sampling Station/New Aerosol Sampling Station) belonging to the Central Laboratory of Radiological Protection that continuously sample atmospheric aerosols with filters and perform online spectrometric measurements, enabling detection of concentrations of Cs-137 and I-131 isotopes at a level of single Bq/m_3 within an hour (below a photo of NASS-500 station in CLRP in Warsaw).
2) 13 automatic PMSs (Permanent Monitoring Station) belonging to the NAEA, which continuously measure:
   - gamma radiation dose rate and gamma radiation spectra caused by air and surface

contamination,

- intensity of atmospheric precipitation and ambient temperature.
- nine stations of the Institute of Meteorology and Water Management (IMWM), performing:
- continuous measurement of gamma radiation dose rate and total alpha and beta activity of atmospheric aerosols;
- measurement of total beta activity and contents of Cs-137 in weekly and monthly samples of total precipitation, as well as assays of Cs-137 and Sr-90 contents in the aggregate monthly precipitation sample (from all stations together).
- thirteen measurement stations of the Ministry of National Defence, located in military units and performing continuous measurements of gamma dose rate automatically registered in the Main Centre for Contamination Analysis (MCCA).

Figure 122. NASS-500 station at CLRP in Warsaw.



PMS STATIONS	ŚWINOUJŚCIE
ASS - 500 STATIONS	SZCZECIN
IMWM STATIONS	GORZÓW WLKP.
MND STATIONS	ZIELONA GÓRA
	ŻAGAŃ
	LEGNICA
	WROCŁAW
	ŚREM
	KOSZALIN
	USTKA
	GDYNIA
	BYDGOSZCZ
	TORUŃ
	ŁÓDŹ
	KATOWICE
	ZAKOPANE
	KRAKÓW
	WARSZAWA
	OLSZTYN
	BARTOSZYCE
	MIKOŁAJKI
	BIAŁYSTOK
	WŁODAWA
	LUBLIN
	RZESZÓW
	SANOK
	LESKO

Figure 123. Network of stations for early detection of contamination in Poland.

The map above presents the network of stations for early detection of contamination. As it can be seen, the stations cover the area of our country quite evenly. It is also worth noting here that the most sensitive of these networks, the ASS-500/NASS-500 network, has registered, as the only network in Poland, the contaminated air from Japan flowing over our country after the accident in the Fukushima Dai-ichi nuclear power plant. The whole knowledge of air contamination in Poland in that time was based on radiological measurements conducted in this very network. Further information about the system of contamination detection and alerts can be found on the Internet, NAEA webpage, http://www.paa.gov.pl/?frame=8.4, and also in the form of lectures of regional institutions and universities, e.g. http://www.sgsp.edu.pl/uczelnia/kdrg/zdid/ks_wsia.pdf.

Independently of the public systems, nuclear plant operators will be obliged to mobilise their own monitoring systems and external measurement centres monitoring the environment—including the radiation status around the NPP.

In Polish regulations concerning radiological protection (see: item 2.10.2), which are complaint with the currently applicable directive 96/29/Euratom:

- occupational exposure rates are in accordance with the new standards of radiological protection of IAEA[218], with the exception of doses for eye lenses—which were significantly decreased in the new IAEA standards;
- all public exposure values are in accordance with the new radiological protection standards[219];

[218] Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards. Interim edition. General Safety Requirements Part 3. No. GSR Part 3 (interim). International Atomic Energy Agency. Vienna 2011. Schedule III. Dose Limits for Planned Exposure Situations. Occupational Exposure.
[219] Ibidem: Schedule III. Dose Limits for Planned Exposure Situations. Public Exposure.

also the basic intervention levels are compliant with the requirements of new radiological protection standards of IAEA or lower, with the exclusion of iodine thyroid blocking level, which is 2 times lower in these standards[220].

Thus, the requirements in the scope of radiological protection set out in Polish regulations, which are compliant with the requirements of the currently applicable Directive 96/29/Euratom, do not significantly differ from the most recent radiological protection standards of IAEA (published in November 2011).

2.8.7. Discussion of the issue of nuclear damage accountability

Civil liability for nuclear damages has been regulated in Poland in the Atomic Law act, amended on 13.05.2011[221], in accordance with Vienna Convention on Civil Liability for Nuclear Damage of 23.05.1963 along with the protocol amending Vienna Convention on Civil Liability for Nuclear Damage of 12.09.1997.

Poland acceded to the Vienna Convention on 23.04.1990 (accession document submitted in 23.01.1990) and has been formally a party to it since that date[222]. Thence, (14.05.2010) Poland also acceded the protocol amending the Vienna Convention[223].

In the scope of civil liability for nuclear damages, regulations of the Atomic Law provide, in particular, as follows:

Art. 102. *1. The operator's liability for nuclear damage shall be limited to the amount equivalent to SDR 300,000,000*[224]*.*

2. In the event when the claims for nuclear damage exceed the amount referred to in Section 1, the operator shall establish a limited liability fund. The procedures for the establishment and distribution of this fund shall be regulated, as appropriate, by the provisions of the Sea Code on the limited liability for sea claims[225]*, (...).*

Art. 103. *1. The operator shall be obliged to conclude a contract for insurance against civil liability for nuclear damage.*

2. If any nuclear material is transported from a nuclear facility, the operator, notwithstanding the obligation referred to in Section 1, shall be obliged to conclude a contract for insurance against civil liability for nuclear damage during transportation.

3. The obligation to conclude a contract for insurance referred to in Section 1 shall arise no later

[220] Ibidem: Annex. Generic Criteria for Protective Actions and other Response Actions in Emergency Exposure Situations to Reduce the Risk of Stochastic Effects.

[221]The uniform text of the Atomic Law act was promulgated in the notice of the Marshall of the Sejm of the republic of Poland of 24.01.2012 which was published on 13.03.2021 in Dz. U. [Polish Journal of Laws of 2012 , No. 0, item 264). http://www.dziennikustaw.gov.pl/DU/2012/264/1

[222] Dz. U. [Polish Journal of Laws] of 1990, No. 63, items 370 and 371.

[223] Dz. U. [Polish Journal of Laws] of 2010, No. 4, item 9.

[224] SDR – Special Drawing Right (unit of account defined by the International Monetary Fund).

[225] The following regulations are concerned: art. 97-102 of the Act of 13.09.2001 – Maritime Code (Dz. U. [Polish Journal of Laws] of 2009, No. 217, item 1689); and art. 11 and 12 of the Convention on Limitation of Liability for Maritime Claims of 19.11.1976 r. (Poland's accession act: Dz. U. of 1986, No. 35, teim 175).

than on the day preceding the commissioning of the nuclear facility, and for non-commissioned facilities – no later than on the day preceding the starting day of the nuclear facility operation.

4. The obligation to conclude a contract for insurance referred to in Section 2 shall arise no later than on the day preceding the transportation of nuclear material from the nuclear facility.

5. The civil liability insurance referred to in Sections 1 and 2 shall cover damages incurred throughout the insurance period. The insurance company shall not be authorized to contractually limit the insurance cover.

6. Subject to Section 7, the minimal guaranteed amount of the insurance as referred to in Sections 1 and 2 in relation to a single event whose consequences are covered by the insurance contract shall be equivalent to SDR 300,000,000.

7. The minimal guaranteed amount of the insurance:

1) referred to in Section 1 – for research reactor or a nuclear facility where nuclear material from the research reactor is kept or stored,

2) referred to in Section 2 – for transportation of nuclear material from nuclear facilities stated in Item 1

– in relation to a single event whose consequences are covered by the insurance contract – no lower than an equivalent in PLN to SDR 400,000, and no higher than an equivalent in PLN to SDR 5,000,000.

***Art. 103c.** 1. If, apart from the damage to the property or environment, nuclear incident caused also personal injury, 10% of the insurance guarantee sum shall be earmarked for settling the claims involving nuclear damage resulting in personal injury.*

2. If within 5 years from the date of nuclear incident the claims against the operator involving nuclear damage resulting in personal injury do not exceed the total amount of the guarantee earmarked exclusively for settling such claims, then the remainder of this guarantee shall be used for settling the claims involving damage to the property or environment, and also the claims for personal injury brought up not later than within 10 years from the date of the nuclear incident.

3. The National Treasury shall guarantee the payment of compensation for nuclear damage:

1) up to the amount stated in Article 102, Section 1, and

to the extent that the damage could not be settled by the insurer from the insurance contract referred to in Article 103, and in cases referred to in Article 98, Section 2,

Item 2[226] *of the Compulsory Insurance, Insurance Guarantee Fund and Polish Motor Insurers' Bureau*

[226] The regulations of the said act, referred to above, have the following wording: Art. 98 section 2 item 2:
„2. Where an insurance undertaking has been declared bankrupt or a petition to declare bankruptcy of an insurance undertaking has been filed, or bankruptcy proceedings with regard to it has been discontinued, if the assets of the debtor are for obvious reasons insufficient even to satisfy the costs of the bankruptcy proceedings, or in the case of a compulsory winding-up being ordered upon an insurance undertaking, if claims of authorised persons cannot be satisfied from assets

Act of 22 May 2003 (Journal of Laws No. 124, Item 1152, with later amendments) to the extent that the damage failed to be compensated by the insurer and the Insurance Guarantee Fund.

Art. 104. *1. Claims for nuclear damage may be filed directly against the insurer.*

Art. 106. *1. In the event of nuclear damage that has been caused by nuclear incident occurring within the territory of the Republic of Poland, the jurisdiction for damage claims shall lie with the district courts of law.*

2. Cases related to damage claims proceedings shall be regulated by the provisions of the Civil Proceedings Code.

3. In the event of nuclear damage that has been caused by nuclear incident occurring outside the territory of the Republic of Poland, the courts' jurisdiction for damage claims shall be determined by the Vienna Convention on Civil Liability for Nuclear Damage, adopted in Vienna on 21 May 1963 Dz. U. [Polish Journal of Laws] of 1990, No. 63, items 370 and 371 and of 2011, No. 4, item 9).

Thus, in Poland, civil liability for nuclear damages is determined in accordance with international principles, as follows:

1) civil liability limit for a nuclear damage of a nuclear plant operator was determined in the amount of SDR 300 million (art. 102 section 1 of the Atomic Law act[227]), and the operator is obliged to conclude a nuclear damage civil liability agreement for such an minimum amount of cover (art. 103 sections 1 and 6 of the act);

2) if claims under a nuclear damage exceed the above amount, the nuclear plant operator shall establish a liability limitation fund (art. 102 item 2);

3) State Treasure guarantees the indemnification payment under a nuclear damage:

- up to the amount of SDR 300 million, and
- to the extent that the damage failed to be compensated by the insurance undertaking under

---

constituting the cover for the technical provisions, the tasks of the Fund also include the satisfaction of claims of the authorised persons from:
(…),
2) compulsory insurance agreements referred to in art. 4 item 4, and life insurance agreements, in the amount of 50% receivables, up to an amount not higher than the equivalent of EUR 30,000 in Polish zlotys, according to the average rate announced by the National Bank of Poland and applicable on the bankruptcy declaration date or on the date of discontinuation of bankruptcy proceedings, or on the day on which compulsory winding-up was ordered,".
Art. 5 item 4:
"Compulsory insurance includes:
(…),
4) insurance stemming from regulations of separate acts or international agreements ratified by the Republic of Poland and imposing the obligation to conclude insurance agreement on certain entities."

[227] In accordance with art. 7 section 1 of the protocol amending Vienna Convention on Civil Liability for Nuclear Damage of 12.09.1997.

the insurance agreement concluded, and in cases of bankruptcy or compulsory winding up of the insurance undertaking, by the undertaking and the Insurance Guarantee Fund;

- the indemnification claim under a nuclear damage can be pursued directly from the insurance undertaking.

2.9. EXTERNAL THREATS TO THE NUCLEAR POWER PLANTS

2.9.1. Discussion of the objection on the insufficient addressing of natural threats

The requirements in the scope of the wide spectrum of **external events and threats** to be taken into account when selecting a location—both natural events and threats as well as those caused by human activity—are set out **in Polish nuclear safety regulations**, and more specifically—in the Atomic Law act and in the 3 basic implementing acts to it:

1. Regulation by the Council of Ministers on detailed scope of assessment with regard to land intended for the location of a nuclear facility, cases excluding land to be considered eligible for the location of a nuclear facility and on requirements concerning location report for a nuclear facility ("Placement Regulation")
2. Regulation by the Council of Ministers on nuclear safety and radiological protection requirements which must be fulfilled by a nuclear facility design ("Design Regulation")
3. Regulation by the Council of Ministers on the scope and method for the performance of safety analyses prior to the submission of an application requesting the issue of a license for the construction of a nuclear facility and the scope of the preliminary safety report for a nuclear facility ("Safety Analyses Regulation").

Quotes from the above mentioned documents are presented below.

****

** Atomic Law Act[228]

Article 35b. *1. Nuclear facilities shall be located within an area which ensures that nuclear safety, radiological protection and physical protection requirements are fulfilled during commissioning, operation and decommissioning of the facility, and that emergency measures can be effectively implemented in response to any radiation emergency.*

2. Before the location for a future nuclear facility is approved, the investor shall perform on-site studies and measurements to evaluate the location in terms of its suitability. The assessment shall address:

[228] Dz. U. [Polish Journal of Laws] of 2012, items. 264 and 908.

1) seismic, tectonics, geological, geo-engineering, hydrogeological, hydrological and meteorological conditions;

2) man-made external incidents;

3) external incidents attributed to the forces of nature;

4) population density and land development;

5) conditions for the employment of emergency measures in response to radiological emergency;

3. The investor shall draw up a location assessment report based on the study results and shall forward it to the Agency's President. The location report shall be reviewed by the Agency's President in the course of the proceedings for granting a nuclear facility construction licence.
4. The Council of Ministers shall establish, by regulation, a detailed scope of a site survey for a future nuclear facility, conditions which make the location inappropriate as referred to in Section 1, as well as requirements for the location report, bearing in mind the necessity to ensure nuclear safety, radiological protection and physical protection during commissioning, operation and decommissioning of the facility, as well as conditions for effective implementation of emergency measures in response to any radiation emergency, in consideration of the recommendations of the International Atomic Energy Agency.

Placement Regulation[229]

The Placement Regulation requires to analyse the following threats:

1) natural threats:
   a. seismic and tectonic threats
   b. geological and
   geotechnical threats
   c. flood threats
   d. depletion of cooling reservoir and the risk of cooling conduits blockage e.
   natural fire threats

2) threats caused by human activity
   a. threats posed by transport infrastructure (connected with possible plane, train, boat crashes and road and water accidents)
   b. threats posed by industrial plants and installations which may have chemical, biological or mechanical impact
   c. threats caused by emission, fire or explosion as a result of human activity
   d. threats connected with damage or improper operation of water installations (such as dams, embankments, pipelines, channels and their closures)
   e. possible threats from acts of terrorism or sabotage
   f. potential threats from telecommunication devices and other installations which emit electromagnetic waves or generate magnetic field or electric field.

In particular, §5 of the regulation contains the exclusion criteria.

[229] Dz. U. [Polish Journal of Laws] of 2012, item 1025.

***§ 5.** The land shall not be considered to fulfil location requirements with regard to a nuclear facility location in case of the following factors:*

1) ground with weak mechanical parameters, including low-bearing, swelling soil or with other unfavourable parameters which cannot be removed, replaced or enhanced, and which occur within the borders of planned placement of a nuclear facility;

2) in the location ground of a nuclear facility in the distance which is less than 20 km from the borders of planned placement of a nuclear facility there is an active fault or fault in relation to which the probability of activation is more than once in 10,000 years and such activation could cause a threat to nuclear safety of a nuclear facility;

3) in the location area there has been an earthquake of 8 grade in EMS-98 scale within the last 10,000 years or there is the probability of earthquake with the same scale which is more than once in 10,000 years;

4) there is the possibility of earthquake with the occurrence probability being more than once in 10,000 years and with the scale below 8 EMS-98, which will prevent the safe operation of a nuclear facility;

5) in the location area there is a risk of the occurrence of geological phenomena threatening the stability of ground such as strong suffosion or carst processes, landslide, rockfall, or other geo-dynamic phenomena which may have impact on nuclear safety of a nuclear facility, and which cannot be structurally compensated;

6) in the location area there is a risk of the occurrence of flooding or inundation threatening nuclear safety of a nuclear facility, which cannot be structurally compensated;

7) in the region in relation to which a factor referred to in § 2 Item 1 Letter (d) was considered, there have been conducted within the last 60 years:

a) activities consisting in extraction of minerals, or

b) activities consisting in the underground storing, without reservoirs, of substances or underground waste disposal, or

c) other activities

− which may cause a threat to nuclear safety of a nuclear facility by inducing seismic shocks, activation or movement of fault structures, subsidence or liquefaction of soils or similar results of the said activities have occurred in this region, whose occurrence during the operation of a nuclear facility would pose a serious threat to nuclear safety of a nuclear facility;

8) it will not be possible to conduct necessary intervention activities in the event when nuclear emergency occurs at a nuclear facility;

9) in a distance which may have negative impact on nuclear safety of nuclear facility there is:

a) a military facility or closed military area with a protection zone of the closed area, b) a plant which may have chemical, biological or mechanical impact on a nuclear facility,

c) a water device within the meaning of the Water Law Act

− if this negative impact cannot be structurally compensated;

10) in a distance which is less than 10 km from the borders of planned placement of a nuclear facility there is a civil airport unless the probability of a crash of a big civil aircraft into a nuclear facility is less than once in 10,000000 years.

