

Nuclear safety and nuclear energy in the 21st century

Adriana Aralica - István Harkai - Michaela Mlynárová - Nadja Polzer

1. Introduction

Nuclear energy generation continues to play a very important role in the 21st century. Although being described as clear energy, its main disadvantage is supposed to be safety of power generation. Nuclear generation began more than 50 years ago and now generates as much global electricity as was produced back then by all sources. Some two-thirds of world population lives in nations where nuclear power plants are an integral part of electricity production and industrial infrastructures. Half of the world's people live in countries where new nuclear power reactors are in planning or under construction.

The use of nuclear energy is related with serious safety issues, which are referred to as nuclear safety (see chapter 2.2 for details).

The research paper will analyze nuclear energy safety in 21st century in Central Europe. After conceptualizing the topic, the paper will present the situation and proportion of the use of energy sources in Austria, Hungary, Slovakia and Slovenia; followed by national opinions on the topic and presentation of energy dependence of each country. In the conclusion we will compare situations in countries, analyze main advantages and disadvantages of nuclear energy, and comment on possible development based on countries' energy dependence.

2. Terms

2.1. Nuclear Energy

Nuclear energy is energy that is generated through the use of Uranium, a natural metal that is mined all over the world. Nuclear energy is created through complex processes in nuclear power stations, and the first nuclear power station was established in 1956 in Cumbria, England. Today, many military operations and vessels use NPP and nuclear energy for their energy source, and nuclear energy is used in many other capabilities such that it provides 16% of the Earth's energy requirements.¹

¹ Atoms for Peace, 'Nuclear Energy' (2011), <<http://www.ifpaenergyconference.com/Nuclear-Energy.html>>, accessed 26 December 2012.

Nuclear energy is created through chemical reactions that involve the splitting or merging of the atoms of nuclei together. The process of splitting an atom's nucleus is termed fission, and the process of merging the nuclei of atoms is termed merging.²

Nuclear energy is created in nuclear power stations, where uranium rods are the fuel used to create the energy or heat. The process goes through fission, where neutrons in the Uranium smash into the nucleus of atoms of Uranium. The Uranium nuclei will then split in half and release an energy that comes in a form of heat. At this point, carbon dioxide in gas form will be pumped into the reactors with the Uranium, removing the heat from the system. The gas turns very hot, and this heat is used to heat water into steam. The steam created from this process will drive the turbines which in turn drive the generators that produce the nuclear energy.³

2.2. Safety of Nuclear Power Reactors

The Atomic Act defines nuclear safety as *“the status and the ability of nuclear installation or transport equipment and operating personnel thereof to prevent uncontrolled development of fission chain reaction or unauthorized release of radioactive substances or ionizing radiation into the working environment or the environment, and to mitigate consequences of incidents and accidents at nuclear installations or consequences of events upon shipment of radioactive material”*.⁴

From the outset, there has been a strong awareness of the potential hazard of both nuclear criticality and release of radioactive materials from generating electricity with nuclear power. As in other industries, the design and operation of NPP aims to minimize the likelihood of accidents, and avoid major human consequences when they occur.⁵

There have been three major reactor accidents in the history of civil nuclear power - Three Mile Island, Chernobyl and Fukushima. One was contained without harm to anyone, the next involved an intense fire without provision for containment, and the third severely tested the containment, allowing the release of radioactivity.

The EU promotes high safety standards in all types of civilian nuclear activities, including nuclear power production, medical research and waste storage. Nuclear safety standards in the EU are based on the requirements of the main international agreements, namely the Convention

² *Ibid.*

³ *Ibid.*

⁴ U.S. Nuclear Regulatory Commission, 'Nuclear Regulatory Legislation' (2011), <<http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0980/v1/sr0980v1.pdf#page=13>>, accessed 26 December 2012.

⁵ World Nuclear Association, 'Safety of Nuclear Power Reactors' (2012), <<http://www.world-nuclear.org/info/inf06.html>>, accessed 26 December 2012.

on Nuclear Safety and the Safety Fundamentals established by the International Atomic Energy Agency (IAEA). The EU nuclear safety directive and nuclear waste directive make these requirements legally binding in all EU Member States.⁶ Following the nuclear accident in Fukushima, the European Commission and the European Nuclear Safety Regulators' Group (ENSREG) agreed on 25 May 2011 on voluntary tests for the EU's 143 nuclear power reactors. These tests were based on a common methodology and assess both natural and man-made hazards (i.e. effects of airplane crashes and terrorist attacks). The assessments were conducted by independent national authorities and through peer review.⁷

2. Austria

2.1. History of nuclear energy use in Austria

After the Second World War the Austrian energy industry focused on utilization of local energy sources. In order to cover the growing demand for electricity they invested in water energy and constructed large thermal power plants. Later due to the positive attitude of the parliamentary parties towards the peaceful use of nuclear energy and due to other framework conditions programs for the development of hydropower were reduced or even cancelled.⁸

Already the energy concept of the government under chancellor Josef Klaus foresaw the construction of nuclear power plants. Concrete plans for building a power plant were developed in 1971, after the federal government under the lead of chancellor Bruno Kreisky took the decision to construct the first nuclear power plant in Austria in March 1971 due to the pressure coming from the governments of the federal states.⁹

For implementation the company GKT (Gemeinschaftskernkraftwerk Tullnerfeld Ges.m.b.H.), has been established. GKT later constructed the Zwentendorf Nuclear Power Plant, which is the only completely constructed nuclear power plant worldwide that never operated.

The construction of the nuclear power plant started in April 1972. Designed as a boiling-water reactor rated at 692 MW electric output it should have covered 10% of the Austrian energy demand.

⁶ European Commission, 'Nuclear energy: Nuclear safety' (2012),
<http://ec.europa.eu/energy/nuclear/safety/safety_en.htm>, accessed 26 December 2012.

⁷ European Commission, 'Nuclear energy: Stress tests' (2012),
<http://ec.europa.eu/energy/nuclear/safety/stress_tests_en.htm>, accessed 26 December 2012.