The terms used in this regulation are defined as follows:

1) borders of planned placement of a nuclear facility – it shall be understood as the area

demarcated by means of a circumference whose radius is equivalent of the distance from the centre to the remotest real property unit, along which nuclear facility is planned to be located, measured from the centre of this real property so that the whole real property is within the borders of circumference demarcated;

2) location area – it shall be understood as land within 5 kilometre distance from the borders of planned placement of a nuclear facility, and in reasonable cases connected with the construction of base which is particularly important for the stability during the erection of facility and after the erection – land enlarged to the extent allowing to obtain comprehensive data and assessment concerning the base stability;

3) location area – it shall be understood as land within 30 kilometre distance from the borders of planned placement of a nuclear facility;

4) active fault – it shall be understood as a fault in relation to which on the basis of professional literature studies, field research and analyses:

a) researchers confirmed the activity in the period of last 10,000 years which could pose threat to nuclear safety and radiological protection of a nuclear facility, or

b) it was found that it could be the source of seismic shock which could lead to a threat to nuclear safety and radiological protection of a nuclear facility with the probability of occurrence bigger than once in 10,000 years.

Data at the level adequate for the strategic environmental assessment and relating to seismic threats are presented in section 4.2 and 10.3 of the Forecast. In 2013-2014, detailed placement studies and analyses shall be conducted for 3 possible locations in order to select the optimal location for the 1st Polish nuclear power plant (NPP). Results of these studies and analyses shall be subsequently used in preparation of the placement report and environmental impact report for the project for the selected NPP location. These data shall be available at the stage of public consultation and cross-border EIA procedure.

Safety Analyses Regulation[230]

§ 8. *When determining the PIE[231] external set approved for safety analyses, it shall be necessary to take into consideration and analyse the adequacy for a given nuclear facility design of the following types of external initiating events and secondary events occurring as a result of these postulated initiating events, in particular:*

1) natural events:

a) earthquakes and active faults,

b) geological–engineering and hydro-geological hazards, including:

– instability of slopes or embankments,

– the risk of occurrence in the soil of processes which are unfavourable for nuclear

[230] Dz. U. [Polish Journal of Laws] of 2012, item 1043.

[231] *PIE – Postulated Initiating Event.*

facility construction, in particular fluidization, swelling and subsidence,

– changes in the soil conditions brought about by static and dynamic load, taking into account seismic phenomena,

– the state and chemical properties of subterranean waters (possible aggressiveness in relation to construction materials, in particular concrete and reinforced steel),

c) hydrological and meteorological hazards, including:

– extreme meteorological parameters, in particular maximum wind velocity, maximum amounts of atmospheric precipitation over a period of 24-hours (rain, snow), extreme air temperature,

– dangerous meteorological phenomena, including lightning and tornadoes;

– flood hazard or flooding of the site due to rainfall and other natural causes,

d) other external events, in particular extreme temperature of cooling water, depletion of cooling reservoir water supplies brought about by natural causes, drought, blocking of flow in the river, excessive growth of aquatic organisms, ice that can cause blockage of water intake or disruption in the functioning of the closed nuclear facility cooling circuit;

2) resulting from human activity:

a) the crashing into the nuclear facility of airplanes, including, in the case of a nuclear power plant, large civilian aircrafts, including the effects of fire and explosion following the direct hitting of a nuclear facility by an aircraft,

b) acts of terror and sabotage,

c) chemical explosion when reprocessing, shipping, reloading and storing chemicals which could explode or create gas clouds, capable of rapid combustion or detonation,

d) failure of water equipment in the understanding of the Water Act, or a part of it, or hazards brought about by its incorrect use,

e) other events, in particular:

– release of combustible, explosive, asphyxiating, poisonous, corrosive or radioactive substances,

– explosions of industrial installations which could generate fragments,

– fires, particularly forest, peatbog, plant, stockpiles of coal and hydrocarbon fuels of low volatility, timber and plastics fires,

– ship crash as a potential threat to the water intake structure,

– electromagnetic disruption and eddy currents,

– blockage of air inlets and outlets or blockage of water intake and discharge through rubble,

– oil spills and fires,

– depletion of cooling reservoir water supplies,

– earthquakes induced by mining activities.

<u>Draft ordinance of a Minister</u>

§ 21. *1. Nuclear facility shall be designed so as to ensure its nuclear safety in case of the* *occurrence of seismic events and their consequences.*

2.
(...).

3. When designing a nuclear facility, consideration shall be given to design seismic events with the shock repetition once every 10 000 years, which generates the highest horizontal ground acceleration spectra. The design seismic event shall define: the shock type and mechanism, its location, magnitude, duration, spectral parameters, vertical and horizontal ground acceleration spectra and the seismic moment tensor.

4. When a nuclear facility is in danger of an induced earthquake taking place, natural and induced earthquakes scenarios shall be taken into account for the purpose of identification of design seismic event.

5. Nuclear facility design solutions shall ensure that in case of a design seismic event taking place, referred to in Section 3, systems and components of construction and equipment of the nuclear facility which are important for performing fundamental safety functions shall resist stress arising from such event, so that the nuclear facility could attain the state of safe switchoff.

6. The requirement defined in Section 5 shall be performed in particular by seismic classification of systems and components of construction and equipment of the nuclear facility depending on their required resistance to seismic stress, taking into account implemented safety functions, and by defining the appropriate technical requirements depending on seismicity class.

§ 22.*1. The nuclear facility design shall take into account the capability of its systems and components of construction and equipment important for performing fundamental safety functions, to resist the consequences of seismic events which are more severe than design seismic event, so as to demonstrate that they will not be suddenly damaged, even in the case of design stress being slightly exceeded.*

2. In designing the facility for seismic events, an assumption will be made for the loss of electrical power supply to the nuclear facility from external power grids as a result of seismic shocks; including pre-emptive shocks and aftershock.

§ 23. *1. In the event of locating the nuclear facility in the areas, referred to in Article 88d, Section 2 of the Water Act of 18 July 2001 (Journal of Laws of 2012, Item 145), or in the areas where the probability of flooding is once every 1000 years or more than once every 1000 years, the nuclear facility shall be designed in a manner to prevent the negative consequences brought about by floods or flooding.*

2.
(...).

3. When designing anti-flooding protection for a nuclear facility, consideration shall be given to the maximum water surface ordinate with the probability to occur once every 1000 years.

§ 33. *The design of a nuclear power plant shall provide for design solutions ensuring its safety in case of a large civilian aircraft crashing into it, so that in the event of such aircraft crash, with limited operator's actions:*
1) the reactor core continues being cooled or the primary reactor containment remains intact;

2) the cooling of spent nuclear fuel or the integrity of the spent nuclear fuel pool is maintained.

****
**

In Poland, (with the exclusion of areas where shocks induced by mining activity occur) **significant seismic threats are not present**. In the northern part of the country—where nuclear power plants are to be located—the Peak Ground Acceleration (PGA) during natural seismic shock with a recurrence interval of 10,000 years can reach approx. 0.05g, while 3rd+ generation nuclear power plants are designed to resist a seismic load corresponding to PGA = 0.3g. There are no significant tsunami risk on the Baltic Sea costs—due to relatively low seismic activity in the region of the sea and the fact that it is a shallow sea—which is also confirmed by Polish geophysicists[232].

As for **flood threats**—on the basis of conclusions from the accident of Fukushima Dai-ichi Nuclear Plant and stress tests of European nuclear power plants—it is planned to increase the requirements relating to the design basis flood value, from a recurrence interval of 1000 years to 10,000 years. In estimation of the design basis flood value all factors and phenomena should be taken into account—both natural and caused by human activity—such as: tsunami, storm surge (also known as meteorological tsunami), surface water reservoirs, floodplains, waves, currents, speed zones, extreme violent storms, winter storms, icing, precipitation, hydro-technical facilities and their possible damages or inadequate operation, and erosion processes.

As for the possibility to provide additional information about natural threats in the Forecast, it has to be pointed out once again that Poland is at the stage of preparation of the Polish Nuclear Power Programme. It is a strategic implementing document including legal, organisational, and formal measures necessary to introduce nuclear energy in Poland. At this stage it is even not certain, what technology, site, cooling system, capacity etc. will be applied (apart from the fact that it shall be a generation III or III+ reactor).

Data at the level adequate for the strategic environmental assessment and relating to seismic threats and flood threats are presented in section 4 of the Forecasts (section 4.2. seismic conditions in Poland, and section 4.3.1 flood threats in Poland). Specification of these analyses at the location level can be found in section 10.3 and in the appendix to the Forecast containing data on remaining locations. In 2013-2014, detailed placement studies and analyses shall be conducted for 3 possible locations in order to select the optimal location for the 1st Polish nuclear power plant (NPP). Results of these studies and analyses shall be subsequently used in preparation of the placement report and environmental impact report for the project for the selected NPP location. These analyses shall obviously also include detailed geological surveys, examinations of seismic and meteorological conditions, and natural threats in a given area. These data shall be available at the stage of public consultation and cross-border environmental impact assessment procedure.

Specification of this information in the Programme itself, in view of its function and nature, is not reasonable.

The Ministry of Economy declares that these issues shall be also examined in detail at the stage of

[232] http://www.twojapogoda.pl/wiadomosci/111180,bylo-tsunami-na-baltyku-czy-nie

EIA procedure for individual NPP locations.

2.9.2. Discussion of the objection concerning the lack of resistance of a nuclear power plant to threats related to terrorist attacks

As for the resistance of nuclear power plant to be ensured in relation to possible terrorist threats we would like to point out that taking those into account is required under implementing regulations to the Atomic Law act: at selection of location—"Placement Regulation" (§2 item 5 letter f) as well as in safety analyses—Safety Analyses Regulation (§8 item 2 letter b); while in the "Design Regulation" (§33) requirements are contained that concern the safety of nuclear power plant to be ensured in the case of a large civil aircraft impact.

The current state of protection of a nuclear power plant against terrorist attacks can be summarised as follows.

1. Design basis solutions for nuclear power plants and designing their buildings and installations in such a way so as to prevent or limit the impact of diverse accidents, and to resist loads connected with extreme natural events—such as earthquakes and hurricanes, or events caused by human activity—as external explosions, make them to a large extent inherently resistant to possible terrorist attacks.
2. Although before the terrorist attacks in the USA on 11.09.2001, nuclear supervision authorities did not required to present aircraft impact resistance deterministic analyses in the process of NPP licencing, however the analyses and tests conducted in the USA—and assuming a crash of a F4 Phantom fighter bomber (1988)[233] or a medium-sized passenger Boeing 707-320 plane (1996) into a nuclear facility[234] demonstrated that the safety containment of a 2nd generation reactor shall resist the impact and will not be destroyed by aircraft parts.
3. After suicide strikes on the WTC and Pentagon of 11.09.2011, both in the USA as well as in EU and other countries—where NPPs are designed and/or used, actions were adopted to improve the protection of NPPs, impact assessments of a possible terrorist attacks on NPPs with the use of a large passenger plane were performed, and relevant amendments to the licencing regulations and designing requirements for NPPs were proposed.
4. For obvious reasons, detailed description of the analyses and modification introduced in structural solutions, as well as physical protection improvements have been classified. Nevertheless, a quite detailed report is publicly available, concerning the analyses conducted in the USA in 2002 and relating to the impact consequences for a wide-body Boeing 767-400 passenger aircraft with full take-off weight and fully tanked, at the speed of 563 km/h[235]. This type of aircraft was selected as the most representative one for air traffic in the USA, especially in terms of its size and weight of its engines. The analyses covered the consequences of impact of this aircraft into: safety containment of a reactor (typical for 2nd generation LWRs), building with spent fuel pools, and containers for "dry"

[233] Footage of 1988 rocked-sled test. Sandia National Laboratories. http://www.sandia.gov.

[234] H. Abbas at al: Aircraft crash upon outer containment of nuclear power plant. Nuclear Engineering and Design. Volume 160, No. 1, 1 February 1996, pp. 13-50(38).

[235] Analysis of Nuclear Power Plants Shows Aircraft Crash Would Not Breach Structures Housing Reactor Fuel. Nuclear Energy Institute. Washington, D.C., December 23, 2002. http://www.nei.org. Deterring Terrorism: Aircraft Crash Analyses Demonstrate Nuclear Power Plant's Structural Strength. ABS Consulting. ANATECH. December 2002.

storage and transportation of spent fuel. The analyses (carried out on the basis of conservative assumptions) showed that the containment shall resist the impact and will not be destroyed, similarly as the spent fuel storage and the containers for dry storage and transport of spent fuel—therefore, no releases of radioactive substances would occur.

5. The assessments conducted in the USA[236] demonstrated that also an attack with the use of a general aviation aircraft, even one loaded with explosives, would not breach the safety containment.
6. The EUR document (European Utility Requirements for LWR Nuclear Power Plants) contains designing guidelines also in terms of NPP buildings' resistance to a plane crash or external explosion. The United States Nuclear Regulatory Commission (US NRC) introduced to the NPP licencing regulations (*Code of Federal Regulations – 10 CFR50, §50.150*) the requirement to present deterministic analyses of impact consequences for a large civil aircraft crashing into NPP facilities. Similar solutions were also introduced in the Polish "Design Regulation” (§33).
7. Design of safety containments (and other structures important for safety of nuclear facilities) of 3rd+ generation reactors have been improved in the recent years to enhance their resistance to an impact of a large passenger plane—although they were already stronger than NPP facilities with 2nd generation reactors whose resistance was confirmed by American analyses from 2002.
8. Nuclear power plants are protected particularly carefully and strongly. Each NPP is equipped with an individually designed system of physical protection, comprising divers technical solutions, and is guarded by well-trained and equipped guard teams—*inter alia* in order to minimise the risk of a land terrorist attack (from outside or inside), and in particular also a bombing attack. The NPP physical protection systems were also significantly improved after the terrorist attacks in the USA on 11.09.2001.
9. Independently of the effectiveness of the physical protection—due to technical solutions of a NPP (multiplication of safety systems, physical and spatial separation, passive devices, and other), as well as unusually strong design of installations and buildings—their successful damage which may lead to releasing large amounts of radioactive substances to the surroundings, is very difficult.
10. Additionally, member states of the EU and NATO use support of these organisations in counteracting terrorist attacks, among other things on the nuclear facilities, as well as remedies in the case of such an attack.

All external threats in the area of currently considered (3 or 4) possible locations of nuclear power plants shall be thoroughly analysed during placement studies and analyses planned for 2013-2014.

2.9.3. Discussion of the argument on the threat to nuclear power plants in the context of insufficient condition of flood defences in Poland.

It is stated in the Forecast, that: "*The flood of 2010 have once again exposed the imperfections of the Polish flood defence system, both its technical,[237] as well as other parts[238]. Floodbank failures*

[236] Robert M. Jefferson Consultant: Nuclear Security: General aviation is not a threat. Albuquerque, New Mexico. May 16, 2002.

[237] Technical methods in flood defence are divided into active (control of retention reservoirs, polder closures, regulation of outflow from dry reservoirs, ice jam crushing etc.) as well as passive methods (usage of floodbanks, polders, relief canals and other non-controlled objects).

and floodings of river valley bottoms were pervasive, as shown by examples such as the area of Wilków commune or parts of Sandomierz by the Vistula River. The lack of information in the scope of flood threat and risk was very keenly felt.

The Ministry of Economy informs that it was, among other things, the aim of the Forecast— the analysis of strategic impact and indication of weaknesses to be supplemented. Also, the Forecast points out the most probable threats in river valleys and highlights their connection with:

- flash floods in results of heavy rainfalls—mainly small watercourses, especially in mountains and highlands,
- floods on main rivers and their tributaries in conditions of prolonging widespread rainfalls—the whole country,
- floods resulting from ice and pancake ice jams—mainly in places with orography prone to flooding or determined with hydro-development (e.g. the barrage in Włocławek),
- Backflow floods—in the seaside during storm, side tributaries during high water level of the main river.

The Ministry of Economy informs that the current issues of adaptation to climate changes, including also the development of early warnings systems are a priority for Poland. It should be underlined, however, that placement of a nuclear plant in a location even potentially affected with flood risk is out of question.

It is also worth noting that among the currently considered locations for the first Polish nuclear power plant (Gąski, Choczewo, Żarnowiec, and the additional one—Kopań), there are no locations situated by rivers—all of them lay near the Baltic Sea coast (the most distant one is Żarnowiec by the Żarnowieckie Lake, within approx. 10 km from the sea). In the foreseeable future, placement of a nuclear plants by rivers or estuaries is not planned.

Obviously, when selecting a location as part of the surveys, the fact that nuclear power plants cannot adversely influence preventive and mitigating measures related to floods both in Poland as well as in neighbouring regions of other countries shall also be taken into account.

2.10. NUCLEAR REGULATORY SUPERVISION IN POLAND

2.10.1. State authorities involved in nuclear safety assurance

Supervisory activities related to safety and environmental impact of power industry in Poland—shall be carried out by control institutions listed and described below—they will include, of course, the whole scope of implementation of nuclear power plants (selection of location, construction, and commissioning), their operation and decommissioning, as well as all parts of environment

[238] Non-technical methods of flood defence include both actions aimed at improving the warning and alarm systems, as well as preventive measures, with raising of awareness of river valley dwellers. An efficient tool in limiting the negative consequences of a flood should be also detailed maps of flood threats.

exposed to impact not only during operation, but also construction, commissioning, and decommissioning of a nuclear power plant.

Nuclear supervision authorities in Poland include the President of the National Atomic Energy Agency (NAEA), the Chief Nuclear Regulatory Inspector (NAEA Vice President), and nuclear regulatory inspectors employed by NAEA. The NAEA President reports to the Minister of Environment—so in our country, supervisory activities connected with nuclear safety supervision and control and radiological protection is separated from and independent of activities connected with promotion and development of nuclear energy as well as ownership supervision over energy companies with majority shareholding of the State Treasury, which at the central government level is exercised by the Ministry of Economy and the Ministry of State Treasury, correspondingly. The Nuclear Supervision has more than 30 years of tradition of effective activity and shall cooperate with the Technical Supervision Authority (supervising pressure devices and installations or those using hazardous substances—including radioactive substances[239], as well as equipment for moving people and cargos—in particular cranes), which also has a good reputation in Poland.

High competence and entitlements of the NAEA President and nuclear regulatory inspectors in the scope of nuclear energy are guaranteed under the amended Atomic Law act of 13.05.2011. In particular, the NAEA President is authorised to:

- Issue and revoke authorisations to organisational units to pursue activities connected with exposure (to ionising radiation) consisting in construction, commissioning, operation or decommissioning of a nuclear facility (in particular nuclear power plant).
- Grant and revoke authorisations to staff of the nuclear power plant who perform activities of particular importance for nuclear safety or radiological protection.
- Issue preliminary assessment of the site of a future nuclear facility (before the investor's application for a nuclear facility construction licence).
- Issue opinion defining the restricted-use area boundaries in the area of the nuclear facility.
- Issue a general assessment (before the investor's application for a nuclear facility construction licence) of the planned organizational and technical solutions to be applied in future activities, as well as documents to be submitted along with the licence application.
- If in result of inspection it is found that:
  - certain system or element of the construction or equipment of a nuclear facility can negatively impact the nuclear safety and radiological protection status of the facility, the NAEA President is authorised to prohibit the use of this system or element in the nuclear facility;
  - certain works in a nuclear facility are conducted in a manner which can negatively impact the nuclear safety and radiological protection status of the facility, the NAEA President is authorised to order suspension of such works;

[239] Draft regulation by the Council of Ministers on the types of technical equipment and devices subject to technical supervision at the nuclear power plant.

- Suspend the commissioning of a nuclear facility, when the results of commissioning tests indicate any risks for nuclear safety or non-compliance with the nuclear safety requirements.

- Order to reduce the power output or to stop the operation of a nuclear facility if further operation of this facility poses any threat to nuclear safety or radiological protection, in his/her assessment. Subsequent increase of power output or the start-up of nuclear facility shall require a written approval of the NAEA President having confirmed that further operation of the nuclear facility poses no threat to nuclear safety or radiological protection.

- Issue (written) consent to renovation of any nuclear facility system, construction element or installation important for the nuclear safety and radiological protection, and each reactor start-up following fuel load or renovation of any system, construction element or installation of the nuclear facility.

- Approve a nuclear facility decommissioning programme.

In organisational terms, Polish nuclear supervision is placed in the NAEA structure, which was reorganised in 2011 with an aim of better adjustment to the needs of nuclear power supervision. The current organisational chart (applicable as of 06.11.2011) is presented below[240]. The Nuclear Safety Department has been expanded particularly. In the next couple of years, it is planned to transform the NAEA into the Office of the Nuclear Safety and Radiological Protection Commission. In 2011, NAEA employed 92 people, of which 25 were nuclear regulatory inspectors. At present, NAEA employs a few persons with long-term experience in the scope of nuclear safety and supervision, gained mainly in times of the implementation of Żarnowiec Nuclear Power Plant in the 80's of the 20th century. They are involved in development of relevant nuclear safety and radiological protection regulations as well as supervisory guidelines (technical and organisational guidelines of the NAEA President).

[240] National Atomic Energy Agency: Activity of the President of the National Atomic Energy Agency and the assessment of nuclear safety and radiological protection in Poland in 2011. http://www.paa.gov.pl/dokumenty/atomistyka2011.pdf

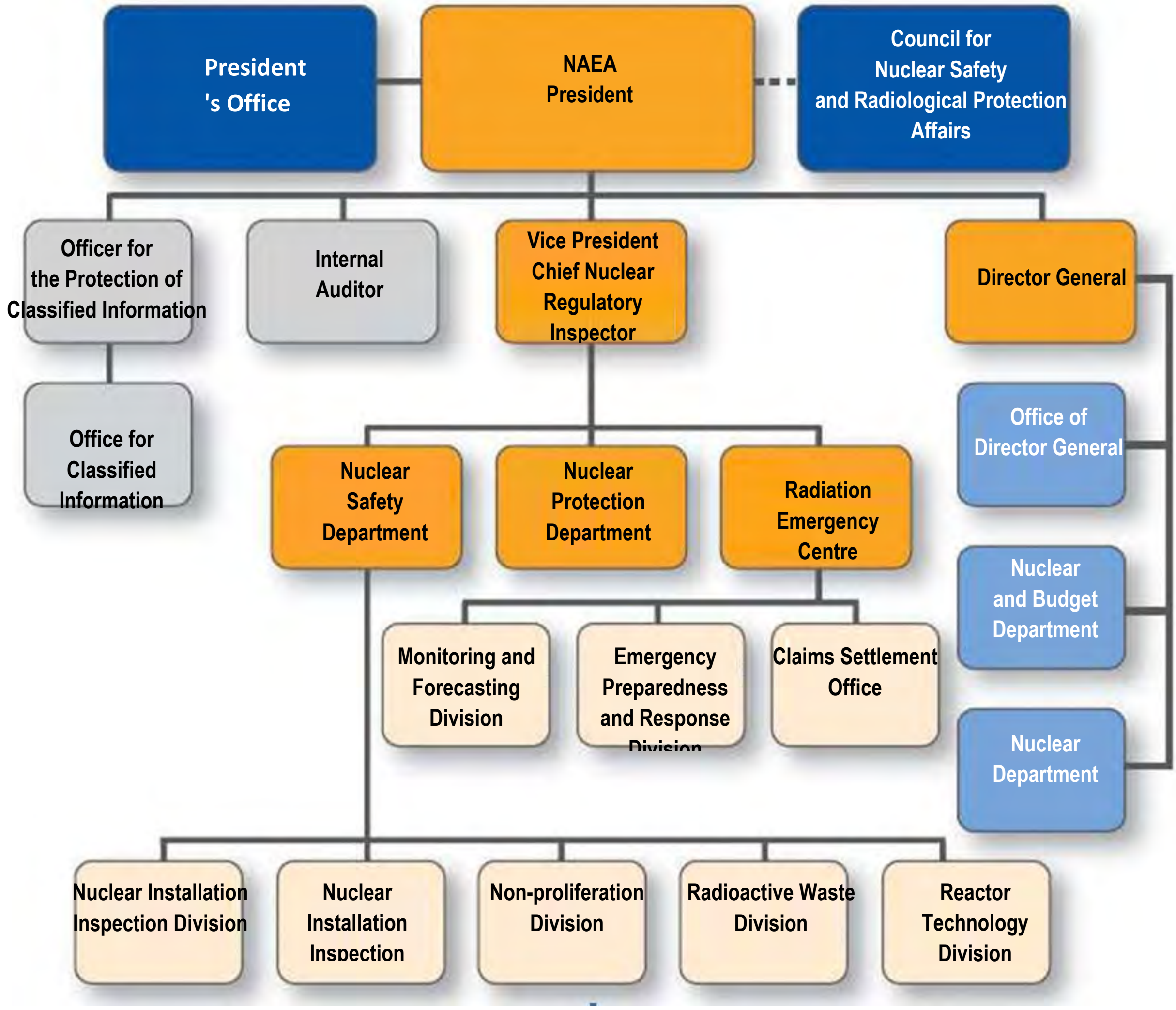


Figure 124. Current organisational structure of the National Atomic Energy Agency.

In 2012-2014, it is planned to employ and train 39 persons for relevant positions, including:

• 17 nuclear regulatory inspectors,

• 13 specialists for safety documentation assessment,

• 9 lawyers or administrative law specialists.

Relevant training shall be ensured, basic and recurring, national and international, for the nuclear supervision specialists. The time necessary for first results to be obtained shall be three years at least. A nuclear regulatory inspector to participate in supervision over nuclear facilities becomes fully independent in work after five years at average.

The NAEA intensely cooperates with the International Atomic Energy Agency (IAEA)—in particular, NAEA representatives participate in works of individual committees for safety standards ((NUSSC, RASSC, TRANSSC, WASSC, NSGC), WENRA and NEA OECD. In the period from January to March 2012, 3 experts delegated by the NAEA actively participated in the peer review of stress tests of European nuclear facilities. These activities significantly contribute to raising the level of knowledge, competence and experience of the Polish nuclear supervision.

The NAEA has signed a number of agreements with nuclear supervisory authorities of various countries. Among them, on 23.09.2010, an agreement was signed with the US NRC on the exchange of technical information and cooperation in the field of nuclear safety, which provides for, *inter alia*, NRC support in the scope of training of staff of the Polish nuclear supervision. A similar agreement was signed by the NAEA also with the French nuclear supervision, ASN—on 9.07.2012. Moreover, the NAEA also entered agreements with nuclear supervision authorities of all neighbouring countries operating nuclear plants. Cooperation agreements with Japanese and South Korean nuclear supervision authorities are in preparation. There are plans to delegate NAEA employees to training in this authorities.

Currently, the Polish Nuclear Supervision uses the expert support of the Technical Support Organisations[241] such as: National Centre for Nuclear Research (NCNR) in Świerk, Institute of Nuclear Chemistry and Technology (INChT) in Warsaw, Central Laboratory for Radiological Protection (CLRP), Institute of Geophysics, Polish Academy of Sciences. Agreement with other Technical Support Organisations are also planned. The agreements obligate specific technical support organisations not to provide services to the nuclear industry within the scope covered with the technical support agreement for supervision purposes. Moreover, NAEA uses the expert back-up of the Council for Nuclear Safety and Radiological Protection, comprising eminent Polish experts in various fields connected with safety assurance for nuclear facilities, and radiological protection.

It should be highlighted that a significant part of tasks of nuclear safety supervision (over equipment of particular importance for safety such as: pressure equipment, main technological systems and safety systems, and also technological transport systems) shall be fulfilled in Poland by the Technical Supervision Authority—which is an extensive organisation (apart from the headquarters in Warsaw: 21 field branches, 2 agencies, and central laboratory), with broad competences and significant tradition (dating back to 1911), employing inspectors with high qualifications and substantial professional experience.

In 15-25.04.2013, the preparedness of the National Atomic Energy Agency for supervision of nuclear facilities—with particular emphasis on nuclear power and fulfilment of supervisory tasks, was assessed by the Integrated Regulatory Review Service (IRRS) of the International Atomic Energy Agency. The opinion issued by the IRRS was very favourable. It was provided in a report[242] and in a press release.

The opinion underscores that NAEA is fully aware of tasks awaiting it in relation with the implementation of the Polish Nuclear Power Programme and the role of nuclear supervision the Agency has to play in it. High competences of NAEA management and employees were noticed. "Both Polish regulations, as well as actions of NAEA ensure sound protection against radiation to Poles", said Robert Lewis, US Nuclear Regulatory Commission (NRC), responsible for the works of IRRS in Poland. "NAEA is focused on its tasks and fully committed to ensuring safety", he added.

Particularly positively the IRRS experts assessed the changes introduced to the regulation at the early stage of the nuclear programme. The relevant amendments to the regulations were introduced in 2011-2012. Apart from that, establishment of active cooperation with the Technical Supervision Authority was considered as "good practice".

[241] Technical Support Organizations – TSOs.

[242] INTEGRATED REGULATORY REVIEW SERVICE (IRRS) REPORT TO Poland. Warsaw, Poland. 15-25 April 2013. IAEA Department of Nuclear Safety and Security. IAEA-NS-IRRS-2013/02.

At the same time, the initial report emphasises that the necessary development of the Agency in the years to come may turn out to be a serious challenge for the NAEA and its management. Therefore, the IRRS mission prepared a number of recommendations and suggestions aimed at strengthening of the management system and facilitation of knowledge management within the NAEA.

At the same time, the assessment of the preparation status of the Polish Nuclear Supervision by the IAEA does not boil down to the IRRS mission only. For example, in 25-29.06 2012, the "EM3" IAEA mission took place: the Expert Mission on Development of Safety Regulations and Regulatory Guides for NPPs . In addition, next specialist missions are planned.

Apart from the Nuclear Supervision bodies and the Technical Supervision Authority, there are also **other control bodies** in Poland which, pursuing their activities as part of their statutory activity in the context of nuclear industry, include the following institutions.

1. The General Directorate for Environmental Protection (GDEP) and Regional Directorates for Environmental Protection (RDEPs)

The General Directorate for Environmental Protection is an institution responsible for implementation of the environment protection policy in the following scope:

- nature protection management, inclusive of, *inter alia,* Nature 2000 areas,
- control of the investment process, with the strategic environmental assessment included,

Also, it fulfils tasks in the scope of environmental prevention and remediation. It is responsible for environmental information management, registration of organisations in the national registry of organisations registered in the Eco Management and Audit Scheme (EMAS). The competences of the GDEP also includes creation and coordination of the national network "Partnership: Environment for Development" in Poland, which is responsible for knowledge and experience exchange between EU countries and institutions implementing EU funds.

Regional directors for environment protection fulfil tasks in the scope of environment protection policy, relating tot the nature protection management, investment process control, with the strategic environmental assessment included, and communication of environmental information within the province. They also issue local legislative acts in the form of regulations, within the limits of their competences.

2. The National Water Management Authority (NWMA) and Regional Water Management Authorities (RWMAs)

The President of the National Water Management Authority is the central government administration body competent for water management matters, and in particular water management and usage (pursuant to art. 89 section 1 of the Water Law act).

The President of the NWMA and RWMA directors exercise control of water management in the following scope:

- implementation of water management plans and programmes prepared in compliance with the act;
- water use;
- compliance with the decisions taken in compliance with the Water Law act;

- water and water works conservation;
- compliance with the responsibilities and restrictions imposed upon land owners;
- compliance with the requirements of the act referring to protected zones and areas;
- compliance with the requirements relating to flood banks and the areas under direct risk of flooding;
- flood preparation and removal of flood damage related to the conservation of water and waterworks;
- installation and maintenance of fixed gauge instruments on the shores and in the water;
- any activities or works which are performed close to waterworks and which could be dangerous for such waterworks or damage them;
- removing water management related damage caused by mining-induced ground movement (article 156 of the Water Law act).

3. Chief Sanitary Inspectorate

The Chief Sanitary Inspectorate is a specialised institution performing public health tasks through control and supervision of the hygiene conditions in various fields of life. Apart from that, the Inspectorate gathers epidemiological data relating to certain diseases and issues decisions in the scope of professional diseases.

4. The General Office of Building Control (GOBC) / The Chief Inspector for Building Control

The General Office of Building Control is an administrative body serving the Chief Inspector for Building Control and acting under the direct management of the latter. Subject to GOBC are the following bodies:

- architectural and building administration bodies and construction supervision bodies,
- construction facilities and works,
- marketed construction products.