⁸ 'AKW Zwentendorf- The atomic power plant that never went into operation' (History from 1946- 2008)
<http://www.zwentendorf.com/en/geschichte.asp?index=2> accessed 27 December 2012

⁹ Katzian Wolfgang, 'Aktuelle Energiepolitik in Österreich und Europa' (Die Zukunft- Diskussionszeitschrift für Politik, Gesellschaft und Kultur) <http://diezukunft.at/?p=2140> accessed 12 December 2012;
'AKW Zwentendorf- The atomic power plant that never went into operation' (History from 1946- 2008)
<http://www.zwentendorf.com/en/geschichte.asp?index=2> accessed 27 December 2012

A public debate about nuclear energy in general and especially about the Zwentendorf Nuclear Power plant occurred as well as several environmental organizations started to mobilize against the use of nuclear power. The Anti- Nuclear Power Plant movement was the beginning of the Green movement in Austria.¹⁰

In June 1978 the government decided on a referendum that should have been implemented on the 5th November 1978 on the usage of nuclear energy and the start- up of the Zwentendorf Nuclear Power Plant. A narrow majority voted against the start- up (50,47%).¹¹ In March 1985 the Zwentendorf Nuclear Power Plant was liquidated. Until then the nuclear power plant and maintenance cost added up to 14 billion schilling (1 billion Euros), 600 million schilling (47,3 million Euros) only for the upkeep. The political consequence drawn from this was a Federal Law on the Prohibition of the Use of Nuclear Fission for Energy Generation in Austria in 1978, which prohibits the construction of fission reactors for electrical power generation.¹²

After the disaster of Chernobyl in 1986 the political and social consensus about the anti-nuclear energy policy prevailed in Austria. In the nineties a new referendum for a nuclear- free Austria was initiated, which was taken over almost in it's entirety in the later in 1999 issued Federal Constitutional Act for a Nonnuclear Austria.¹³ Since then there were no more public discussions about the use of nuclear energy in Austria.

2.2. General situation

2.2.1. Energy policy and strategy

The main aim of the Austrian energy policy is a sustainable energy supply based on secure and economically affordable energy sources.

¹⁰ Kontroverse um den Bau von Zwentendorf vor der Volksabstimmung (apa historisch- Zeitgeschichte online) http://www.historisch.apa.at/cms/apa-historisch/dossier.html?dossierID=AHD_19781105_AHD0001#Kapitel_0 accessed 27 December 2012

¹¹ Die Volksabstimmung (apa historisch- Zeitgeschichte online) http://www.historisch.apa.at/cms/apa-historisch/dossier.html?dossierID=AHD_19781105_AHD0001#Kapitel_0 accessed 27 December 2012

¹² 'AKW Zwentendorf- The atomic power plant that never went into operation' (History from 1946- 2008) <<http://www.zwentendorf.com/en/geschichte.asp?index=2>>; Nach der Volksabstimmung (apa historisch- Zeitgeschichte online) http://www.historisch.apa.at/cms/apa-historisch/dossier.html?dossierID=AHD_19781105_AHD0001#Kapitel_0 accessed 27 December 2012; Bundeskanzleramt- Rechtsinformationssystem (676. Bundesgesetz: Verbot der Nutzung der Kernspaltung für die Energieversorgung in Österreich) http://www.ris.bka.gv.at/Dokumente/BgblPdf/1978_676_0/1978_676_0.pdf accessed 27 December 2012

¹³ Bundeskanzleramt- Rechtsinformationssystem (Federal Constitutional Act for a Nonnuclear Austria) http://www.ris.bka.gv.at/Dokument.wxe?Abfrage=Erw&Dokumentnummer=ERV_1999_1_149 accessed 27 December 2012

The core objectives of the Austrian energy strategy are cost effectiveness, environmental and social compatibility, a secure supply of energy and also competitiveness.

There should be an improvement in energy efficiency at all stages of the use of energy. The focus of research is set on renewable energy, such as hydro power, wind power, biomass and photovoltaic.¹⁴

2.2.2. Austria's local energy production

The development of the production of local energy shows in the long run a clear increase of the production of renewable energy on the one hand and a strong reduction of fossil fuels on the other hand. The domestic generation increased in the period from 2005/2010 for 20%, while the production of renewable energy increased even for 33%. The combination of the usage of hydropower and other renewable energies such as biomass cover 72,7% of the national energy production. Due to the Federal Constitutional Act for a Nonnuclear Austria, it doesn't operate any nuclear power plants and doesn't plan to do so in future.

The domestic energy generation covers only 34,4% of the gross domestic consumption, therefore Austria needs to import the greater part, especially of the fossil fuels.¹⁵

2.2.3. Austria's energy dependency

The main imported energy sources in Austria are oil, electricity and renewable energies, but primarily gas. The Austrian dependency on the import of energy supplies amounts to 61,6% what is clearly above the European average, which is around 53%.¹⁶

At the moment Austria covers 14,7% of its electricity requirement by „grey electricity“, which contains around 4% of electricity generated by nuclear power plants.

In April 2012 the Austrian energy providers agreed to oblige themselves to quit buying electricity generated by nuclear power plants and that only electricity with a proof of origin from non-nuclear sources is allowed to be sold.¹⁷

¹⁴ Federal Ministry of economy, family and youth (Energy strategy and policy)
<http://www.en.bmwfj.gv.at/Energy/Energystrategyandpolicy/Seiten/default.aspx> accessed 27 December 2012

¹⁵ Federal Ministry of economy, family and youth (Energienstatus 2012)
<http://www.bmwfj.gv.at/EnergieUndBergbau/Energieversorgung/Documents/Energienstatus%202012.pdf> accessed 27 December 2012

¹⁶ Federal Ministry of economy, family and youth (Energienstatus 2012)
<http://www.bmwfj.gv.at/EnergieUndBergbau/Energieversorgung/Documents/Energienstatus%202012.pdf> accessed 27 December 2012;

¹⁷ Die Presse- RechenTrick: Österreich soll atomstromfrei werden
http://diepresse.com/home/panorama/klimawandel/749813/RechenTrick_Oesterreich-soll-atomstromfrei-werden
accessed 27 December 2012

2.2.4. Austria's role in international energy politics related to nuclear energy and nuclear safety

Austria's role in nuclear safety/ nuclear energy is based on the cooperation with the relevant international organizations. To name just a few of them as examples:

One of them is the IAEA (International Atomic Energy Agency), which main aim is to promote the peaceful use of nuclear energy worldwide and which has its headquarter in Vienna.¹⁸

It is also a member state of the Organization for Security and Co-operation in Europe (OSCE), which is the largest security organization in the world and promotes the dialogue on energy security and the sustainable initialization of natural resources. The headquarter of OSCE is based in Vienna too.

2.3. Austria's national policy and nuclear safety

Austria has never operated a nuclear power plant and has no intention to do so in the future. The main concerns arise primarily for the nuclear power plants in the neighboring countries, as a nuclear disaster would affect also the Austrian environment and the health of its inhabitants. Because of the high danger which arises from using nuclear energy and operating nuclear power plants Austria attempts for a harmonization and the steady increase of international nuclear safety. As Austria has undertaken a lot of bilateral activities with its neighboring countries their main purpose is to exchange information on nuclear installations and work on early warning- methods and action plans for the prevention (but also emergency plans for concrete cases) of nuclear emergencies. Austria plans to contribute to all international activities, which aim at improving nuclear safety levels worldwide also in future.¹⁹

3. Hungary

3.1 The powerplant of Paks and its portion in the power supply of Hungary

¹⁸ International Atomic Energy Agency- Our Work <http://www.iaea.org/OurWork/> accessed 27 December 2012

¹⁹ 5th National Report of AUSTRIA for the Convention on Nuclear Safety in accordance with Article 5 for the CNS Review Meeting 2011
<http://www.google.at/url?sa=t&rct=j&q=&esrc=s&source=web&cd=10&ved=0CI8BEBYwCQ&url=http%3A%2F%2Fwww.lebensministerium.at%2Fdms%2FImat%2Fumwelt%2Fstrahlen-atom%2Fatomenergie%2FCNS%2F5th-National-Reportof-Austria-2010%2F5th%2520National%2520Reportof%2520Austria%25202010.pdf&ei=fZrcUJeAC8bNtAaloYDQDQ&usg=AFQjCNFXE5y0VfaGESZkdrybBgeNz4wL2A&sig2=zSiROQ6GZJOyEi--6x7BBQ&bvm=bv.1355534169,d.Yms&cad=rja> accessed 27 December 2012

The only nuclear power plant – with four reactors – which produces electricity is located in Paks, Tolna County, near the Danube River. But it is not the only facility where nuclear reactor operates. The first reactor was built in 1959, in the Research Center for Physics of the Hungarian Academy of Sciences.