2.10.2. Requirements of Polish nuclear safety regulations

In order to prepare legal infrastructure adequate for the nuclear industry supervision, the Atomic Law act was significantly amended (13.05.2011), and a special act on the preparation and implementation of investments in nuclear facilities and accompanying infrastructure (29.06.2011). Moreover, several implementing acts to the Atomic Law were prepared and amended—including regulations of the Council of Ministers on safety requirements for a nuclear facility and on safety analyses and the content of the preliminary safety report for a nuclear facility. In particular, these amended and new regulations transpose the requirements of Directive 2009/71/EURATOM of 25 June 2009 establishing a Community framework for the nuclear safety of nuclear installations to the Polish legislation.

The following new implementing acts (regulations) to the Atomic Law act, related to nuclear power regulation, have been already implemented:

- Regulation by the Council of Ministers of 27 December 2011 on periodical safety assessment of a nuclear facility (Dz. U. [Polish Journal of Laws] of 2012, item 556).

- Regulation by the Council of Ministers of 27 December 2011 on the specimen of quarterly report on the contribution to the decommissioning fund (Dz. U. of 2012, item 43)
- Regulation by the Minister of Finance of 14 September 2011 on guaranteed minimum amount of the compulsory civil liability insurance of the nuclear facility's operator (Dz. U. no. 206, item 1217)
- Regulation by the Minister of Economy of 23 July 2012 on detailed rules of establishment and operation of the Local Information Committees and cooperation in the scope of nuclear facilities (Dz. U. item 861)
- Regulation by the Minister of Environment of 18 November 2011 on the Council for Nuclear Safety and Radiological Protection (Dz. U. no. 279, item 1643)
- Regulation by the Minister of Environment of 9 November 2011 on the standard form of identity document of nuclear regulatory inspector (Dz. U. no. 257, item. 1544)
- Regulation by the Minister of Health of 29 September 2011 on psychiatric and psychological tests of employees performing activities important for nuclear safety and radiological protection at the organizational unit conducting activities related to exposure which consist in commissioning, operation or decommissioning or a nuclear power plant (Dz. U. no. 220 item 1310)
- Regulation by the Council of Ministers of 10 August 2012 on detailed scope of assessment with regard to land intended for the location of a nuclear facility, cases excluding land to be considered eligible for the location of a nuclear facility and on requirements concerning location report for a nuclear facility (Dz. U. of 2012, item 1025)
- Regulation of the Council of Ministers of 31 August 2012 on nuclear safety and radiological protection requirements which must be fulfilled by a nuclear facility design ("Design Regulation") (Dz. U. of 2012, item 1048)
- Regulation of the Council of Ministers of 31 August 2012 on the scope and method for the performance of safety analyses prior to the submission of an application requesting the issue of a license for the construction of a nuclear facility and the scope of the preliminary safety report for a nuclear facility (Dz. U. of 2012, item 1043)
- Regulation by the Council of Ministers of 10 August 2012 on activities important for nuclear safety and radiological protection in an organizational unit conducting activity which consists in commissioning, operations or decommissioning of a nuclear power plant (Dz. U. of 2012, item 1024)
- Regulation of the Council of Ministers of 11 February 2013 on requirements for the commissioning and operation of nuclear facilities (Dz. U. of 2013, item 281)
- Regulation of the council of ministers of 11 February 2013 on nuclear safety and radiological protection requirements for the stage of decommissioning of nuclear facilities and the content of a report on decommissioning of a nuclear facility (Dz. U. of 2013, item 270)
- Regulation by the Council of Ministers of 10 October 1012 on the amount of payment to cover the costs of final management of spent nuclear fuel and radioactive waste and to cover the costs of nuclear power plant decommissioning performed by the organisational unit which has been granted operation licence for the plant (Dz. U. of 2012 r., item 1213)
- Regulation of the Council of Ministers of 24 August 2012 on nuclear regulatory inspectors (Dz. U. of 2012, item 1014).

In addition, the two following regulations on nuclear installation supervision shall be issued—as implementing acts to the Act on Technical Supervision (their drafts have been already prepared and they no undergoing consultation):

- Regulation by the Council of Ministers on the types of technical equipment and devices subject to technical supervision at the nuclear power plant.

- Regulation by the Minister of Economy on technical conditions for technical supervision of technical equipment and devices subject to technical supervision at the nuclear power plant.

Polish regulations set out the highest standards of nuclear safety applicable currently in the world, complaint with the most recent international requirements (in particular safety objectives for new generation reactors contained in IAEA SSR-2/1 document and WENRA Declaration of 2010[243]), taking into account also the requirements of EUR document and lessons learned in result of the accident in Fukushima Dai-ichi NPP and stress testing of European nuclear power plants.[244]

The safety objectives for new generation reactors, referred to above and adopted in Polish regulations, include practical ruling out (in deterministic terms, with the use or relevant design basis solutions) of accidents with core degradation which could lead to early damage of safety containment of the reactor and very large releases of radioactive substances to the environment, and limiting the impact of accidents with core degradation which have not been ruled out, so as to significantly limit the necessity of intervention to protect health of the population to a limited area and time. The requirements in this scope are contained in art. 35b section 2 of the Atomic Law (amended in 13.05.2011) and §9, §10 and §32 of "Design Regulation"; relevant requirements from these regulations are presented below.

Moreover, the conclusions based on the analyses of the Fukushima Dai-ichi NPP accident and stress tests in the European nuclear power plants have been already included in the final version of the draft "design regulation", in particular those relating to: the manner of accounting for external threats, increasing the required autonomy of a nuclear power plant in terms of power supply and cooling water resources, application of additional or alternative power supply and residual heat discharge systems and devices, etc.

<u>Atomic Law Act</u>

Art.
36c.

(
…
)

2. Should any emergency arise that may lead to the degradation of the reactor core, the design of the nuclear facility shall have in place specific solutions that will be most likely to prevent:
1) a chain of incidents leading to premature release of radioactive substances, i.e. incidents that

[243] WENRA Statement on Safety Objectives for New Nuclear Power Plants. November 2010.
[244] European Utility Requirements for LWR Nuclear Power Plants. Revision C. April 2001.

require intervention measures to be employed outside the nuclear facility, if no time is left to implement them;

2) a chain of incidents leading to considerable releases of radioactive substances, i.e. incidents that require general public protection measures to be employed which would be unlimited in time and space.

Design Regulation

***§ 9.** Nuclear facility design shall ensure the limitation of releases of radioactive substances beyond the reactor containment in case of the occurrence of accident conditions so that in the event of:*

3) design basis accidents, there is no need to take any intervention measures beyond the limits of the restricted-use area;

4) extended design conditions, there is no need to take:

a) early intervention measures beyond the limits of the restricted-use area of the nuclear facility during the releases of radioactive substances from the nuclear facility,

b) medium-term intervention measures at any time whatsoever beyond the limits of the emergency planning zone,

c) long-term intervention measures beyond the limits of the restricted-use area of the nuclear facility.

***§ 10.** The design of the nuclear power plant and the research reactor shall ensure the attainment of:*

1) the probability of the reactor core degradation to occur less frequently than once every 100 000 years of the reactor operation;

2) the probability of releases to the surroundings of radioactive substances to occur less frequently than once every 1000 000 years of the reactor operation, in such volumes that, beyond the limits of the restricted-use area, any of the intervention levels could be exceeded, thus requiring consideration as to whether early or long-term intervention measures should be taken, whilst beyond the limits of the emergency planning zone the intervention level could be exceeded requiring the consideration as to whether medium term intervention measures should be taken;

3) probability of accident sequences to occur considerably less frequently than once every 1000 000 years of reactor operation, potentially leading to the premature failure of the reactor containment or to very large releases of radioactive substances to the surroundings.

***§ 32.** 1. The design of a nuclear power plant and research reactor shall take into account accident sequences which bypass the reactor containment, even without fuel melting, capable of leading to the direct release of radioactive substances beyond the primary reactor containment, by applying the following solutions:*

5) appropriate safety reserves when designing systems connected to the reactor cooling circuit;

6) minimising the number of culverts located in the primary reactor containment;

7) isolating fittings which are appropriately reliable and which are duplicated on the pipelines connected to the reactor cooling circuit, passing through the primary reactor containment;

8) in case of a pressurized water reactor – safety measures in order to minimise the loss of reactor coolant and the releases of radioactive substances beyond the reactor containment if the pipes in the steam generator are ruptured.

2. Nuclear power plant and research reactor shall be designed so as to prevent the occurrence of *severe accidents, which could lead to a premature failure of the primary reactor containment, or it shall be demonstrated that the probability of occurrence of such accidents is so small that it is not necessary to include it in the design.*

3. The accidents, referred to in Section 2, shall cover in particular:
1) hydrogen explosion;
2) failure of the reactor vessel with pressure which could lead to:
a) ejection of the molten core material and direct heating of primary reactor containment or
b) generation of high-energy particles which could threaten the integrity of primary reactor containment;
7) steam explosion, which could threaten the integrity of primary reactor containment;
8) reactivity-initiated accidents, including – in pressurized water reactors – heterogenic dilution of boric acid.

4. The design of a nuclear power plant and research reactor shall provide for solutions ensuring limitation, by means of the reactor containment system, of the consequences of severe accidents involving reactor core degradation, in particular by:
5) stopping and cooling the reactor molten core;
6) limiting the consequences of interaction between the reactor molten core and concrete;
7) limiting leakage from the reactor containment, taking into account stress resulting from the oxidisation of fuel claddings and hydrogen combustion and other strains which could occur during severe accidents;
8) extending the time after the lapse of which it will be required to use operator's intervention measures or other measures with the purpose of bringing the accident under control.

****

Polish regulations on the protection against ionising radiation

- Regulation by the Council of Ministers of 18 January 2005 on ionizing radiation dose limits (Dz. U. [Polish Journal of Laws] of 2005, item 168).
- Regulation by the Council of Ministers of 27 April 2004 on intervention levels for various intervention measures and criteria for cancelling intervention measures (Dz. U. no. 98, item 987);

are compliant with the currently applicable Directive 96/29/Euratom, which is based on the radiological protection standards published in 1996 by the International Atomic Energy Agency (IAEA)[245] and taking into account the recommendations of the International Commission on Radiological Protection (ICRP) issued in 1996.

In November 2011, the IAEA published new radiological protection standards[246] as the new Euratom directive. The standards have not yet been implemented in the EU law.

It should be noted, however, that in currently applicable regulations in Poland:

[245] International Basic Safety Standards for Protection Against Ionizing Radiation and for the Safety of Radiation Sources. Safety Series No. 115. International Atomic Energy Agency. Vienna 1996.
[246] Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards. Interim edition. General Safety Requirements Part 3. No. GSR Part 3 (interim). International Atomic Energy Agency. Vienna 2011.

- occupational exposure rates are in accordance with the new standards of radiological protection of IAEA[247], with the exception of doses for eye lenses—which were significantly decreased in the new IAEA standards;
- all public exposure values are in accordance with the new radiological protection standards[248];
- also the basic intervention levels are compliant with the requirements of new radiological protection standards of IAEA or lower, with the exclusion of iodine thyroid blocking level, which is 2 times lower in these standards[249].

Thus, the requirements in the scope of radiological protection set out in Polish regulations, which are compliant with the requirements of the currently applicable Directive 96/29/Euratom, do not significantly differ from the most recent radiological protection standards of IAEA (published very recently, in November 2011).

To be sure, Polish regulations on the protection against ionising radiation shall be amended immediately—after the new Euratom directive is actually adopted in this matter.

In addition to the regulations, there are plans to issue a number of **nuclear supervision guidelines** (as technical and organisational guidelines of the President of the National Atomic Energy Agency), whose initial list is presented below. Drafts of four of these documents (1.2, 3.1, 3.3, 3.4) have been already prepared.

<u>Initial list of planned nuclear supervision guidelines:</u>

1. General guidelines
    - 1.1. Requirements for integrated management systems for nuclear power plants (at the stage of designing, and construction, commissioning, operation, and decommissioning)
    - 1.2. Licencing procedures for nuclear power plants (on the issuing of opinions on location, initial assessment of technological and organisational solutions, and construction, commissioning, operation, and decommissioning licences)
2. Placement guidelines
    - 2.1. Requirements for meteorological monitoring for nuclear power plants
    - 2.2. Requirements for hydrological and hydrogeological monitoring for the purposes of the assessment of flood hazards for which nuclear power plants.
    - 2.3. Requirements for seismic monitoring for nuclear power plants
    - 2.4. Requirements for the assessment of geotechnical conditions of nuclear plants locations
    - 2.5. Requirements for radiological monitoring for nuclear power plants (at the stage of designing, and construction, commissioning, operation, and decommissioning)
    - 2.6. Requirements for the assessment of threats to nuclear power plants from external events
3. Design and construction guidelines
    - 3.1. Specific requirements of nuclear safety and radiological protection for the design of a

247 Schedule III. Dose Limits for Planned Exposure Situations. Occupational Exposure.
248 Schedule III. Dose Limits for Planned Exposure Situations. Public Exposure.
249 Annex. Generic Criteria for Protective Actions and other Response Actions in Emergency Exposure Situations to Reduce the Risk of Stochastic Effects.

nuclear power plant with a 3rd generation reactor

3.2. Fire protection requirements for nuclear power plants

3.3. Specific requirements for safety analyses for nuclear power plants

3.4. Specific requirements for safety reports for nuclear power plants

3.5. Guidelines on classification of safety of systems, structures and equipment of nuclear power plants

4. Guidelines on commissioning and operation

4.1. Requirements for records systems and nuclear material control in nuclear power plants

4.2. Requirements for qualifications, training schemes and verification of competences, as well as procedures of granting authorisations for nuclear power plant staff

4.3. Requirements for the conduct and assessment of physical tests during commissioning of a nuclear power unit

4.4. Requirements relating to quality assurance for software for nuclear power plants

4.5. Radiological protection requirements for staff in nuclear power plants

4.6. Requirements for monitoring and control of radioactive substance releases from nuclear power plants

4.7. Guidelines on safety specifications (including limits and conditions of operation) for a nuclear power plant

4.8. Guidelines on monitoring and control of radiation embrittlement of materials of pressure vessels of nuclear power reactors

4.9. Guidelines on the scope, format, and frequency of communication of operation-related information from nuclear power plants to the NAEA President (required under art. 37 section 3 and art. 37c section 1 item 3 of the Atomic Law act)

4.10. Guidelines on the procedures of preparation and implementation of renovations and upgrades in nuclear power plants

4.11. Guidelines on emergency planning and preparations on the premises of a nuclear power plant 4.12 Guidelines on emergency planning and preparations outside the premises of a nuclear power plant

2.11. DETAILED DATA OF TECHNOLOGICAL SOLUTIONS AND CRITERIA ADOPTED FOR THE SELECTION OF LOCATIONS

2.11.1. Discussion of the objection that the SEA Forecast lacks detailed technical and technological analyses

The specific nuclear technology for power plants to be applied in Poland has not yet been selected—namely the reactor type and design basis solutions for a nuclear power unit, including those related with cooling systems, and in particular also residual heat discharge systems (for heat from the reactor and spent fuel pool) for the ultimate heat sink. The location has not yet been selected either—even for the 1st Polish nuclear power plant, and cooling solutions will depend also on the location. Both the selection of NPP technology as well as the location for the 1st Polish NPP shall be performed not earlier than in 2 years.

Nevertheless, it is already known and obvious that only NPP technologies of the 3rd and 3rd+ generation, fulfilling strict requirements of Polish nuclear safety regulations, shall be admitted for use in Poland. In order to prepare legal infrastructure adequate for the nuclear industry supervision, the Atomic Law act was significantly amended (13.05.2011), and a special act on the preparation and implementation of investments in nuclear facilities and accompanying infrastructure (29.06.2011). Moreover, several implementing acts to the Atomic Law were prepared and amended—including regulations of the Council of Ministers on safety requirements for a nuclear facility and on safety analyses and the content of the preliminary safety report for a nuclear facility. In particular, these amended and new regulations transpose the requirements of Directive 2009/71/EURATOM of 25 June 2009 establishing a Community framework for the nuclear safety of nuclear installations to the Polish legislation (see detailed information in item 2.10.2).

It should be underlined, that Polish regulations set out the highest standards of nuclear safety applicable currently in the world, complaint with the most recent international requirements (in particular safety objectives for new generation reactors contained in the document of the International Atomic Energy Agency (IAEA) SSR-2/1 and the Declaration of the Western European Nuclear Regulators' Association (WENRA) of 2010[250]), taking into account also the requirements of EUR document and lessons learned in result of the accident in Fukushima Dai-ichi NPP and stress testing of European nuclear power plants.[251]

The safety objectives for new generation reactors, referred to above and adopted in Polish regulations, include practical ruling out (in deterministic terms, with the use or relevant design basis solutions) of accidents with core degradation which could lead to early damage of safety containment of the reactor and very large releases of radioactive substances to the environment, and limiting the impact of accidents with core degradation which have not been ruled out, so as to significantly limit the necessity of intervention to protect health of the population to a limited area and time. Regulations contained in the implementing acts to the Atomic Law ("design" regulation and regulation on the safety analyses and the content of preliminary safety report) require unambiguously the design-basis solutions for a nuclear power plant to ensure safety not only in the case of design-basis accidents, but also to ensure bringing the radiological consequences of beyond-design-basis accidents, defined as design extension conditions, under control, and reducing them. It is a requirement typical for new generation power reactors—in line with the safety objectives defined in IAEA SSR-2/1 and WENRA Declaration of 2010.

In addition, Polish law regulations set out a number of safety criteria and requirements for nuclear power plants (such as e.g. the requirement of resistance to the impact of a large civil aircraft, requirements relating to the construction of the reactor safety containment—which must be comprised from the primary and secondary casing, the requirement to apply passive solutions in certain devices and systems important for safety—including hydrogen recombination), which can be fulfilled only by the most recent designs.

The conclusions based on the analyses of the Fukushima Dai-ichi NPP accident and stress tests in the European nuclear power plants have been already included in the final version of the draft "design regulation", in particular those relating to: the manner of accounting for external threats,

[250] WENRA Statement on Safety Objectives for New Nuclear Power Plants. November 2010.
[251] European Utility Requirements for LWR Nuclear Power Plants. Revision D. October 2012.

increasing the required autonomy of a nuclear power plant in terms of power supply and cooling water resources, application of additional or alternative power supply and residual heat discharge systems and devices, etc.

The compliance with these requirements is supervised by the independent Polish Nuclear Supervision, cooperating with the Technical Supervision Authority and other state control institutions, whose extensive authorisations are also described in section 14.

Information about reactor system concepts contained in the "Forecast..." are based on only on manufacturers' information, but also analyses carried out by nuclear supervision authorities, in particular such as US NRC (United States), HSE-ONR (United Kingdom), and STUK (Finland).

2.11.2. Discussion of the objection on the lack of detailed surveys for individual locations

The Ministry of Economy would like to inform that such detailed aspects will be subject to the EIA procedure carried out before the decision on placement of a nuclear facility is issued, as well as before the construction permit is granted. As part of the procedure, public and cross-border EIA procedure shall be conducted. Therefore, all stakeholders will possess knowledge of the adopted technological solutions and the related impact.

Poland is still at the initial stage of implementation of nuclear energy. At present, the strategic document—Polish Nuclear Power Programme—is being prepared. It is a strategic implementing document including legal, organisational, and formal measures necessary to introduce nuclear energy in Poland. It does not specify any technological details. The only specifications relate to possible locations and the 3rd or 3rd+ generation reactors to be used exclusively in the Polish nuclear power plants. The environmental impact assessment of PNPP in order to define possible consequences, significantly extends this information by way of:

- analysis of the reactors that can be offered in Poland
- analysis what radiological impact is related to individual reactor types
- what conditions are connected with individual possible locations.
- what types of cooling systems are possible and the consequences related to them

These analyses are carried out at a possible and reasonably justified detail level. In this case, it is not reasonable to require precise and final results, technical and technological data etc., as these issues shall be subject to thorough analysis as part of the EIA procedure.

In this context, attention should be paid to the provision of **art. 5 of directive 2001/42/EC of the EUROPEAN PARLIAMENT AND THE COUNCIL** of 27 June 2001 **on the assessment of the effects of certain plans and programmes on the environment** (Official Journal of the EU L of 21 July 2001), 1. In the case when, pursuant to art. 3 section 1, the environmental impact assessment is required, a report shall be prepared, identifying, describing, and estimating the possible significant environmental impact of the implementation of a plan or programme, as well as reasonable alternative solutions taking into account the objectives and geographical coverage of the plan or programme. Information to be provided for that purpose are defined in appendix I. 2. The environmental report, prepared in line with section 1**, contains information which can be reasonably required taking into account the current state of knowledge and assessment methods, as well as the content and detail level of the plan or programme, its stage in the decision-making process and the scope in which certain matters can be assessed in a more adequate manner at various stages of this process, in order to avoid repeating assessments.**

Analogical provisions are also set out in Polish legislation—pursuant to art. 52 of the act on disclosure of environmental information, environmental protection, public participation in environmental protection, and environmental impact assessments, "information contained in the Forecast of the Environmental Impact Assessment, referred to in article 51 section 2, should be developed in accordance with the current state of knowledge and assessment methods, as well as adjusted to the content and detail level of the document drafted, and its implementation stage in the process of preparation of draft documents related to this document".

Poland is one of the first countries in Europe to submit a strategic document on nuclear energy implementation to the SEA. It can be for that reason that the expectations related to the detail level to be applied are too high. The Ministry of Economy is of the opinion that it is not justified to compare the content and detail level of the PNPP Forecast of the Environmental Impact Assessment to the EIA Report.

It should be also reminded that in 2013-2014, detailed placement studies and analyses shall be conducted for possible locations (Choczewo and Żarnowiec, plus possibly 2 additional sites—Gąski and probably Kopań) in order to select the optimal location for the 1st Polish nuclear power plant. Results of these studies and analyses shall be subsequently used in preparation of the placement report and environmental impact report for the project for the selected NPP location.

In calculations of radiological risk, whose results were provided in the SEA Forecast, standard, but conservative assumptions on meteorological conditions were adopted to ensure a conservative assessment of radiological impact of the accidents under consideration. Detailed measurements, observations and analyses of meteorological conditions for the possible sites of nuclear power plants currently considered by the investor (Choczewo, Żarnowiec, and additionally also Gąski and Kopań) shall be conducted as part of detailed placement surveys and analyses planned for 2013-2014 to select an optimal location for the 1st Polish nuclear power plant.

Environmental impact of a specific nuclear power plant (i.e. in s specific location and for a specific technology and configuration) shall be determined in detail in the environmental impact report for the project, which is necessary to obtain the environmental decision. Each planned construction of a specific nuclear plant shall be subjected to separate national and cross-border consultation.

2.11.3. Discussion of the objection on obscure site selection criteria

The site has not yet been selected even for the 1st Polish nuclear power plant (NPP). Selection of an optimal location for the first NPP shall be made on the basis of results of detailed (placement and environmental) surveys and analyses of the 3 possible locations, which shall be carried out in 2013-2014.

As for the list of 27 locations from the ME list, the procedure of conduct is described in section 10.3 of the SEA Forecast. In historical terms, studies aimed at selection of the location for the first nuclear power plant with capacity of 2,000 MW have been started in mid-60's of the 20th century. In result of placement surveys conducted in 1969–1970, a decision was taken in December 1972 to place the first nuclear power plant in Poland by the Żarnowieckie Lake. The construction of "Żarnowiec" Nuclear Power Plant was started in 1982. At the same time, studies were carried out to determine the second site, ended in June 1988 with the decision of Piła province governor to place the second nuclear power plant, Warta, in Klempicz. Concurrently with the final stage of placement surveys and studies for the second nuclear power plant, placement studies were conducted to prepare materials necessary to start the placement process for the third and following plants. At the first stage, a macro-spatial analysis of possible nuclear plant locations throughout Poland was prepared, and in result, 62 possible location areas were selected. The stage was ended in 1989. In the second stage, the list of locations was reduced to 29 sites. Further surveys and studies has been stopped because of the cancellation of the nuclear power development programme.

In 2009, the Ministry of Economy, in agreement with local governments, updated location proposals for nuclear power plants, considered until 1990. New offers were also collected. On that basis, a list of 27 possible locations of nuclear power plants was prepared. In result of the update, a location ranking was prepared on the basis of the following factors (see also: information in item 59):

1) Connection with the power system,
2) Geology, earthquakes and volcanic studies,
3) Seismology and seismic engineering,
4) Hydrology (including ground water, floods and tsunamis),
5) Availability of cooling water, intake and discharge
6) Demography and land usage,
7) Meteorology and weather conditions (including wind directions, tornados and hurricanes).,8) Studies on fauna and flora,
9) Nuclear safety and radiological protection aspects,
10) General environmental impact,
11) Risks from human activity,
12) Local infrastructure,
13) Cultural and historical locations,
14) Accessibility and evacuation routes,
15) Air, land, and sea transport characteristics,
16) Legal aspects,
17) Public consultation.

From among 27 possible locations, results of the expertise conducted on the basis of preliminary analyses indicated 4 recommended ones (Żarnowiec, Warta-Klempicz, Kopań and Nowe Miasto). For that reason, the said locations are also called in that way (recommended and reserve locations) in the SEA Forecast. The Forecast contains analysis of all 27 locations and one additional location in Gąski. Recommended and reserve locations are indicated in the main text of the SEA Forecast—section 10.3. Other locations are listed in the appendix to the Forecast of the Environmental Impact Assessment—other location alternatives. This fact is also described in the main text of the Forecast.

As for the additional site, it should said that after it was introduced, the Ministry of Economy updated the Polish Nuclear Power Programme and the Forecast, and carried out an additional round of public consultation. In this case the criteria of availability of cooling water were most important (preference was given to sea water in an open cooling circuit—which enables to reduce investment outlays and obtain higher generation efficiency due to lower temperatures of cooling water) as well as locations in the northern part of the country (Pomorskie and Zachodnio-Pomorskie provinces)—due to the energy deficit in this part of the country.

Surveys consisting in the assessment of placement and environmental conditions in the locations selected for further studies shall provide the basis for selection of the optimal alternative in environmental social, and economical terms, for which the EIA procedure shall be conducted. Thus, the information about the location considered optimal shall be available after the studies carried out by the investor are ended.

2.11.4. Discussion of the objection on the lack of identification of all possible causes of accidents

For each of the 3rd generation reactors proposed in Poland, an extensive safety documentation was prepared, which is reviewed by the nuclear supervision authorities in the countries that lead in nuclear power development. At the detail level of PNPP and SEA Forecast, it is not possible to present all possible causes of accidents under consideration. An exhaustive answer would need extensive descriptions and substantiations covering hundreds of pages for each reactor. Such procedure will be possible and shall be conducted after the safety analysis for the specific reactor type for the first Polish nuclear power plant is carried out. This answer is limited to explanations relating to the selected "accident types" for one of possible reactor types, the EPR.

2.11.4.1. The issue of safe hydrogen recombination

Autocatalytic hydrogen recombiners work at very lower hydrogen concentrations, approx. 0.5%, which is significantly less than 4.1% concentrations at which there is a possibility of hydrogen combustion, let alone the 10% which is the bottom threshold for transition of deflagration into detonation. Pressure and temperature in the safety containment can be directly determined on the basis of reaction energy (142 MWs/kg) and atmospheric volume in the containment, on the assumption that the atmosphere behaves as an ideal gas. In the case of a typical PWR with a large, dry safety containment, deflagration of hydrogen concentrations of 10% in air whose initial temperature is 20°C under a pressure of 1 bar can result in a pressure growth to 4.3 bars and growth of temperature in the air to 980°C[252]. After deflagration, temperature and pressure quickly decrease to initial values in order of heat flow from gases to walls of the safety containment.

The flammability limit for the pure hydrogen and air mixture is 4.1% of hydrogen to 80% of hydrogen. When the steam content exceeds 53%, the mixture of air and hydrogen does not burn, independently of the hydrogen amount.

The NRC, after extensive analyses, found that large dry safety containments have a large resistance margin which allows them to resist pressures related to hydrogen combustion. In the programme

[252] Lohnert G,.H. The EPR approach to hydrogen control during severe accidents, in: TC Meeting on Identification of Severe Accidents for the Design of Future NPPs, Vienna 9-13 October 1995, IAEA TC-870.3, Vienna 1996

of individual studies on nuclear power plants it was determined that in large dry safety containments, hydrogen combustion does not pose a risk[NUREG 1560] and [NUREG 1150]. Therefore, the NRC does not require hydrogen recombination is such containments, but only to ensure hydrogen mixing[253], to prevent occurrence of high local concentrations. On the other hand, in accordance with the requirements of the French and German Nuclear Safety Commission (RSK), reactors in Europe are equipped with hydrogen recombiners.

In order to eliminate the risk of detonation, the effectiveness of measures reducing hydrogen content should enable a situation in which, when an amount of hydrogen is released equivalent to the release of 100% of fuel claddings in result of reaction with water steam, taking into account a relevant kinetics of the reaction, the local hydrogen concentration would not exceed 10% by volume at any point. Moreover, it needs to be demonstrated that global deflagration of hydrogen at such a concentration will not threaten the tightness of the containment284.

RSK observed that after a cooling circuit breach, the presence of steam in the containment ensures neutral atmosphere even at high hydrogen concentrations, but after the steam is condensed, hydrogen may start to burn. Therefore, RKS recommended to install passive autocatalytic hydrogen recombiners which can operate in the presence of steam already at low hydrogen concentrations. RKS noted that the efficiency of the recombiners cannot be expected to be high enough to ensure low hydrogen concentration directly after maximum releases from the core, and discussed the possibility of application of a double recombination and ignition system. However ultimately, after taking the containment durability into account, RKS recommended to equip reactors in passive autocatalytic hydrogen recombiners[254]. Such solution was adopted in the EPR. The containment of this reactor is able to resist pressure amounting to

0.55 MPa at a temperature of 170 °C, so loads greater than the maximal pressure during hydrogen combustion, and the efficiency of the recombiners ensures reduction of the hydrogen content before steam is condensed.[255]

Along with the increase of hydrogen fraction in the atmosphere, temperature of gases at the outlet from the recombiner grows. At the hydrogen concentration of 4%, gas temperature at the outlet reaches the levels of 300 $_{o}$C, and temperature of the catalyst surface—approximately 500 $_{o}$C. Given higher hydrogen concentrations, spontaneous ignition cannot be excluded, however experience shows that catalyst efficiency decreases at a concentration above 8%, which results in limitation of the maximal temperature of catalyst surface. Nevertheless, even the observed temperatures near 500 °C are close to the spontaneous ignition temperature which is 600 °C[256].

In the case of an ERP, assuming a scenario with breached primary circuit, the gas mixture in the containment is comprised of 30% of air, 10% of hydrogen, and 56% of water steam, which makes hydrogen combustion impossible. Pressure of this mixture is lower than 0.46 MPa. After complete condensation of the steam, gases would be comprised of 75% of air and 25% of hydrogen at a

[253] Nuclear Regulatory Commission, ProbabilisticRiskanalysisBranch, FeasibilityStudy for a Risk-InformedAlternative to 10CFR 50.44 ”Standards for CombustibleGas Control System in LWR Power Reactors”, August 2000 284 TSO Study Project on development of a CommonSafetyApproach in the EU for largeRevolutionaryPWRs, EUR 20163, October 2001
[254]Bekanntmachung von Empfehlungen der Reaktor-Sicherheitskommission Vom 15.Juni 1994, RSK-284-E1
[255] UK EPR FundamentalSafetyOverview Volume 1: HeadDocument, Chapter A: EPR Design DescriptionPage : 98 / 185
[256] Lohnert G,.H. The EPR approach to hydrogen control during severe accidents, in: TC Meeting on Identification of Severe Accidents for the Design of Future NPPs, Vienna 9-13 October 1995, IAEA TC-870.3, Vienna 1996

pressure of 0.1% MPa. This mixture could explode. However, the kinetics of pressure reduction in result of spraying of the interior of EPR containment ensures that after 30 minutes of spraying, a mixture composition is reached containing 13% of hydrogen, 35% of air and 53% of steam at a pressure of 4.1 bar. It it came to the ignition point, pressure in the containment would increase only by 0.1 bar[257].

The analyses conducted as part of the EPR design showed that using autocatalytic passive recombiners is sufficient without igniters[258]. Recombiners are distributed mainly in the premises of the primary circuit, which enables to start hydrogen recombination just after it began to be released from the point of breach and with high efficiency, as the hydrogen concentration will reach the highest values on these premises. Some recombiners are placed in the containment to facilitate the global convection and avoid stratification of gases inside.

The recombiners are placed high enough over the floor to ensure their proper cooling. At the same time, they are situated at a sufficient distance from the devices important to safety (especially electrical devices and cables), so as not to damage them with the stream of hot gases leaving the recombiners.

The calculations are performed with the use of experimental data concerning deflagration and transition of combustion into detonation. If the risk of such an approach cannot be excluded, direct calculation of the impact of combustion process is performed on the basis of pessimistic simplifying assumptions.

In addition to passive autocatalytic recombiners, protection against excessive hydrogen concentration is ensured by torn membranes which constitute a ceiling above the steam generators and open passively when pressure difference grows, to facilitate global convention in the safety containment. In the lower part of the containment and over each of four steam generators there are also ventilation windows, opened passively to facilitate natural global convection. Thanks to these safety measures, hydrogen concentration is maintained below the level of 10% within the entire free volume of the safety containment. Areas where higher concentration can occur are so small that the burning front cannot accelerate there and cause transition into detonation.