This reactor had 2 MW thermal power capacity, and it was used for physical researches.²⁰ The system has been rebuilt twice, which resulted a higher – 10 MW – rated power.

A 100 kW thermal powered instructor reactor has started to work in 1971, which was built in the Budapest University of Technology and Economics. This reactor is used for nuclear technical, radiochemical, archeological and medical researchers.

From 1982 to 1987 the most important chain-link of the Hungarian current supply was built in Paks. The power-plant has got four VVER-440/213 reactors. In these days the Paks Power Station provides more than 38% of the Hungarian power generation.²¹

The VVER-440/213 is a Soviet type reactor which belongs to the family of the *pressurized water reactors (PWR)*. The „*VVER*” acronym means water-water energetic reactor, which comes from the Russian translation of this terminus technicus. The number 440 refers to the original capacity of the reactor. One reactor was able to produce 440 MW electricity. Thanks to the developements in the last 20 years, the four blocks of the Paks Powerstation have reached the 500 MW rates. The four blocks are able to generate 1970 MW energy altogether.²²

The reactors are operated by uranium dioxide (UO₂). The uranium dioxide is squeezed into pastille, then it is placed into cylinder made from zirconium-niobium. This cylinder, full of with helium, prevents the radioactive fissions get into the cooling water.

The *heating rods* are included into bundles. The bundles form *heating element trusses (fuel cell)*. A fuel cell includes 126 wands. The power station has got 312 pieces of fuel cell. The fuel cells are separated from each other by the *cooling water*. The life expectancy of a cell is four years.

For safety reasons *absorbent cells* are used beside the fuel cell. The absorbent cells are made from boron steel. In case of malfunction, the power-plant's function - with all the 37 cells - can be suspended safely. At this time, the absorbent cells descend into the active zone where they stop the chain reaction under 13 minutes.

²⁰ It was used in isotope production, chemical and nuclear physics researches.

²¹ Reactors in Hungary (Reaktorok Magyarországon (<http://atomeromu.hu/reaktortortenelem>)) accessed 25 December 2012.

²² The VVER-440/213 reactortype (A VVER-440/213 reaktortípus (<http://atomeromu.hu/a-paksi-atomeromu-felepitesi>)) accessed 25 December 2012

Though the chain reaction is stopped, the heat build-up continues to run. That is why the cooling of the reactor is also necessary. If the cooling system has a malfunction, the *additional malfunctional cooling system* will prevent that the melted radioactive fission-product get into the environment.

The worst malfunction is the damage or fracture of the *primary main line*, although the chance of it is really small. According to the calculations it would occur in every 100,000 years. During the malfunction, the radioactive steam with high temperature leaves. This event is prevented by the *hermetic space* and the *localization system*.

The cooling and the security systems use electricity. If an incidental power failure happens, three diesel generator provide the necessary energy from block by block, which is enough to stop the whole system in the safety way.²³

3.2 The Power-station of Paks and its safety

After the disaster of Three Miles Island in 1979 and the Chernobyl disaster in 1986, the safety requirements were raised to a higher level in the Paks Power-plant. Observing the safety criteria and making new rules are controlled and checked by the *Hungarian Atomic Energy Authority*.²⁴

The Paks Power-plant also have to be fit for three fundamental safety conditions; the effective regulation of the nuclear chain reaction, the transportation of the produced energy and the prevention of the radioactive substances getting into the environment. This is the so-called *defense in depth*.²⁵ Defense in depth uses *engineering barriers*.

The defense in depth system defines five levels. Every level has to prevent that the problem reach the next level. At the *first level* the system tries to check and filter out the errors. At the *second level* a concrete malfunction have to be treated. At the *third level* the automatic safety systems and human intervention help to correct the fault. At the *fourth level* severe accidents are managed and its consequences are eased. The *fifth level* is the worst, when the radioactive contamination steps out to the environment.²⁶

²³ Safety protection systems (Biztonságvédelmi rendszerek (<http://atomeromu.hu/a-paksi-atomeromu-felepites>)) accessed 25 December 2012

²⁴ 25/2009. (IV. 2.) OGY határozat

²⁵ Safety of nuclear powerplants (Atomerőművek biztonsága (<http://atomeromu.hu/Biztonság>)) accessed 25 December 2012

²⁶ Safety of nuclear powerplants (Atomerőművek biztonsága (<http://atomeromu.hu/Biztonság>)) accessed 25 December 2012

These five principles have been developed by the International Atomic Energy Agency and the operating company is responsible for compliance with the rules. This company in Hungary is the MVM Paks Nuclear Power Plant Closed Company Limited by Shares.

The Hungarian legislation is not only concerned to the guidelines of the International Atomic Agency, but the question of safety as well. The supreme statute in Hungary is the *Nuclear statute*²⁷ which specify five administrations loaded by various functions. The most important among them is the *Hungarian Atomic Energy Authority*. The issues of building, operating and decommissioning of power-plants belong to the scope of authority of the Hungarian Atomic Energy Authority. The Authority also deals with the problem of storageing and processing nuclear wastes.

The *National Public Health and Medical Officer Service* is responsible for the prevention, controlling and regulation of the personal radiation protection.

The supervisors assigned by the *environment minister and the minister of agriculture*, measure and detect the radioactive contaminations around the nuclear facilities.

The *Oner-Network system* deals with the radioactive pollutions are got to the atmosphere.

3.3 Radioactive waste

According to the Nuclear statute, the state is liable for placing, storing, treating of the radioactive wastes. In this context the company, which produces the waste, has to pay the costs.

The radioactive wastes is categorized by the Hungarian statutes²⁸ according to its states of matter, exothermic reactions, activity concentration and the half-life of the radionuclides.²⁹

The wastes are stored in near-surface (15-30 meters deep) or in subsurface (300 meters deep) storages. Hungary has got two storages for nuclear wastes. One in Püspökszilágyi (Pest County) which is a near-surface holding with 5000 cube meter, and another one in Bábaapáti (Tolna County).³⁰ Bábaapáti is the latest nuclear waste storage, which is 96 meters long and it is located 200 meters deep under the ground. In one chamber, 500 containers of nuclear wastes (4600 barrels) can be stored. The full capacity of Bábaapáti is 40,000 cube meters. Between the power-plant and the storage-place special vehicle fleet is used for transportation. Interesting addition,

²⁷ 1996. évi CXVI. törvény az atomenergiáról (1996. évi CXVI. statute about the nuclear energy)

²⁸ No. 14344. standard (modified in 2004 by the No. 23/1997. Ordinance of the Minister of Welfare)

²⁹ Radioactive wastes and its classifications (Radioaktív hulladékok és besorolásuk (<http://atomeromu.hu/hulladekkezeles>)) accessed 25 December 2012

³⁰ The placement of the small-and medium-level radioactive waste of the Paks power-plant (A paksi atomerőmű kis- és közepes aktivitású radioaktív hulladékainak elhelyezése (<http://atomeromu.hu/hulladekkezeles>)) accessed 25 December 2012

that the quantity and activity of the nuclear waste, which is generated in the Paks power-plant, is less than it is expected by the technical specification.³¹

3.4 The malfunction in 2003³², the following monitoring by the IAEA, and the stress test in 2012

The last, more serious malfunction occurred in 10th of April, 2003, when the presence of inert gas was detected by the instruments around the block II. The source of the leak was one of the cleaning tanks, which was used for cleaning the fuel cells from the sedimentations. But the fuel cells in the cleaning tank were damaged. These damages were caused by the incorrect designing of the cleaning tank. Owing to the incorrect designing, the cells did not get the necessary cooling, so they were overheated. The malfunction was ranked into INES 2, and later it was upgraded to INES 3, which means that the malfunction was serious but it did not risk its own environment.

During the malfunction the residents who were most exposed to radiation suffered 0,13 µSv radiation. This rate is only 1,5 thousandths of the radiation per one year which affects the civilians, so it does not have got risk.

The Hungarian government requested the International Atomic Energy Agency to investigate the malfunction from 16-25th of June in 2003. The monitoring delegation team came from Austria, Canada, Finland, the Czech Republic, the United Kingdom and the United States of America.³³

After Fukushima disaster, all of the nuclear power-plants had to undergo a stress test. The Paks Power-plant passed this test, but it has got some deficiency. Luckily the power-station is able to stand against the earthquakes, and its protection system is enough to resist an incidental flood of the Danube. On the other hand, it would necessary to develop the ventilation- and the cooling system.³⁴

³¹ Greenfo, 'Fogad a bátaapáti atomtemető' <http://www.greenfo.hu/hirek/2012/12/08/fogad-a-bataapati-atomtemeto> (08 December 2012) accessed 25 December 2012

Radioaktív Hulladékokat Kezelő, 'Nemzeti Radioaktív hulladék-tároló' (2009) <http://www.rhk.hu/letesitmenyeink/nrht/> accessed 25 December 2012

³² 'Országos atomenergia hivatal' http://www.haea.gov.hu/web%5Cv2%5Cportal.nsf/feladatok_hu/9558363C3794F674C1257109004EC3CD?OpenDocument accessed 25 December 2012

³³ IAEA monitoring in 2003. (NAÜ-vizsgálat 2003-ban (<http://atomeromu.hu>)) accessed 25. December 2012

³⁴ Origo.hu, 'Átment a paksi erőmű az uniós vizsgán' (10. April 2012) <http://www.origo.hu/idojaras/20121004-atment-a-paksi-eromu-az-unios-vizsgan-stresszteszt-atomenergia-biztonsag.html> (04. October 2012) accessed 28. December 2012

3.5 The development of the power-plant of Paks

The nuclear energy in Hungary is considerably supported, despite the nuclear disaster of Fukushima. The main supporter is the Hungarian government. According to the plans of the government³⁵, two new reactor-blocks will be built from 2020 to 2030, while the existing reactor-blocks will be stopped until 2037.

Based on the survey, which is made in 2008, the two new reactor block will be able to reach the 3000 MW capacity, which would be enough to satisfy the electrical needs of Hungary beside sustainable price stability. The expansion is justified by the low carbon-dioxide emission, which also helps to reach our obligations of climate protection.³⁶

4. Slovakia

4.1 General situation on nuclear power plants

The era of nuclear power industry started in the former Czechoslovakia in August 1958 by the construction of the prototype A1 Nuclear Power Plant in Jaslovské Bohunice which is now in decommissioning because of an accident during fuel assembly in 1977. Currently there are 4 VVER 440/213 nuclear units in operation- two units in Jaslovské Bohunice and another two in Mochovce, which were subject of systematic safety assessment and upgrading in accordance with new regulations and international standards in the IAEA document “Safety Issues and their Ranking for NPP VVER 440/213”.³⁷ Total installed power of operated VVER 213 units is 1,940 MW. In Mochovce there are also another two VVER 440/213 units with significantly upgraded design under construction.³⁸

In the process of the Eastern Enlargement, as the EU was very cautious about welcoming countries, which relied on power from Soviet- era nuclear power facilities, especially after Chernobyl disaster in 1986, Brussels demanded the prompt closure of Soviet-built first generation, high risk reactors. And also because of the anti-nuclear campaign spearheaded by Austria over Soviet-built reactors it was agreed, as a part of EU accession negotiations, that the

³⁵ 23/1997. számú népjóléti miniszteri rendelet

³⁶ Hvg.hu, ‘Kétharmadot kapott a magyaroktól a paksi erőmű’ (26. September 2011) http://hvg.hu/gazdasag/20110926_paksi_atomeromu_kozvelemenyny_kutatas accessed 25. December 2012

³⁷ Nuclear Regulatory Authority of the Slovak Republic, ‘The stress tests for nuclear power plants in Slovakia’ (National report 30.12. 2011) <http://www.ujd.gov.sk/files/NS_Zatazove_testy_JE_SR_ang.pdf> p.25, accessed 26. December 2012

³⁸ Chudoba Štefan, ‘Small country with high nuclear potential: scientific support for nuclear decommissioning’, (2012), http://ec.europa.eu/dgs/jrc/downloads/events/20120911decommissioning/jrc_20120911_decommissioning_stefan_chudoba.pdf, accessed 26. December 2012

two VVER 440-230s at Bohunice would be shut down by 2006 and 2008. Since then these V1 units are also in decommissioning.^{39,40}

4.2 Energy dependence

After this kind of a commitment, the government refuses to think about closing any other of its nuclear power plants. Even after the Fukushima accident in 2011, when Germany announced plans to shut down its nuclear power plants by 2022, as according to the former prime minister, this kind of a decision would leave the country without 50% of its energy needs and called for a middle way of increasing the safety levels and meeting the highest criteria on security instead.⁴¹