The maximum hydrogen concentration caused by releases resulting from oxidation of the whole zirconium in the core drops below 4% within 12 hours after the accident. The adiabatic isochoric pressure curve in the containment is below the resistance curve of the containment in all scenarios involving hydrogen combustion.

2.11.4.2. The issue of reliable power supply to be ensured

Reliability of power supply to important safety systems and devices of nuclear power plants was one of four main items checked during stress tests conducted in the European Union in 2011 after the Fukushima accident. In the case of an EPR, emergency power supply is ensured by four emergency Diesel generators located in separate buildings-bunkers, separated geographically to

[257] Lohnert, ibid

[258] UK EPR FundamentalSafetyOverviewVolume 2: Design And SafetyChapter F: Containment And Safeguard Systems Sub-Chapter: F.2 Section: F.2.4 Page :4 / 8

protect them against combined loss of power in the case of aircraft crash. The bunkers are resistant to earthquake and flood, and have their own fuel supplies. In addition, there are two other generators in the case of a severe accident, in the event when all main generators are damaged. Nuclear supervision authorities in Finland, France, and the United Kingdom, and also China, stated that the EPR was designed just before the Fukushima accident and its power supply sources are sufficiently reliable and do not require modifications.

2.11.4.3. Specific emergency processes and safety issues

- cooling of a degraded reactor core in the case of severe accidents — the issue was subject to many years of research. The concept for AP1000 reactor (in-vessel corium retention) as well as for EPR—core cather have been reviewed and approved by the nuclear supervision authorities. In the case of other concepts, e.g. Korean 1400 MWe reactor, the method of cooling of a degraded core shall be examined by the Polish nuclear supervision authorities, it the reactor is announced as a proposal for Poland. Anyway, the selected reactor concept shall be reviewed in these terms.
- outlets of safety valves in a boiling water reactor (ESBWR): a characteristic property of boiling water reactors is the problem of steam outflow from the cooling circuit.

It cannot be discharged to the environment because it contains iodine and other fission products. In ESBWR, similarly as in the prior BWR solutions, the discharged steam flows to the steam concentration pool which ensures good leaching of fission products from the water steam. Doses caused by such a discharge are negligibly small.

- breach of the heat exchanger pipe in a steam generator in pressurised water reactor is one of dangerous accidents in 2nd generation reactors, but it does not lead to dangerous consequences in EPRs and AP1000 reactors. In the case of an EPR, special engineering solutions and the pressure threshold system are selected in such a way so as to make the pressure in the emergency core cooling system on a lower level than the threshold pressure for closure of the relief valve on the steam side. Such solution ensures that releases are stopped very quickly. The said accidents are examined in detail in safety documentation of these reactors, and results of radiological analyses are contained in PNPP.
- postulated break of cooling system pipeline of the reactor between the reactor building and the control room in the case of a boiling water reactor (ESBWR), namely an accident consisting in a breach of main steamline outside the safety containment is described in ESBWR documentation, section 15.4.5 Steamline Break Accident Outside Containment. Because iodine concentration is steam is many times lower than in water, the radiation impact of steam are fairly smaller than the impact of an accident consisting in break of a feedwater line, described in ESBWR documentation[259], and also in PNPP. In terms of environmental safety, the most dangerous variant should be provided and this is done in PNPP.
- passive safety systems—functional reliability, possible defects, causes of malfunction,

[259] 26A6642BP Rev. 09, ESBWR Design Control Document/Tier 2, section 15.4.7, Feedwater Line Break Outside Containment.

necessity and possibility of control tests. All these properties of passive safety systems are carefully tested in many years of research programmes and works of nuclear supervision authorities. Reactors built in Poland must have all their components practically tested in experiments, in accordance with the requirements of the Atomic Law act and regulations of the Council of Ministers.

- leading technical concepts—consequences of implementation of digital systems in safety tasks (centralisation limits, dealing with rapid technological change, necessity of permanent wiring of the exchanger in the case of protective circuits important for safety.

An example of digital system implementation is the EPR constructed in Flamanville 3, approved by nuclear supervision authorities in France, China, and the USA. According to the designers of the reactor, the system reduces the risk of human error thanks to technical and operational support ensured to operator, and also thanks to instructions of conduct displayed in non-standard situations.

In 2010, nuclear supervision authorities in Finland, France and the United Kingdom put forward a number of questions related to the entirely digital technology of control of reactor shutdown and safety systems. These questions did not indicate a low level of safety of the EPR, but concerned the functional independence of control systems and safety measures as well as systems not connected with safety of the reactor. After discussion with the designers, Finnish and British supervisory authorities demanded permanently wired systems to be added to the design, while French authorities and US NRC approved the design presented by AREVA as correct. Polish authorities have not decided in this matter yet and shall deal with this detailed issue at a definitely later level, if the EPR is selected for the first Polish nuclear power plant. It is worth adding that the suggested lack of safety of TELEPERM® XS (TXS) system offered by AREVA are far from reality. The system has been ordered and already installed in 74 reactors in 13 countries, it enables advanced processing of information important for reactor safety, and it was awarded "Technical design of the year" title in Platts' Global Energy Awards competition in 2011, and it also obtained the Best of the Best award in this-year conference of the Nuclear Energy Assembly in the USA, organised annual by the Nuclear Energy Institute[260].

- Radiological aspects—radiation load during operation, radioactive emissions during standard operations and in case of accident.

3rd generation reactors take advantage of the operational experience of previous reactor solutions. Radiation doses caused by 2nd generation reactors are known and it is also know that they were decreased over years. It allows a reliable assessment of the expected doses from 3rd generation reactors. PNPP provides extensive information about the expected doses, both for standard operating conditions as well as for accidents. It should be remembered at the same time, that this is initial information, and a detailed examination of radiological threats shall be performed by nuclear supervision authorities at the stage of reviewing the safety report for the reactor type selected for Poland.

- Aspects connected with the final part of fuel cycle—operating waste, demolition concepts.

[260] USA: AREVA announces second installation of digital Instrumentation & Control (I&C) system, 1.8.2012

At the present stage, funds are planned to ensure safe storage of radioactive waste and decommissioning of a plant. More detailed information about the fund can be found in item 2.7.5. From the point of view of threats to which neighbouring countries are exposed, this issue should not be a problem, as independently of the depth and geological formation in which the waste will be stored, it shall definitely not cause a threat within a perimeter of hundreds of kilometres separating the repository in Poland from the neighbouring countries.

- Severe accidents—possibility to mitigate the impact of an accident in a nuclear power plant.

It is certainly the most controversial matter which can rise concern among population. Poland is definitely of the opinion that nuclear power plants must be safe and not cause any threat to population outside the small restricted-use area. Intervention levels which were set in Poland already 8 years age are low and compliant with the levels recommended by the International Atomic Energy Agency. The restricted-use area is defined in such a way so outside it, doses received in the case of design basis accidents do not result in necessity of intervention measures, and in the case of severe accidents in the UK EPR[261] no actions within a distance greater than approx. 3 km are necessary. Specific arrangements for other reactors will be made after their designers submit safety reports and after these reports are reviewed by the nuclear supervision authorities in Poland, but in no case the hazard area shall reach neighbouring countries. Poland has chosen a 3rd generation reactor and is prepared to incur the relevant high costs of its construction to exclude hazards in the case of design basis accidents and severe accidents in this reactor.

2.12. HUMAN RESOURCES DEVELOPMENT

Polish government is aware of the key importance of preparation of competent staff in a relevant number for the success of the nuclear power development programme and its safety, and is aware of related challenges and problems. In the last few years, a couple of Polish universities launched post-gradual courses in the field of nuclear energy, as well as majors connected with nuclear energy within full-time studies. In preparation of university personnel, Poland obtained support from countries with developed nuclear industry—including in particular France. Specialised occupational training of staff for the first Polish nuclear power plants shall be conducted mainly abroad, first of all in training centres and nuclear power plants of the country which will be the technology supplier.

2.12.1. EDUCATIONAL OFFER OF POLISH UNIVERSITIES AND INSTITUTES, AND THE FOREIGN SUPPORT FOR PNPP

Education in the scope of nuclear power dates back to the period in which the first nuclear research reactor, EWA, was commissioned in the nuclear research centre in Świerk (1958). In 1957-1994, majors related with nuclear power were run by 5 technical universities in the country: AGH University in Cracow and Technical Universities of Gdańsk, Łódź, Silesia, and Warsaw. The studies were conducted in the form of full-time and post-graduate courses. Education of specialists in this field was virtually abandoned after the construction of a nuclear power plant in Żarnowiec was

[261] We are talking specifically about the EPR-UK reactor type offered for the United Kingdom, because the US EPR's parameters are slightly different.

cancelled. Selected courses on nuclear energy were still conducted for the students of mechanical and power engineering majors. Mostly, these were optional courses.

The reactivation of education in the field of nuclear energy took place almost immediately after the plans to introduce nuclear energy to the Polish power sector were announced in 2009. Technical universities, and not only them—also other universities, on the basis of their own experience and current guidelines and trends started to prepare education plans for the nuclear sector staff. Education of this staff includes also teaching of educators, namely scholars who are to teach subjects related with nuclear energy. The training programme is conducted in cooperation with France.

The current educational offer ensures teaching possibilities in the scope of both nuclear energy, as well as other applications of nuclear technologies. Some centres also offer possibilities to take a part of the curriculum abroad, e.g. the Warsaw University of Technology and the Silesian University of Technology cooperate in this scope *inter alia* with KTH in Stockholm, where student may pursue a part of master studies and diplomas.[262]

According to the most recent Work Service ranking, nuclear engineering shall be one of 15 fields in which today high school graduates will have the greatest chances to find a job. The interest of students in this field is also growing. According to data of the Ministry of Science and Higher Education, nuclear engineering was ranked 23 among the most crowded faculties in the current academic year—applications were filed by as many as 11 thousand persons.

Currently, education possibilities in the scope of nuclear power offer are offered, among others, by the following centres[263]:

- AGH University of Science and Technology in Cracow—Faculty of Physics and Applied Computer Science, major: physics; specialisation: nuclear physics; Faculty of Energy and Fuels, major: Energy; specialisation: nuclear energy;
- The Gdańsk University of Technology—interdepartmental courses in power engineering (Faculties: Ocean Engineering and Ship Technology, Mechanical Engineering, Electrical Engineering and Automation).
- The Cracow University of Technology—Faculty of Electrical and Computer Engineering, major: power engineering;
- The Łódź University of Technology—Faculty of Mechanical Engineering, major: power engineering;
- The Poznań University of Technology—Faculties: Electrical Engineering, Chemical Technology, Civil Construction, Physics, major: power engineering; specialisation: nuclear power. The Silesian University of Technology—Faculty of Energy and Environmental Engineering, major: Mechanics and Machinery Design, specialisation: civil engineering; major: power engineering; specialisation: nuclear power; Faculty of Electrical Engineering, major: Electrical Engineering, specialisation: electrical power

[262] http://poznajatom.pl/materialy_dla_prasy/wedlug_studenta_i_wykladowcy_,289/
[263] http://www.cku.pwr.wroc.pl/888220.dhtml

engineering;

- The Warsaw University of Technology—Faculty of Mechanical Engineering, Power Engineering, and Aviation, major: nuclear power engineering;
- The Wrocław University of Technology—Faculty of Mechanical and Power Engineering, major: power engineering, specialisation: thermal nuclear power engineering;
- The "Staff for Nuclear Power and Technologies in Industry and Medicine" consortium (UMCS, Wrocław University of Technology, Warsaw University of Technology)—Wrocław University of Technology: Faculty of Mechanical and Power Engineering, major: power engineering, specialisation: construction and operation of power systems; Maria Curie Skłodowska University: Faculty of mathematics, physics and computer science, specialisation: nuclear safety and radiological protection; University of Warsaw: Faculties of Chemistry and Physics, macro-major: power engineering and nuclear chemistry.

The Warsaw University of Technology has signed a preliminary memorandums of understanding with two American universities: North Carolina State University and Oregon State University[264]. Master studies in this specialisation are conducted at the Faculty of Power and Aeronautical Engineering (PaAE), TUW. The university invites professors from these two American universities to give lectures in Poland and sends students there to study at these universities and for internships in American nuclear companies. The PaAE Faculty of the Warsaw University of Technology disposes of its own funds to invite American specialists to Poland and to send students to the USA. The latter stay in America for a couple of weeks and in accordance with the agreements, do not have to settle tuition.

The Warsaw University of Technology launched a two-semester Post-Graduate Studies in Nuclear Engineering, offered to the future management and engineering staff.

Since October 2012 at the University of Łódź, the course computer science in nuclear industry has been available. The course is supposed to train people who, in the future Polish nuclear power plant, will *inter alia* operate the reactor, analyse the processes taking place in it, and ensure safety of the staff onsite. The university is also preparing special post-graduate studies for the management staff of Polska Grupa Energetyczna, focused on physics, legal and economic issues, and safety[265].

The Maria Curie Skłodowska University in Lublin has been offering studies in majors of physics, specialisation: nuclear safety and radiological protection, for 5 years, initially in cooperation with the POLATOM Nuclear Energy Institute in Świerk on the basis of an agreement concluded on 20.12.2005, and currently with the National Centre of Nuclear Research established after the merger of the Nuclear Energy Institute and Nuclear Affairs Institute in Świerk. Already 2010, first students graduated from the bachelor's studies, and continue 2nd degree master studies. Students of Technical Universities in Warsaw, Gdańsk, Katowice and other cities are educated in cooperation with foreign universities, in Stockholm, France, and the USA.

First graduates have already received diplomas at a couple of universities and technical universities. They are employed at NAEA, CLRP, NCNR, PGE, consulting companies and other Polish

[264] http://wiadomosci.onet.pl/nauka/amerykanie-pomoga-w-szkoleniu-kadr-dla-polskiej-en,1,4189089,wiadomosc.htm 19.02.2011
[265] http://lodz.gazeta.pl/lodz/1,35153,11304670,Uniwersytet_wyksztalci_kadry_dla_elektrowni_atomowej.html

enterprises. Apart from regular courses at technical or other universities, NCNR organises every year a couple of days of Nuclear Engineering Workshops, with lectures and practical courses from morning to evening, with a great attendance—usually more than 200 persons.

In accordance with the nuclear power programme (PNPP, section 11.2), a training of the so-called "educators" has been launched in France for the needs of Polish universities. The training included two internships for two groups of Polish university lecturers and the cooperation is continued. The first course was organised in 2009, the second one in 2010, groups of lecturers from Poland were comprised of 20 and 25 persons, respectively. The period of internship was from 3 to 6 months. Currently, further courses are organised in France. It would be, however, premature, to plan courses until 2020, as Poland has not yet selected the reactor, and the selection of the reactor supplier shall determine further courses.

On the French side, the cooperation is coordinated by the French international nuclear agency, ANFI, which organises courses based in training centres and with participation of EDF and AREVA specialists. The quality of courses is very high, French lecturers are undoubtedly the most competent teaching staff in Europe, but one should be aware that the main burden of training for our university lecturers and also our staff of nuclear energy shall be borne by the country of the reactor supplier for the Polish nuclear power plant. If Poland chooses the EPR, the training courses in France shall be continued and include more people, and their scope will be increased. But if another reactor will be selected by Poland, e.g. an American-Japanese reactor, the training centre shall be moved from France to another country.

An incentive for the experts with international education and after foreign training to take up jobs within PNPP will be their passion for the nuclear engineer profession and high prestige of this profession, the fascination with challenges with which those who will introduce nuclear power as a new branch of technology will have to cope, and good wages.

2.12.2. Estimated staffing requirements of the PNPP

The International Atomic Energy Agency recommends to start the related activities with determination of the scope of knowledge, skills, and talents of the employees necessary in implementation of a nuclear power programme and with development of educational and training institutions to prepare the staff. The number of workers of a nuclear power plant depends on a number of factors:

- number of units,
- location of the plant in relation to the residence centres,
- number of outsourced services,
- legislative requirements for construction and operation of a nuclear power plant,
- environmental law,
- labour law,
- amount of effort necessary for the purposes of public information and education.

In 2005, the employment rates in nuclear power plants in the United States were reviewed. In turned out that the average number of staff of a nuclear power plant with a single unit is approx.

800 workers. Below, the break down of the staff in line with required skills is presented[266].