And as Slovakia is the European Union's third most nuclear-dependent state after France and Belgium, with atomic energy accounting for 50 % of its electricity production⁴², the position of the Ministry of Economy of the Slovak republic is clear, the country will rely on nuclear energy in the future. According to the Minister of Economy, *Tomáš Malatinský*, "Slovakia is planning the long-term use of nuclear energy in its energy mix, since it significantly contributes to energy security and thus economic independence," adding that after putting two more units in Mochovce into service and replacing the currently shut- down V1 in Bohunice with the new power plant with the capacity of 2400MW, which plans are in the stage of preparations and negotiations with possible investors, Slovakia, with a surplus balance of electricity, can actually switch from an importer into an exporter of electricity.⁴³

The reason for state's support of nuclear energy is mainly because of its status of an importer of electricity which is unacceptable in the long- term perspective. In terms of electricity production, Slovakia remained by 2007 a net exporter. This changed after Slovakia committed itself to shut down two reactor units in Jaslovské Bohunice as part of the EU accession process

³⁹ Daly John C.K., ' Slovakia's Nuclear Schizophrenia: Shut Down, Continue As Usual, or Boldly Go -- Where?' (article by Oilprice.com 6.January 2012) <http://www.minyanville.com/businessmarkets/articles/slovakia-slovakia-energy-policy-nuclear-power/1/6/2012/id/38734> accessed 26. December 2012

⁴⁰ Soizick Martin, Charles Digges, ' Upcoming EU enlargement revives long-standing nuclear battle' (10.February 2004) http://www.bellona.org/english_import_area/international/russia/nuke_industry/co-operation/32498 accessed 27.December 2012

⁴¹ Nuclear power daily, 'Slovenia, Slovakia rule out nuclear plant closures' (30.May 2011) <http://www.nuclearpowerdaily.com/reports/Slovenia_Slovakia_rule_out_nuclear_plant_closures_999.html> accessed 27.December 2012

⁴² IAEA Power reactor information system, ' Nuclear Share of Electricity Generation in 2011' <<http://www.iaea.org/PRIS/WorldStatistics/NuclearShareofElectricityGeneration.aspx>> accessed 27.December 2012

⁴³ Energia.sk, ' Tomáš Malatinský: Jadrovej energie sa neplánujeme vzdáť' (conference 26.November 2012) <<http://www.energia.sk/clanok/jadrova/tomas-malatinsky-jadrovej-energie-sa-neplanujeme-vzdat/8862/>> accessed 27.December 2012

and thus the country lost its exporter status solely because of political commitments. It has also caused a growth in high voltage prices and issues with reserve power for the grid.⁴⁴

4.3 Safety of nuclear power plants in Slovakia

The supervisory body for nuclear safety in Slovakia is The Nuclear Regulatory Authority of the Slovak Republic (UJD SR) which controls whether all activities of the authorization holders are in compliance with nuclear safety rules. Its main assignment is to “*perform state supervision activities upon the nuclear safety of the nuclear installations with the objective to use the nuclear energy in the Slovak Republic safely and in such a way that no threat will jeopardize public health, property and environment*” and it should guarantee to citizens of SR and international community that “*the nuclear energy will be used in the Slovak Republic for the peaceful purposes only and that the Slovak nuclear installation are designed, constructed, operated and decommissioned in compliance with relevant legislation*”⁴⁵

In accordance with the Slovak national legislation all plants in Slovakia are subject to Periodic Safety Reviews with 10 years periodicities as well as they have been a subject of 20 independent IAEA missions since 1991. In view of the lessons learned from 11.3. 2011 Fukushima accident the owner and operator (the holder of the operating permit) of all operating and constructed nuclear units in Slovakia- a stock company *Slovenské elektrárne a.s.* (SE a.s.) has committed himself to perform so called stress tests on all units in operation or under construction. The legislative basis has been updated recently with the progress in the development of the IAEA Safety Requirements and established WENRA Reference. The state supervision over nuclear safety is performed in accordance with the Atomic Act (No. 541/2004) and Regulation No. 430/2011 on laying down details of the requirements for nuclear safety. According to the UJD SR “*the legislation reasonably covers also the issues relevant for the European stress tests*”.⁴⁶

The stress tests included an analysis of unexpected incidents such as floods, earthquakes, power failures, a long term interruption of water supply and other system checks. In order to determine the safety margins of nuclear units, a method, that verifies all conditions necessary for

⁴⁴‘Energy Mix in Central European Countries of the V4 Group: The Quest for Stability’ (XXI. World Energy Council Montreal 2010) <<http://www.worldenergy.org/documents/congresspapers/310.pdf>> p.10, accessed 27.December 2012

⁴⁵JESS, ‘Safety of nuclear power plants’(2011) < <http://www.jess.sk/en/home/about-nuclear-power-industry/safety-of-nuclear-power-plants>> accessed 27.December 2012

⁴⁶Nuclear Regulatory Authority of the Slovak Republic, ‘The stress tests for nuclear power plants in Slovakia’(National report 30.12. 2011) <http://www.ujd.gov.sk/files/NS_Zatazove_testy_JE_SR_ang.pdf> p.8, accessed 27. December 2012

the functioning of the system (power supply, working media, measurement, environmental conditions, the availability of the operator, the existence of guidelines, human reliability and availability of sufficient logistical and administrative conditions) and assess when these systems eventually fail due to the increased load caused by external influences, was used.⁴⁷

The final report confirmed what preliminary reports indicated- nuclear power plants in Slovakia, which are in operation or under construction, meet the safety requirements that are imposed on them today. The UJD SR stated that *"there were no such deficiencies identified which would question further safe operation of existing units and continued construction of new units."* However, the report also adds that the area for increasing security still exists and therefore proposes a number of specific measures that should be implemented in the power plants in the near future, for example adding new emergency diesel generators and providing additional fire brigade pumps for removal of water in case of flooding.^{48,49}

Following the findings, the report also recommends what should be done in the future to extend the time for stabilization of the power plant in case of an emergency, and also for the power plant to become more resistant in light of the *"lessons of Fukushima."*⁵⁰

4.4 The public opinion and NGOs in Slovakia

However, the NGO *Greenpeace Slovakia* expressed concerns about trustworthiness of the stress tests claiming that they are just a farce to reassure the public that all the reactors are safe and both nuclear power plants are in their best condition. The NGO bases its claims on the fact that the tests were not aimed at the major issues that jeopardized the health of people in Japan. According to the nuclear engineer *Mr. Dalibor Stráský*, the stress tests considered only *"the perfect accident"* – perfect in sense that in most cases were examined the consequences of a failure of just one of the systems, assuming that other systems will work as expected. The safety strategy should also take into consideration that the biggest thread does not have to be

⁴⁷ See No. 47

⁴⁸ Reuters, 'Slovak nuclear power plants pass stress tests' (3.January 2012) <<http://www.reuters.com/article/2012/01/03/us-nuclear-slovakia-stress-idUSTRE8020CD20120103>> accessed 27. December 2012

⁴⁹ Energia.sk, 'Zhrnutie výsledkov záťažových testov na Slovensku' (3.January 2012) <<http://www.energia.sk/analyza/jadrova/zhrnutie-vysledkov-zatazovych-testov-na-slovensku/5544/>> accessed 27. December 2012

⁵⁰ Energia.sk, 'K finálnej správe o záťažových testoch' (3.January 2012) <<http://www.energia.sk/redakcny-komentar/jadrova/k-finalnej-sprave-o-zatazovych-testoch/5546/>> accessed 27. December 2012

necessarily the rupture of the main circulation pipeline but for example melting of nuclear fuel, which was the case in Fukushima, Chernobyl or Three Mile Island.⁵¹

One of the main problems is also insufficient emergency and evacuation plans. The proof of possible failure can be, according to Greenpeace, the last year's false alarm in Bohunice, when it apparently came to failure of communication between rescue units, power plants and components of the civil service, as people living in the environs of the power plant, even after 30 minutes, were not informed about what was happening.⁵²

The public opinion in Jaslovské Bohunice and also in Mochovce is in favor of nuclear energy. According to the poll taken in 2009 in the environs of Mochovce, 75% of respondents support the completion of the third and the fourth unit of NPP.⁵³

In favor of the construction of a new NPP in Jaslovské Bohunice in 2010 was 62,4% of inhabitants of Slovakia and 59,8% of inhabitants of the region Jaslovské Bohunice. 71,1% of Slovaks thinks that a new NPP would provide energy self-sufficiency of the country. However, it is expected that the support dropped slightly after the Fukushima accident; unfortunately the data from 2011/2012 are not yet available.⁵⁴

5. Slovenia

5.1 Slovenian energy policy

The main document of Slovene energy regulations is the Energy Act⁵⁵ which determines principles of Slovene energy policy. Since Slovenia is a member state of the European Union (EU), goals of Slovene energy policy have to follow EU guidelines. One of the basic strategic documents on Slovene energy policy is the Resolution on the National Energy Programme⁵⁶

⁵¹ Energia.sk, 'Správy o stress testoch nám poskytli strelivo' (1. February 2012) <<http://www.energia.sk/rozhovor/jadrova/spravy-o-stresstestoch-nam-poskytli-strelivo/5829/>> accessed 27. December 2012

⁵² Energia.sk, 'Greenpeace: záťažové testy elektrární sú len fraškou a manipulujú verejnú mienku' (3. January 2012) <<http://www.energia.sk/tlacova-sprava/jadrova/greenpeace-zatazove-testy-elektarni-su-len-fraskou-a-manipuluju-verejnu-mienku/5542/>> accessed 27. December 2012

⁵³ SLOVENSKÉ ELEKTRÁRNE, a.s. 'Atómová elektrárň Mochovce 3. stavba: Všeobecne zrozumiteľné záverečné zhrnutie' (July 2009) <http://www.seas.sk/img/SEAS/SE%20Documents/Spolocnost/EIA_EMO34/zhrnutie_SK.pdf>, p.68, accessed 27. December 2012

⁵⁴ JESS, 'Kvantitatívny prieskum verejnej mienky' (2011) <<http://www.jess.sk/sk/home/pre-media/tlacove-spravy/reprezentativny-quantitativny-prieskum-verejnej-mienky>> accessed 27. December 2012

⁵⁵ Energetski zakon. Uradni list Republike Slovenije Nr. 27/2007 from 26 March 2007.

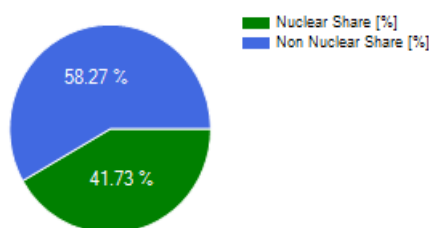
⁵⁶ Resolucija o nacionalnem energetskem programu. Uradni list Republike Slovenije Nr. 57/2004 from 27 May 2004.

from 2004. In 2009 Green Paper on National Energy Programme⁵⁷ was prepared. Guidelines for the new national energy programme, encompassed in the Green Paper, are prepared based on goals of energy policy and according to broader development goals of the country. They are also coordinated with goals of the EU energy policy and international obligations of the country.⁵⁸

5.2 Energy Profile of Slovenia

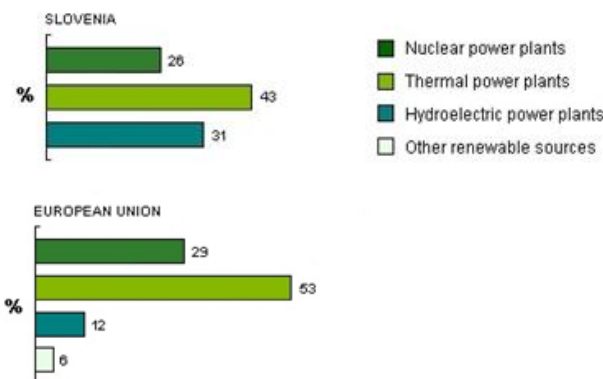
Main sources of electrical energy production in Slovenia are nuclear, fossil (coal, oil, gas) and hydro energy. Coal is still an important source of electrical energy in Slovenia but its main disadvantage is the viewpoint of environment protection because of combustion gasses. Slovenia imports most of the gas from Russia, one third from Algeria and smaller amounts from Austria. Compared to coal is gas combustion relatively clean, but its disadvantage is dependency on import and high price.⁵⁹ Slovenia has rather limited energy reserves.⁶⁰ Water energy in Slovenia is already almost completely exploited.⁶¹ As shown in Table 1, nuclear energy presents almost 42 % of power generation in Slovenia.

Table 1: Electricity production share in 2011



Source: IAEA 2012e.

Table 2: Shares of electricity generated in 2008 by power producers



Source: Nuklearna elektrarna Krško 2012.

⁵⁷ Ministrstvo za gospodarstvo, 'Zelena knjiga za Nacionalni energetski program Slovenije' (2009), <http://www.gen-energija.si/upload/files/Zelena_knjiga_NEP_2009.pdf>, accessed 11 November 2012.

⁵⁸ Gen energija, 'Slovenska energetska politika' (2012), <<http://www.gen-energija.si/si/o-energiji/energetska-prihodnost/slovenska-energetska-politika>>, accessed 11 November 2012.

⁵⁹ Gen energij, 'Prednosti jedrske energije za Slovenijo' (2010), <http://www.gen-energija.si/upload/katalogi/prihodnost_jedrske_energije_za_SLO.pdf>, accessed 11 November 2012.

⁶⁰ IAEA, 'Country Nuclear Power Profiles: Slovenia' (2012), <http://www-pub.iaea.org/MTCD/Publications/PDF/CNPP2012_CD/countryprofiles/Slovenia/Slovenia.htm#Footnote*>, accessed 23 December 2012.