Categories of the required workers	Number
Design engineers	30
Chemical engineers	20
Nuclear engineers	25
Administrative staff, analysts, other personnel	335
Maintenance technicians—including electricians, measurement and control systems technicians, mechanics	135
Mechanical engineers	15
Construction engineers	5
Training staff	35
Unit control and supply operators	75
Computer engineers, electrical engineers, and measurement and control systems engineers	20
Radiological protection and radioactive waste management technicians	35
Physical security staff, fire brigade	70
Total	800

In addition to the nuclear plant staff, a high-level personnel is necessary with technical or equivalent university diploma to ensure manning of the nuclear supervision office, investor's offices, design offices, technical supervision office etc. The investor team shall comprise 200-250 persons in total.

The employment in nuclear supervision authorities varies in different countries due to differences in the operational models of national nuclear supervision. In some countries, the authorities directly employ specialists to assess documentation, and even to conduct research for the needs of the supervision, while in other countries, nuclear supervision authorities outsource analytical works and studies to external institutions, including technical support organisations (TSO). Moreover, the difference also stem from the investment processes in the course related with the construction of new nuclear facilities, decommissioning of the old ones, and also different number of users (licence holders) of ionising radiation sources for medical and industrial applications.

The highest employment rate per unit is recorded for the nuclear supervision authorities in Finland[267] (71 - taking into account Olkiluoto 3 as the fifth unit, apart already operating four), while in Czech Republic, where there are 6 units, there are 32 workers employed in supervision per one unit[268], and in the United Kingdom—28. In Slovakia, it is 22.5 employees[269].

In Poland, the authority competent for nuclear safety is the National Atomic Energy Agency (NAEA), while the institution competent for technical safety is the Technical Supervision Authority (TSA). Both institutions shall cooperate in the scope of licencing processes and supervision of nuclear power plants.

[266] Ł. Koszuk Kadry dla energetyki jądrowej www.atomowyautobus.pl/referaty/kadry_ref.pdf
[267] http://www.stuk.fi/stuk/en_GB/avainluvut/
[268] Zpráva o výsledcích činnosti SÚJB při výkonu státního dozoru nad jadernou bezpečností jaderných zařízení a radiační ochranou for 2011, SUJB, Praga, 2012, p. 7
[269] http://www.hse.gov.uk/nuclear/organisational-structure.htm

As at the end of 2011, there were 86 FTEs at the NAEA. Assuming the situation in Czech Republic as a reference, it may be estimated that Poland shall need from 130 to 180 nuclear supervision workers for the purposes of implementation of the national nuclear programme.

At operation stage, one plant shall permanently employ 900-1600 workers of permanent crew and approx. 1000 seasonal workers for renovations and fuel replacement. A significant part of the crew, especially on low- and medium level positions, will come from local recruitment.

3. CHANGES INTRODUCED INTO THE FORECAST AS RESULT OF OF THE PROCEEDINGS OF THE STRATEGIC ENVIRONMENTAL ASSESSMENT

In result of national public consultation and agreements with competent authorities, a number of changes were introduced to the forecast. Editorial errors were corrected and inaccuracies removed. **The corrections were made in line with the table summing up public consultation for the locations in which the comments were submitted.** Moreover the Forecast was supplemented by a new location in Gąski.

It should be also added that during the strategic environmental assessment, a number of explanations related both to the Polish Nuclear Power Programme as well as its Forecast of the Environmental Impact Assessment were provided. In addition, the Ministry of Economy commissioned additional materials describing and explaining the course and impact of the Chernobyl accident and accidents in TMI and Fukushima.

Another supplementation of the Forecast of the Environmental Impact Assessment is the summary of most frequent comments, conclusions and answers provided by the Ministry of Economy, contained in chapter 2 of this study.

4. METHOD OF INCLUDING THE FINDINGS RESULTING FROM THE STRATEGIC ENVIRONMENTAL ASSESSMENT INTO THE FINAL VERSION OF THE POLISH NUCLEAR POWER PROGRAMME

During the strategic environmental assessment, the following recommendations were developed and considered necessary to be accounted for in the final version of the Polish Nuclear Power Programme.

The following additional information was introduced to the Polish Nuclear Power Programme following the strategic environmental assessment.

1. Additional information about Polish nuclear safety regulations.

The amended Atomic Law act stipulates delegations to issue **a number of new implementing acts**, regulating various aspects of safety of nuclear facilities—especially nuclear power plants. **All implementing acts to the Atomic Law required in the amended act have been already issued and entered into force**, and among them:

- Regulation by the Council of Ministers of 27 December 2011 on periodical safety assessment of a nuclear facility (Dz. U. [Polish Journal of Laws] of 2012, item 556).
- Regulation by the Council of Ministers of 27 December 2011 on the specimen of quarterly report on the contribution to the decommissioning fund (Dz. U. of 2012, item 43)
- Regulation by the Minister of Finance of 14 September 2011 on guaranteed minimum amount of the compulsory civil liability insurance of the nuclear facility's operator (Dz. U. no. 206, item 1217)
- Regulation by the Minister of Economy of 23 July 2012 on detailed rules of establishment and operation of the Local Information Committees and cooperation in the scope of nuclear facilities (Dz. U. item 861)
- Regulation by the Minister of Environment of 18 November 2011 on the Council for Nuclear Safety and Radiological Protection (Dz. U. no. 279, item 1643)
- Regulation by the Minister of Environment of 9 November 2011 on the standard form of identity document of nuclear regulatory inspector (Dz. U. no. 257, item. 1544)
- Regulation by the Minister of Health of 29 September 2011 on psychiatric and psychological tests of employees performing activities important for nuclear safety and radiological protection at the organizational unit conducting activities related to exposure which consist in commissioning, operation or decommissioning or a nuclear power plant (Dz. U. no. 220 item 1310)
- Regulation by the Council of Ministers of 10 August 2012 on detailed scope of assessment with regard to land intended for the location of a nuclear facility, cases excluding land to be considered eligible for the location of a nuclear facility and on requirements concerning location report for a nuclear facility (Dz. U. of 2012, item 1025)
- Regulation of the Council of Ministers of 31 August 2012 on nuclear safety and radiological protection requirements which must be fulfilled by a nuclear facility design (Dz. U. of 2012, item 1048)
- Regulation of the Council of Ministers of 31 August 2012 on the scope and method for the performance of safety analyses prior to the submission of an application requesting the issue of a license for the construction of a nuclear facility and the scope of the preliminary safety report for a nuclear facility (Dz. U. of 2012, item 1043)
- Regulation by the Council of Ministers of 10 August 2012 on activities important for nuclear safety and radiological protection in an organizational unit conducting activity which consists in commissioning, operations or decommissioning of a nuclear power plant (Dz. U. of 2012, item 1024)
- Regulation of the Council of Ministers of 11 February 2013 on requirements for the commissioning and operation of nuclear facilities (Dz. U. of 2013, item 281)
- Regulation of the council of ministers of 11 February 2013 on nuclear safety and radiological protection requirements for the stage of decommissioning of nuclear facilities and the content of a report on decommissioning of a nuclear facility (Dz. U. of 2013, item 270)
- Regulation by the Council of Ministers of 10 October 1012 on the amount of payment to cover the costs of final management of spent nuclear fuel and radioactive waste and to cover the costs of nuclear power plant decommissioning performed by the organisational unit which has been granted operation licence for the plant (Dz. U. of 2012 r., item 1213)
- Regulation of the Council of Ministers of 24 August 2012 on nuclear regulatory inspectors (Dz. U. of 2012, item 1014).

In addition, the two following regulations on nuclear installation supervision shall be issued—as implementing acts to the Act on Technical Supervision[270]:

- Regulation by the Council of Ministers on the types of technical equipment and devices subject to technical supervision at the nuclear power plant
- Regulation by the Minister of Economy on technical conditions for technical supervision of technical equipment and devices subject to technical supervision at the nuclear power plant.

Polish regulations match the highest standards of nuclear safety applicable currently in the world, and they are compliant with the most recent international requirements (in particular safety objectives for new generation reactors contained in IAEA SSR-2/1 document and WENRA Declaration of 2010[271]), taking into account also the requirements of the EUR document and lessons learned in the wake of the accident in Fukushima Dai-ichi NPP, and stress testing of European nuclear power plants.[272] It should be emphasised that Polish regulations already include most of the requirements proposed by the European Commission on 13 June 2013, in the draft amendment to Directive 2000/71/Euratom[273].

The safety objectives for new generation reactors referred to above and adopted in Polish regulations, **include practical ruling out of accidents with core degradation which could lead to early damage of the safety containment of the reactor and very large releases of radioactive substances to the environment,** and limiting the impact of accidents with core degradation which have not been ruled out so as to significantly reduce the necessity of intervention aimed at the protection of health of the population to a limited area and time. **The conclusions based on the analyses of the Fukushima Dai-ichi NPP accident and stress tests in the European nuclear power plants** have been already taken into account, and in particular those relating to: the manner of accounting for external threats, increasing the required autonomy of a nuclear power plant in terms of power supply and cooling water resources, application of additional or alternative power supply and residual heat discharge systems and devices.

2. <u>Tasks of the Technical Supervision Authority</u>.

The Technical Supervision Authority (TSA) shall supervise the installations and structures of nuclear power plants in the scope defined in art. 37, 37c and 37e of the Atomic Law act and the provisions of art. 5 section 4 and art. 8 section 5a of the Act on Technical Supervision and implementing acts thereto (defined in art. 5 section 4 and art. 8 section 5a). **The TSA supervision includes: designing; materials and components used to manufacture, repair, or renovate; production; operation; repair and renovation, and decommissioning—of installations and structures of nuclear power plants subject to technical supervision** (in the scope defined under regulation by the Council of Ministers referred to in art. 5 section 4 of the Act on Technical Supervision). Moreover, TSA prepares also relevant bills, and in particular: amendments to the act on technical supervision and secondary legislation thereto—in the scope of supervision of installations and structures of nuclear power plants.

[270] Their drafts have been already prepared and they no undergoing consultation.
[271] WENRA Statement on Safety Objectives for New Nuclear Power Plants. November 2010.
[272] European Utility Requirements for LWR Nuclear Power Plants. Revision D, October 2012.
[273] Draft proposal for a COUNCIL DIRECTIVE amending Directive 2009/71/EURATOM establishing a Community framework for the nuclear safety of nuclear installations. Brussels, 13.6.2013. COM(2013) 343 final.

3. Additional information about prospecting and training of staff.

Prospecting and relevant training of staff is one of important challenges a nuclear plant investor has to face. The investor's own high technical and organisational competences are of crucial importance for ensuring safe and efficient implementation and operation of Polish nuclear power plants.

The investor/operator must plan their activities to ensure and train relevant staff to satisfy the operational needs of the nuclear power plant. Persons intended for the positions involving activities of particular importance for nuclear safety and radiological protection shall undergone mandatory psychological and psychiatric examination at the recruitment stage—in accordance with a relevant regulation by the Minister of Health[274], constituting an implementing act to the Atomic Law.

Specialised training for the staff of key importance for management and operation of nuclear safety and radiological protections **and the personnel intended for the positions related with plant maintenance, and planning and carrying out maintenance activities and renovations with particular consequences for nuclear safety and radiological protection** shall be initially conducted with the use of the training base and programmes of the nuclear plant technology supplier. Simultaneously, the investor shall implement and organise their own training centres with relevant equipment—including a full-scope nuclear unit simulator, which shall gradually take over the implementation of the main part of occupational training for the operating staff—including follow-up training.

Persons intended for the positions in nuclear power plants to perform activities of particular importance for nuclear safety and radiological protection shall be obliged to—apart from obtaining authorisations granted by plant examination boards or training centres—**to obtain authorisations of the NAEA President to perform the said activities,** on the basis of a positive examination result. A relevant implementing act to the Atomic Law has been issued, determining, among other things, the procedure and conditions of authorisations to be granted by the NAEA President, examination principles, qualification requirements and scopes of required training for persons applying for authorisations granted by the NAEA President.

4. Information about Fukushima Dai-ichi Nuclear Power Plant accident and its impact.

In March 2011, in the Japanese Fukushima I Nuclear Power Plant (Fukushima Dai-ichi) situated near the north-eastern part of Honsiu island, on the coast of the Pacific Ocean, an immense nuclear accident took place. The plant is comprised of 6 units with boiling water reactors (BWR), with total net capacity of 4546 MWe.

The event that initiated the accident was an extremely strong 9-degree earthquake on 11 March 2011, whose epicentre was located several tens of kilometres away from the eastern coast of Honsiu. The earthquake did not cause damages in the plant itself, but it resulted in a tsunami—of a height up to 14 m, which flooded the poorly protected Fukushima I power plant. Since the plant was then cut off of the national power system because of damages to transmission grid caused by the earthquake, safety systems were fed by emergency Diesel generators. Water rushed into the control room and flooded unprotected, low premises with Diesel generators, which resulted in total failure of emergency power supply and

[274] Regulation by the Minister of Health of 29 September 2011 on psychiatric and psychological tests of employees performing activities important for nuclear safety and radiological protection at the organizational unit conducting activities related to exposure which consist in commissioning, operation or decommissioning or a nuclear power plant (Dz. U. [Polish Journal of Laws], no. 220 item 1310).

immobilisation of nearly all safety systems. The chain of events initiated in that way led to core degradation in reactors No. 1-3, damage of nuclear fuel stored in the spent fuel pool of reactor No. 4, breach of the primary safety containment of reactor No. 2, and explosion in buildings of reactors No. 1-4 (in result of hydrogen detonation), which were followed by substantial releases of radioactive substances to the environment. The authorities evacuated the area within 20 km from the power plant, that was then extended to certain areas located north-west of the primary area.

Although the accident, due to the total amount of releases, was rated INES level 7 (despite the fact that the events in individual plant units did not exceed level 5), nobody was hurt in result of ionising radiation. Decontamination of contaminated areas is currently under way, and compensations are paid to the disadvantaged. Some of people evacuated during the accident have already returned to their homes.

The accident had serious consequences both in Japan as well as in other countries. In Japan, authorities decided to reform the national nuclear safety system and create a new, independent supervision authority (Nuclear Regulatory Authority, NRA). Almost all units in nuclear power plant were shut down and it was decided that they need to be upgraded in accordance with new, stricter requirements of the newly created NRA. It is expected that until the end of 2013, the authority shall issue authorisations for restarting 8 nuclear units.

A couple of months after the accident, the then Japanese government, under pressure of the discontent part of the society, announced a change in the national power policy towards gradual phasing-out of nuclear energy. The temporary shutdown of nearly all nuclear units caused a capacity deficit in the national power system, growth of fossil fuel imports, very high deficit in foreign trade, stoppage or reduction of industrial production in many factories, growth of unemployment caused by the escape of industry to the countries of Northern and Eastern Asia, a GDP decrease and a growth in energy prices, as well as a general deterioration of economic standing. All these factors make restoration works in the country after the tsunami of March 2011 significantly slower.

In January 2013, the new Japanese government decided to abandon the plans to phase out the nuclear energy. The government admitted that nuclear energy is indispensable for the economic growth. The prime minister announced restarting of the shutdown reactors (provided that they shall fulfil new safety requirements), and construction of new nuclear units.

The European Commission responded with ordering of stress tests, which are additional safety analyses of safety of nuclear facilities under conditions of extraordinary natural hazards such as floods, hurricanes, and earthquakes. The stress tests were coordinated by the European Nuclear Safety Regulators Group (ENSREG). They were conducted by all EU countries, and Switzerland and Ukraine. The peer review of stress tests results was attended also by Polish experts delegated by the NAEA. Detailed reports are published on the ENSREG webpage. In general, it was acknowledged that the safety level of European nuclear power plants allows to decide that immediate shutdown of any of them is not necessary. In certain facilities, the report identified areas to be improved, which were started by the operators soon thereafter (e.g. purchase and installation of new Diesel generators).

In the case of Poland, the Fukushima accident does not result in the need to change legislation or detailed requirements of nuclear supervision authorities, or strategic government documents, because power plants with 3rd generation reactors are designed with external threats and accidents such as that of Fukushima I taken into account. In particular, they account for the necessity of ensuring safety under conditions of emergency power supply failure, with the use of the so-called passive safety systems. The risk of hydrogen detonation is limited virtually to zero thanks to passive and reliable systems removing hydrogen from the reactor building Such power plants are equipped with strong safety containments, resistant to airplane crash and terrorist attacks.