⁶¹ Gen energija, 'Prednosti jedrske energije za Slovenijo' (2010), <http://www.gen-energija.si/upload/katalogi/prihodnost_jedrske_energije_za_SLO.pdf>, accessed 11 November 2012.

Table 2 shows that Slovenia relies mostly on thermal power plants; share of thermal power plants is higher for 10 % from the EU average. In the table the NPP share presented only 26 % since NPP Krško is co-owned by Slovenia and Croatia and each state receives half of the produced electrical energy.

In 2011 Slovenia imported less than one half of electricity demand. Energy dependence of Slovenia in 2011 was 48 %, which is less than in previous years. Reduction was mainly the consequence of smaller consumption of gas and slowdown in consumption of petroleum products where Slovenia is completely dependent on import.⁶²

Production of primary energy was in 2011 higher for 2 % than in 2010. Higher production was the result of higher production of the NPP (for 10 %). Total share of energy from renewable sources of energy in final gross consumption in Slovenia was 19 % in 2010. In 2011 39 % of electrical energy was produced by NPP, 38 % by thermal power plants and 23 % by hydro power plants.⁶³ From renewable sources of energy 24 % of electrical energy was produced.⁶⁴

NPP Krško produces more than 40 % of electrical energy in Slovenia; half of the produced energy is sent to Croatia which owns half of the power plant. In Slovenia more than one fifth of the electrical power demand is produced by nuclear energy. Besides its efficiency and safety the special meaning of this kind of energy is that it does not cause carbon dioxide emissions.⁶⁵

In the last years Slovenia imports averagely more than one fifth of energy demand. Share of imported electricity is great and means dependence on political and economic circumstances in other countries. Import needs are even harder to meet because of general growth of electricity demand in Europe and because of cessation of major energy facilities in Southeastern Europe. Besides that some thermal power plants are dependent on coal, oil and gas import.⁶⁶

5.3 Nuclear Power Plant Krško

⁶² Statistični urad Republike Slovenije, 'Letna energetska statistika, Slovenija' (2011) – začasni podatki (2012), <https://www.stat.si/novica_prikazi.aspx?id=4695>, accessed 11 November 2012.

⁶³ *Ibid.*

⁶⁴ Zelena Slovenija, 'Iz obnovljivih virov skoraj četrtna elektrike' (2012), <<http://www.zelenaslovenija.si/novice/1844-iz-obnovljivih-virov-skoraj-cetrtina-elektrike>>, accessed 11 November 2012.

⁶⁵ Gen energija, 'Prednosti jedrske energije za Slovenijo' (2010), <http://www.gen-energija.si/upload/katalogi/prihodnost_jedrske_energije_za_SLO.pdf>, accessed 11 November 2012.

⁶⁶ *Ibid.*

Slovenia has one NPP in commercial operation since 1983, the NEK (*Nuklearna elektrarna Krško*). Construction started in 1975 and it was connected to the grid in 1981, entering commercial operation in 1983. In 2001 its steam generators were replaced and the plant was uprated 6% then and 3% subsequently. Its operational life was designed to be 40 years, but a 20-year extension is being sought. The Krško NPP is a pressurized water reactor plant of 696 MW(e), delivered and constructed by Westinghouse, and is jointly owned with the Republic of Croatia. The operational and safety record of Krško NPP is good and complies with all international standards and highest safety requirements.⁶⁷

After modernization and the transition to the 18-month fuel cycle, it can produce over 5.8 TWh in a year without outage, and around 5.4 TWh in a year with the outage, which means that, in accordance with the bilateral treaty on the Krško NPP, between 2.7 and potentially over 2.9 TWh of electricity is available for the Slovenian market annually. In addition to the important share of the electricity produced, the Krško NPP is also characterized by extremely high reliability of production, and by achieving its ambitiously set goals it is classified in the top quarter of the best functioning NPP in the world. At the same time, it is placed among the ten power plants in the world, which can function for 510 days without shutdown, which has an important effect on ensuring the stability of electric power system and reliable supply to customers.⁶⁸

Under the Contract between the Government of the Republic of Slovenia and the Government of the Republic of Croatia on the regulation of status and other legal relations connected to investment in the Krško NPP, its exploitation and decommissioning, and the Memorandum of Association, both of which entered into force on 11 March 2003. The basic capital of the Krško NPP is divided into two equal shares owned by the partners GEN energija and Hrvatska Elektroprivreda. The Krško NPP produces and supplies electricity exclusively in favour of the two partners, who each have the right and obligation to use 50% of its total output.⁶⁹

Current NPP's operational life was originally designed for 40 years, which means that it would be in operation until 2023. However, because of very good maintenance and the replacement of major vital components, the Krško NPP is in very good condition. Krško NPP

⁶⁷ IAEA, 'Country Nuclear Power Profiles: Slovenia' (2012), <http://www-pub.iaea.org/MTCD/Publications/PDF/CNPP2012_CD/countryprofiles/Slovenia/Slovenia.htm#Footnote*>, accessed 23 December 2012.

⁶⁸ *Ibid.*

⁶⁹ *Ibid.*

has completed its ageing program in 2008 which is a basis for plant life extension for additional 20 years, i.e. up to 2043.⁷⁰

Apart from power generation, Slovenia has a research reactor TRIGA Mark II, a 250 kW(th), used mainly for R&D and for training activities. TRIGA is part of the Institute Jožef Stefan. TRIGA Mark II research reactor has been operating since 1966.⁷¹

5.3.1. Krško NPP safety

The Slovenian Nuclear Safety Administration (SNSA) acts as safety authority in the field of nuclear and radiation safety except for medical one which is covered by Slovenian Radiation Protection Administration (SRPA). The SNSA is a part of the Ministry of the Environment and Spatial Planning. The major nuclear facility supervised by the SNSA is the Krško NPP. Besides the Krško NPP, there are also other nuclear installations, i.e. TRIGA Mark II research reactor, an interim storage of low and medium radioactive waste, the closed uranium mine Žirovski Vrh and all industrial all industrial companies as well as individuals dealing with radioactive sources.⁷²

Operational Low and Intermediate-level wastes are stored at Krško, as is used fuel. The 1996 strategy for long-term management of used fuel recommends direct disposal of it, but leaves open the possibility of a later decision to reprocess it.⁷³

In October 2012 Slovenian Nuclear Safety Administration published that in the European Commission report on European NPP and on stress tests it was written that all European NPP fulfill all current safety standards, but in the light of the Fukushima tragedy some improvements could be done. Each NPP was evaluated based on 11 different measures which were recognized as useful and necessary for mitigation of effects of extreme natural and similar disasters around the building of NPP, while carrying out stress tests. The report claims that Krško NPP is the best in Europe because it is the only one, which has already or will soon carry out all 11 measurements. This report can confirm that Slovenia has responded timely and appropriately.⁷⁴

5.4 Slovenian public opinion on nuclear energy and Krško NPP safety

⁷⁰ *Ibid.*

⁷¹ *Ibid.*

⁷² *Ibid.*

⁷³ World Nuclear Association, 'Nuclear Power in Slovenia' (2012), <http://www.world-nuclear.org/info/inf114_nuclearslovenia.html>, accessed 26 December 2012.