Responses of individual countries to the Fukushima accident were diverse, both most of them opted for continuation of their nuclear power programmes. The only country in Europe that undertook specific actions aimed at phasing-out the nuclear energy is Germany. Belgium declared that is shall not extend the life cycles of its units, and Switzerland forbade to build new ones. Italy suspended its programme, restored in 2009, for 5 years. Other countries are planning to maintain the current number of reactors (Spain), construction of new ones (United Kingdom, Netherlands, Sweden, Czech Republic, Hungary, Slovenia, Poland, Lithuania, Bulgaria, Romania, Turkey) or go along with the investments in the course (France, Finland, Slovakia, Ukraine, Russia, Belarus), with a perspective of starting new ones. In the United States, first authorisations for construction of new nuclear units since the 80's were issued after the Fukushima accident. Also the countries of South-Eastern Asia (China, South Korea, Vietnam, Bangladesh, Thailand) implement their own programmes, as well as South American countries (Argentine, Brazil), and Arab countries (United Arab Emirates, Saudi Arabia) The International Atomic Energy Agency anticipates that the total installed capacity in nuclear power plants globally shall go up from the current 373 GWe to 456-740 GWe in 2030. Similar forecasts are presented by the International Energy Agency, which in the World Energy Outlook 2012 estimates that the installed capacity in nuclear power plants shall increase to 580 GW in 2035. Both organisations point out that the Fukushima Dai-Ichi accident has slowed the development of nuclear power for some time, but it has not stopped it, and the perspectives of the sector as a whole are sound.

5. Reduction of the negative impact of the power industry on the environment.

The essential positive environmental result of the implementation of the Programme shall be minimize of negative environmental impact resulting from the current operation of the energy sector, in particular by way of reduction of social costs connected with electricity generation, as well as **reduction in emissions of greenhouse gases.**

6. Combined electricity and heat generation to be included in the process of selection of the location.

The selection of sites for future nuclear power plants is a particularly important aspect, as the locations selected determine many aspects of the environmental impact. At the stage of obtaining the decision on environmental conditions, equivalent locations shall be analysed. In selection of locations, **it is necessary to take into account and analyse technological possibilities and economic efficiency of combined generation of heat and electricity at a NPP.** As it was demonstrated in the Forecast of the Environmental Impact Assessment it is **an alternative which enables a significant reduction of negative environmental impact of a NPP**. The option of cogeneration shall be one of the factors taken into account in selection of the site for the first nuclear power plant in Poland.

7. Actions aimed at reduction of possible social conflicts

The development of new methods of electricity generation in Poland, and in particular the development of nuclear power industry, needs agreement and acceptance of the society. The development of nuclear energy should be carried out in a manner preventing the possible social conflicts from escalating, with full transparency of actions and dialogue with all stakeholders. It is important to achieve, in addition to best practices and technologies ensuring safety of a nuclear power plant, the intended objectives, i.e. supply cheap and "ecologically clean" energy, taking care of the environment and improving the quality of life of citizens. As a target, nuclear power plant must become an element that diversifies power sources and lead to satisfaction of the needs and ensuring energy security of the country. Also, each citizen must have an unalienable right to information about the operation of the nuclear power plant and its impact on the environment (unless communication of such information will put the facility at risk). For that purpose, it is necessary to introduce an information and education programme. **Such programme cannot be based on a nuclear power propaganda. It should provide reliable information to the society and indicate advantages and disadvantages of nuclear energy and its place among other methods of energy generation.**

8. Action on the stage of the Environmental Impact Assessment

It is proposed to introduce the following **additional criteria** at the stage of the environmental impact assessment:

- comprehensive account of necessary infrastructure to be created for the needs of the NPP location and one environmental decision for the whole enterprise.
- The application for the environmental decision shall be submitted after the expert works aimed at assessing the environmental impact for at least two equivalent locations are completed. The final location shall be selected after the initial environmental impact assessment of the NPP is carried out. The results shall be published and subjected to initial public consultation outside the official procedure. Only on the basis of the information obtained in this way the investor shall selected the site. With regard to the site, an application shall be submitted for environmental decision. Such approach shall guarantee that environmental protection issues shall be given appropriate consideration at the same level of importance as social and economic matters.

5. PROPOSED METHODS AND FREQUENCY OF MONITORING OF THE RESULTS OF IMPLEMENTATION OF PROVISIONS CONTAINED IN THE DOCUMENT

Below, you will find a concise description of the proposed initial monitoring scope for the environment in the area of nuclear power plants. The monitoring shall be focused on the results of implementation of the provisions of the Polish Nuclear Power Programme.

5.1. Protection of environment and health in the nuclear power plant location area against ionising radiation and other harmful influence connected with the construction, commissioning, operation and decommissioning of nuclear power plants

The nuclear safety and radiological protection of certain nuclear power plants, and in particular the reduction of negative impact on health of the population and environment in the area of the nuclear power plants is an obligation of the investor/operator. Requirements in the scope of nuclear safety, radiological protection, and impact of nuclear facilities on the health of people and the environment are set out in relevant regulations, supervisory guidelines, and conditions of authorisations. The status of nuclear safety and radiological protection, and the impact of the nuclear power plant on health of the population and the environment, is supervised by competent regulatory authorities—in particular the Nuclear Supervision Authorities and specialised laboratories.

Reliable information should be communicated or rendered available to the public opinion about the status of nuclear safety and the impact of the nuclear power plant on the health of the population and the environment around the plant, through press and electronic media, and in particular the Internet.

At the stage of surveys and location assessment, location selection, decision on the location selection, environmental decision[275], construction permit, and in the licencing process for a nuclear power plant (a procedure of issuance, by the NAEA President, of: preliminary assessment of the planned location, initial assessment of organisational and technical solutions, and the construction permit)[276] relevant analyses of safety and the impact of the nuclear power plant on the environment during operation and in the case of accidents are carried out, as well as the inventory of the condition of the environment within the location area. On the basis of the analyses and assessments carried out at the above mentioned stages, the size of the restricted-use area is determined, and also possible intervention areas for each of the planned plants. Then, boundaries of the said restricted-use and intervention areas shall be communicated (along with a relevant procedure of conduct in the case of accident) to the society.

During standard operation, nuclear power plants emit—in controlled and monitored conditions—radioactive substances to air and water, which can impact the environment and the health of population in the area of the plants (see the SEA Forecast, item 7.1.1). Amounts of these releases must be minimised and must not exceed limits (that guarantee safety of health and environment in the area of the nuclear power plant), defined for each plant by the Nuclear Supervision Authorities. However, in transient states (anticipated operational occurrences) and in emergency conditions, unintended releases of radioactive substances to the environment of the nuclear power plant may occur in amounts significantly exceeding the emission limits defined for the standard operation (see the SEA Forecast, items 7.1.2-3). On the basis of the analyses of scenarios of transient states and emergency conditions, and characteristics of the related possible releases of radioactive substances, intervention areas are determined to ensure protection of health of the population around the NPP, and a relevant external emergency plan is prepared.

The SEA Forecast assesses the impact of anticipated emissions of radioactive substances on the environment and people during standard operation, transient states and emergency conditions (item 7.3-7), and also the impact of releases of other harmful substances, discharged waste heat, and noise (section 8).

At the stage of surveys, assessment, and selection (determination) of the location, the environment

[275] Pursuant to the requirements of the act of 3 October 2008, on the Provision of Information on the Environment and its Protection, Public Participation in Environmental Protection and Environmental Impact Assessments (as further amended).
[276] Pursuant to the act of 29 November 2000 – Atomic Law as further amended): art. 4 section 1 item 2, art. 35b section 3, art. 36a, art. 36f andt. 39b; and the act of 29 June 2011, on the Preparation and Implementation of Investments in the scope of Nuclear Facilities and Accompanying Infrastructure: art. 5, 15, 17, 20 and 23.

condition inventory in the location area is carried out[277], in particular in terms of radiological conditions (this is an investor's task). After the location is selected (determined) and during the construction of the NPP, but not later than 3 years before the planned commissioning—the investor should perform complete measurements of radiological conditions in the ecosphere in the region of the future plant to gather a complete data base of the ionising radiation background which will provide a reference in the future for environmental impact assessments for the NPP at the stage of operation and decommissioning.

Then, during the startup[278], the whole life cycle and during the process of decommissioning of the nuclear power plant, measurements, monitoring and analyses of the following—in accordance with the detailed schemes approved by the Nuclear Supervision Authorities and other competent state supervisory and control authorities—should be carried out:

emissions of radioactive substances and other harmful substances to the environment, and the amount of discharged waste heat;

impact of the above mentioned emissions on the environment and health of population in the location area of the nuclear power plant.

The state of the environment and the health of population stemming from the above measurements, monitoring, and analyses shall be compared with the state from before the commissioning of the nuclear power plant. The investor, operator, or the organisation that decommissions the NPP, shall be responsible for these activities, correspondingly.

The results of the measurements, monitoring, and analyses on the environment and the health of population in the location area shall be submitted to the Nuclear Supervision Authorities and other competent supervisory bodies and offices.

Irrespectively of the above, the said institutions and state laboratories (and CLRP in particular)—within their jurisdiction and competence—shall perform their own control measurements, monitoring, and assessments.

5.2. Assessment of the environment condition in the nuclear power plant location area after the selection of location and the commencement of construction, and during construction (before commissioning)

[277] In this context, the NPP locaiton region shall be understood as the area within 15-30 km from the ventilation chimneys of reactors. For a specific location, the range of the location area is determined individually with a decision of the Nuclear Supervision Authorities on the basis of the proposal of the investor, operator, or the organisation that decommissions the NPP (correspondingly).

[278] The initial moment of the startup shall mean the first shipment of fuel to the NPP (which requires a prior authorisation of the NAEA President for commissioning).

5.2.1. Ionising radiation background

The surveys should include natural and artificial radioactivity of the environment (that is both natural as well as artificial radioactive isotopes), and radioactive contamination of population residing in the location area of the nuclear power plant.

Measurements and analyses of the ionising radiation background in the location area of the nuclear power plant shall include in particular:

- Measurements and analyses of γ radiation dose rates, and determination of the annual dose equivalent—in various spots and localities in the location area; taking into account the contribution of radioactive isotopes in the soil on the basis of activity measurements for radionuclides, and surface contaminations.
- Activity measurements for radioactive isotopes in the air, and radioactive air contamination: the average annual global β activity.
- Measurements of radioactive contamination of the total precipitation: the aggregated global β activity, and the activity of individual radionuclides.
- Measurements of radioactive contamination of freshwater and bottom sediments:
    - Radioactivity of surface and deepest-level water: global β activity and the activity of individual radionuclides;
    - Radioactivity of bottom sediments in reservoirs: the activity of individual radionuclides;
    - Radioactivity of ground water: the activity of individual radionuclides;
    - Radioactivity of water in public water intakes: total α activity and total β activity.
- Measurements of radioactive contamination of selected foodstuffs—the average for Poland and in the location area:
    - Milk: the activity of Cs-137, K-40 and Sr-90,
    - Cereals and concentrated feeds, vegetables and fruit, meat, poultry, eggs, milk, fish—(the average annual global β activity),
    - The activity of Cs-137 in: meat, fish, various vegetables and fruit, cereals, forest mushrooms, forest berries, grass, and concentrated feeds.
- Measurements of radioactivity of coastal waters of the southern area of the Baltic Sea: the activity of individual radionuclides in the sea water, bottom sediments, aquatic vegetation, and fish.
- Soil radioactivity measurements: the global β activity and the activity of individual radionuclides, and surface contamination of soil.
- Measurements of radioactive contaminations—assays of the activity of Cs-137 and Sr-90—for the selected ecosystems, including reservoirs: soil, surface water, bottom sediments, flora (vascular plants—including meadow species and algae) and fauna (clams, snails, epiphytic fauna, fish).

A relevant programme of comprehensive radiometric surveys should be developed, matching the specific location. The programme should cover the area within 15-25 km from the NPP location.

5.2.2. Environmental contamination with chemicals

Measurements and analyses should in particular include:

- Atmospheric air contamination: SO_2, NOx and dust of various grain sizes; including also concentrations of pollutants (such as: SO_4^{2-}, Cl_1 , NO_3^{1-}, NH_4^{1+}, $Fe^{2+,3+}$, Ca^{2+} , Mg^{2+}) in aerosols and rainwater.
- Chemical contamination of reservoirs: studies of physico-chemical properties of water (hydrochemical surveys).

Subject to analyses should also be the impact of the nuclear power plant operation leading to the increased chemical contamination of the reservoir, in particular in result of:

- growth of salt concentration in result of increased evaporation—in the reservoir used for cooling within an open circuit,
- discharge of treated / neutralised rain and industrial wastewater (including from water demineralisation and treatment stations used for technological purposes) and domestic wastewater (also from laundries),
- possible chemical control of living organisms overgrowing the internal surfaces in the cooling systems[279].

5.2.3. Radioactive contaminations of population

Before proceeding to the commissioning of a nuclear power plant, the health condition of the population should be assessed in order to provide a reference point in the future to assess the radiological impact of the nuclear power plant.

In addition, measurements and analyses should be carried out—for the purposes of comparison with data for other regions of Poland and other countries.

The scope of radiometric measurements for population should include in particular:

- the bone content (for sex and age groups) of radionuclides such as Ra-226, Pb-110 and Sr-90, as well as stable heavy metals;
- stress on gonads and bone marrow from doses of γ radiation and cosmic radiation: the average dose rate outside buildings, the average equivalent dose rate.

[279] E.g. cooling water systems and maintenance water through chlorine dispensing.

5.3. Monitoring of environmental impact of nuclear power plants at the commissioning, operation and decommissioning stages

The investor, operator, or the organisation that decommissions a nuclear power plant shall be obliged to:

- monitor emissions of radioactive substances and other harmful substances to the environment,
- carry out regular measurements and environmental and health impact assessments in the nuclear power plant location area, and in particular: estimate radiation doses connected with these emissions of radioactive substances and assess their impact on the health of population,
- regularly report the results of the monitoring to the Nuclear Supervision Authorities and other competent state supervisory bodies,

in the scope and with frequency defined in detailed schemes prepared in line with the requirements of applicable regulations, supervisory guidelines or conditions of relevant authorisations, and agreed upon with the Nuclear Supervision Authorities and competent state supervisory bodies. The monitoring reports shall be publicly available in accordance with the Act on the Provision of Information on the Environment and its Protection, Public Participation in Environmental Protection and Environmental Impact Assessments.

Irrespectively of the monitoring activities carried out by the investor, operator, or the organisation that decommissions the nuclear supervision authorities, the Nuclear Supervision Authorities and other competent state supervisory bodies shall perform independent monitoring activities in the scope of the environmental impact of the nuclear power plant—through regular control measurements.

5.3.1. Monitoring of emissions of radioactive substances and other harmful substances to the environment

The monitoring shall cover emissions of radioactive substances and other harmful substances to the environment—to water and air.

The scope of monitoring of radioactive substances shall include in particular:

- Air emissions of: radioactive noble gases (radioactive isotopes of krypton and xenon, Ar-41), tritium (H-3), carbon C-14, radioactive isotopes of iodine (from I-131 to I-135) and other β- and γ-radioactive isotopes forming aerosols (Cs-134, Cs-137, Sr-90, Co-58, Co-60, Te-132);
- Water emissions of: tritium (H-3), carbon C-14, and β- and γ-radioactive isotopes (Ag-110m, Fe-55, Co-58, Co-137, Cr-137, I-131, Mn-54, Sb-124, Sb-125, Sr-89, Sr-90, Te-123m).

The scope of monitoring of emissions to the environment of other harmful but non-radioactive substances shall stem from the requirements contained in the applicable regulations, and in particular Directive 2010/75/EU.

5.3.2. Monitoring of impact of nuclear power plants on the environment in the area of their location

5.3.2.1. Radiation impact monitoring

The coverage of monitoring in relation to air and land paths of dissemination of radionuclides in the environment shall include the area within 15-30 km from the ventilation chimneys of nuclear power plants, while for water paths of dissemination—a defined section of the water system upstream and downstream of the discharge point for diluted rainwater from the power plant.

Radiation monitoring shall include in particular:

- Distribution mapping and γ-radiation spectrometry (with the use of TLDs and field radiometric stations);
- Determination of concentration of radionuclides (through sampling and measurement in: air (measurements of aerosols and atmospheric precipitation), surface and ground water—especially in drinking water, soil, bottom sediments, wide assortment of land vegetation—especially crops (cereals, vegetables, grass and other forage plants), milk, meat of farm animals and fish, other aquatic animals, aquatic vegetation, concentrated feeds, and processed foodstuffs made of local products.

5.3.2.2. Monitoring of the conditions and state of the environment

Monitoring of the conditions and state of the environment in the location area of the nuclear power plant shall include in particular:

- Hydrological, hydrothermal and hydrogeological measurements;
- Chemical contamination measurements (for non-radioactive substances) for air and water (hydrochemical assays)—taking into account the contamination related to operation of external cooling systems and their cleaning: in general, in the scope of factors defined in item 6.2.2 of the Forecast;
- Ecological surveys of land and water ecosystems, and in particular: phytosociological observations, assessment of plant biomass and phytoplankton production, assessing of chlorophyll concentration and water clarity;
- Meteorological monitoring;
- Seismic monitoring.

6. TABLES OF CONTENTS

6.1 Table of figures

6.2. Index of tables

6.3. Detailed table of contents