⁷⁴ Uprava Republike Slovenije za jedrsko varnost, 'Nuklearna elektrarna Krško najbolje pripravljena na izredne dogodke' (2012), <<http://www.ursjv.gov.si/si/info/novica/article/4597/5700/3f5b8c2378c7a2685f3c2db3976de005/>>, accessed 11 November 2012.

Opinion poll about Slovenian public opinion on nuclear technology in Slovenia, carried out in 2011, showed that Slovenes believe that NPP are medium economical (as most economical were marked solar and wind power plants. Slovenian population believes that NPP are not safe for people and environment (69 % of the population); only 13 % said that NPP are safe. Accordingly 64 % respondents said that disposal of low- and medium-radioactive waste is not safe. More than one half of respondents (51,2 %) disagree with construction of a new NPP in Slovenia; 14,1 % disagree until the issue of radioactive waste disposal is resolved; and 16,5 % agree with construction, if a new NPP would be constructed based on the safest modern technology.⁷⁵ Negative opinion about nuclear energy is shared also by Greenpeace Slovenia which claims that nuclear energy is dirty, dangerous and expensive. They also claim that by using nuclear energy renewable sources of energy are not sufficiently exploited.⁷⁶

On the other hand experts from the Slovenian Nuclear Experts Association claim that Krško NPP is safe and that the possibility for an accident similar to the one in Fukushima is extremely low.⁷⁷ Their viewpoint was confirmed also by the European Commission.⁷⁸ Clearly there is a gap between public opinion in one hand and experts' conviction on the other.

6. Conclusion

All the technologies, which are used by the mankind, necessarily imply the risk and the chance of a disaster. With appropriate controls and precautionary measures the nuclear power plants are the most cost-effective and environmentally friendly electricity-producers. They pollute the environment less than the thermal power-plant, which uses fossil fuels and coals. NPP do not cause greenhouse gas emissions and therefore considerably contribute to the reduction of human impact on climate change. The hydropower-plant is also more dangerous than the nuclear power plant because the HPP destroys the biosphere of the river, where it is located.

The competitive position of NPP arises from the fact that nuclear power plant produce a great amount of electricity from little amount of fuel and that fuel price sums to small share (round 12

⁷⁵ Ninamedia, 'Raziskava javnega mnenja' 2011, <<http://www.arao.si/uploads/datoteke/Javno%20mnenje%202011.pdf>>, accessed 26 December 2012.

⁷⁶ Greenpeace Slovenia, 'Jedrska energija: umazana, nevarna in draga' (2011), <http://www.greenpeace.org/slovenia/si/kaj-delamo/jedrska/fukusima/standard-page13/>, accessed 26 December 2012.

⁷⁷ Društvo jedrskih strokovnjakov Slovenije, 'Razlaga težav z jedrskimi elektrarnami po potresu in cunamiju na Japonskem' (2011), <<http://www.djs.si/1novice/JaponskaPotres.htm>>, accessed 26 December 2012.

⁷⁸ Uprava Republike Slovenije za jedrsko varnost, 'Nuklearna elektrarna Krško najboljše pripravljena na izredne dogodke' (2012), <<http://www.ursjv.gov.si/si/info/novica/article/4597/5700/3f5b8c2378c7a2685f3c2db3976de005/>>, accessed 11 November 2012.

%) of electricity production costs. Changes in uranium price at the world market affect the electricity production prices less than for example price changes of gas or oil. The price for electricity coming from nuclear power plants is stable and predictable and is lower than the price from thermal power plant on fossil fuels (coal, oil, gas). Nuclear power plant also does not have to cover costs for greenhouse gas emissions which increase price of electricity from thermal power plants.⁷⁹

In Central European countries the renewable energy sources are not able to fully satisfy the electrical needs of the population and the factories. These technologies are only together suitable to reach the sustainable energy production. But to building up this structure is rather expensive but also necessary. Necessary, because the investing in the energy sector not only contents the electrical needs, but it is invaluable knowledge for the country as well.

Despite many of its advantages, nuclear power plants are opposed on moral grounds as well as on environmental grounds. By many groups, they are opposed because of their close linkage with the development of nuclear weapons, they can also be seen as a target of terrorist attacks. We must not forget to mention that also aftermaths like the one of Chernobyl cannot be forgotten easily, not to mention that we still do not know how huge the impact of the Fukushima accident on the environment and the life of people in Japan is going to be in future.

As the main fuel for NPP is uranium- scarce metal mined from the ground in similar way as coal is mined, which is not a renewable source of energy so one day the supply of uranium will run out making all the nuclear power plants obsolete. Yet the produced nuclear waste remains 'active' over many years and disposing it safely is an issue which needs to be addressed properly. There still exists also the risk of accidental discharge of radioactivity, which can be harmful for the environment as well as for the human being. The mining itself represents a huge risk of water or soil contamination.^{80,81}

In summary, nuclear power-plants demand high qualification on the field of engineering, physics and chemistry and they are able to produce electricity cheaply and safely and the safety can be reached by watchful usage, regular controls, increasing safety levels and executing stress tests which can tell us about preparedness of NPPs in case of certain types of accidents.

⁷⁹Gen energija, 'Prednosti jedrske energije za Slovenijo' (2010), <http://www.gen-energija.si/upload/katalogi/prihodnost_jedrske_energije_za_SLO.pdf>, accessed 11 November 2012

⁸⁰'Nuclear Energy: Disadvantages of Nuclear Energy' (2011) <http://www.ianswer4u.com/2011/12/nuclear-energy-disadvantages-of-nuclear.html#axzz2GMM4JyHZ> accessed 28.12.2012

⁸¹Examiner, '7 Reasons why nuclear power is bad for the environment and the nation' (11. December 2009) <http://www.examiner.com/article/7-reasons-why-nuclear-power-is-bad-for-the-environment-and-the-nation> accessed 28.12.2012

Even though every NPP in Hungary, Slovakia as well as Slovenia passed the latest stress tests, with minor recommendations for improvements, experts agreed that nuclear accidents do not happen for reasons that we can expect. What caused the melting of the reactor core in a reactor at Bohunice A1 in Greisfelde in Germany, Three Miles Island in USA, Chernobyl and Fukushima was just something that was unexpected.

Nevertheless, according to the positions of government of these four countries in Central Europe, it is obvious that those countries, which already have a nuclear power plant, have no intentions to shut them down and stop producing nuclear energy. They are even more willing to support the constructions of new sources of nuclear energy. On the other hand, countries like Austria, which is a big opponent of nuclear power plants, have no intention to start to support them and remain to fight against the usage of nuclear power.

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